Integrated Design, Design Management and the Delivery of Major Hospitals

Anne Wood Symons, MSc, B.Arch (Hons), RIBA, ARIAS, MCIOB

14110596

The Bartlett School of Construction and Project Management

Submitted in Partial Fulfilment of the Requirements of the Doctor of Philosophy at University College London

‘I, Anne Wood Symons confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.'

"Management techniques misapplied wreak havoc among the complex and highly charged relationships of the design group. But scientific management like matrix algebra, is one of those 20th century facts of life with which the architect, for good or ill, must come to terms. It is no more sensible to reject its usefulness out of hand than it would be to deny oneself the possibility of using thin concrete shells and stick to mud walls and thatch."

Zambelli (2017) quoting Derbyshire and Austin-Smith (1962)

Abstract

There is a failure to fully achieve client expectations and to deliver integrated hospital building solutions that function to all spatial and equipment requirements. Often this is because the construction of hospitals is based on designs established several years before the start on site. A retrospective abductive, auto-ethnographic case study approach has been taken in the examination of four major hospital projects over a period of 30 years. The level of design integration and effect of design management and coordination issues relating to stakeholder engagement, roles and responsibilities, static and dynamic briefing and the integration of major medical equipment has been explored at a project level, then contextualised within a wider delivery model to understand the impacts of these on integrated delivery and systems integration. Five temporal periods were observed, four of them relating to the retrospective case studies these were: (1) prescriptive integration – where traditional procurement with Design, Bid, Build delivery was combined with standards and guidance; (2) dysfunctional integration – where the adoption of Private Finance Initiative (PFI) with Design and Build delivery transferred traditional roles and reduced standardisation; (3 and 4) adaptive integration 1 and 2 – which saw both a gradual de-regulation of standards; and, an understanding for standards, and (5) the fifth temporal disintegration period – where guidance from the wider delivery model ceased to be updated due to top down policy reorganisation and lack of centralised control and includes a current case study. Throughout these temporal periods, it was found that the national delivery models have had a significant influence on hospital project delivery and particularly systems of systems integration. A new model based on layering principles that shows the impact of wider delivery models on systems integration is proposed to improve the provision of 'state of the art' facilities at project completion.

Key words: Integrated Design, Integrated Project Delivery (IPD), Major Hospital Requirements, Layering, Standards and Guidance

Impact Statement

The autoethnographic methodology used in this thesis, although retrospective, impacts strongly on what is currently happening in the construction sector with particular reference to delivery models for healthcare projects due to the failure of the private finance initiative and the decision by the UK government not to continue with its usage.

The thesis also demonstrates that it is not only the project financing model which is problematic, but also the form of contract – Contractor led Design and Build and the skills and capabilities of the people working in the construction sector. There is a lack of healthcare specific technical design, planning and qualification and the generic field of design management requires customisation to orientate it on this highly complex setting. This work also highlights the need to review statutory requirements for building control and the inclusion of control of infection as a statutory requirement.

The current Covid-19 pandemic not only highlights the issue of infection control but the need for acuity adaptability to cope with such situations. The ad hoc manner in which hospital facilities have been altered and the lack of central guidance and procurement (Personal Protective Equipment -PPE) demonstrates the need for a new integrated approach to the delivery of healthcare in both the wider delivery system and at project delivery level as outlined in this thesis.

The importance of providing national guidance relating evidence-based design, ergonomic studies and post occupancy evaluations and the role of the wider system is fundamental to healthcare design and needs an integrated and researched approach as demonstrated in this thesis to avoid large sums of money being spent on ill thought out, knee jerk reactions to this current pandemic.

The layering framework developed over the temporal periods for design has been used in post occupancy research and will be a valuable tool for post Covid-19 evaluation to assess a facilities capability to adapt to pandemic or other trauma situations. There are opportunities for academic research to investigate large healthcare building projects and address the gap in literature relating to building functionality as distinct from civil engineering led infrastructure projects.

It has contributed to the Network Plus Framework for Transforming Construction and the NHS Health Infrastructure Plan (HIP) programme.

It also highlights a need for academia and industry to work together to develop courses to provide the skills required by industry, especially in creating new roles as Design Systems Integrator where the individual concerned will require to demonstrate cross discipline qualifications and experience.

Acknowledgements

After finishing my MSc in Planning Buildings for Health degree in 2006 my tutor Phil Astley suggested that I should undertake a PhD. At the time I was just about to start on a new major project and had to put any thoughts of doing this to one side. Several years later when I left the construction company ,I decided that I would like to pick up the threads from my previous MSc studies into 'Procurement Methods for Major Hospital Buildings in Scotland' and 'Template Tyranny '(relating to Nucleus Hospital System) and apply to do a PhD. It was at this point that I contacted Phil to ask for his advice and he introduced me to Grant Mills who encouraged me to apply to UCL. I would therefore like to thank Phil for all his encouragement in progressing with my studies.

In relation to completing my PhD I would like to thank Grant Mills and Aeli Roberts my supervisors for all their help and direction with this thesis. Their knowledge and skills have been invaluable as coming from an architectural and construction practice background adapting to academic life was something of a challenge as even though I had completed two masters' degrees the focus was very technical.

On a personal level, my greatest thanks go to my god-daughter Joanna and her husband Tom without whose help in providing hospitality and accommodation in London -it would have been very difficult commuting from Edinburgh and Manchester. I would also like to thank two of my friends from the MARU course Carolyn and Sarah who have provided both encouragement and acted as 'sounding boards' for my ideas as well as hospitality in Worthing and London.

Last but not least I would like to thank my friends in Edinburgh, Anne and Mike – Joanna's parents and Barbara and Rod for their support and encouragement, Dr Jo Hockley who has given me advice and support having completed her PhD in Palliative Care and mentored me during stays in her house in the Marche. I have also been fortunate in being able to 'escape' to Sopot in Poland to spend time with my friend Krystyna and family and to Jane and her family in Knutsford – my second home.

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List of Frequently Used Abbreviations

ADB - Activity Data Base

AIA - American Institute of Architects

APM - Association of Project Management

BIM - Building Information Modelling

BMA - British Medical Association

CE - Chief Engineer

CI - Critical Incident

CIBSE - Chartered Institute of Building Surveyors

CIOB - Chartered Institute of Building

CP - Contractor's Proposals

CPI - Coordinated Project Information

CSA - Common Services Agency, Scottish Health Service

CT - Computerised Tomography

DB - Design and Build

DBB - Design-Bid-Build

EuHPN – European Health Property Network

FC - Financial Close

FBC - Full Business Case

GIRFT - Get it Right First Time

HBN - Health Building Note

HIP – Health Infrastructure Plan

HOR - Hybrid Operating Room

HTM - Health Technical Memorandum

ICE - Institution of Civil Engineers

IGLC - International Group for Lean Construction

IStructE - Institute of Structural Engineers

IPD - Integrated Project Delivery

JCT - Joint Contracts Tribunal

JV - Joint Venture

MARU – Medical Architecture Research Unit

MES - Managed Equipment Supplier

M&ES - Mechanical and Electrical Subcontractor

MRI - Magnetic Resonance Imaging

NBS - National Building Specification

NEC - National Engineering Contract

NHS - National Health Service

NICE - National Institute for Health and Clinical Excellence

PB - Preferred Bidder

PFI - Private Finance Initiative

PF2 - Private Finance 2

POE - Post Occupancy Evaluation

PPP - Public Private Partnership

PSC - Public Sector Comparator

PSCP - Principal Supply Chain Partner

RAS - Robot-Assisted Surgery

RCN - Royal College of Nursing

RCP - Requirements Crunch Point

RDD - Reviewable Design Data

RFI - Request for Information

SD - Significant Development

RIBA - Royal Institute of British Architects

RICS - Royal Institute of Chartered Surveyors

SHPN - Scottish Health Planning Note

SHTM - Scottish Health Technical Memorandum

SI - Systems Integration

SPS - Scottish Prison Service

SPV - Special Purpose Vehicle

TCR - Trust Core Requirement

TPO – Temporary Project Organisation

Glossary

Abductive Reasoning: a form of reasoning that bridges the complex and dynamic relationship between theoretical knowledge, empirical research and professional best practice. It is often applied using case studies to understand a real-life context with multiple variables and multiple sources of evidence, where phenomena boundaries are unclear. The process of abduction may start or finish with hypotheses or the selection of a premise/proposition. Abductive reasoning starts from a flexible position, simultaneously iterating from data collection to theory development.

Activity Zones: is the description given to spaces within a room dedicated to specific activities

Adaptive Integration: describes the situation following dysfunctional integration where the different parties begin to understand each other's' strengths and weaknesses and work towards integrating design and construction to achieve client expectations.

Agile Management: is an iterative and incremental method of managing the design and build activities for engineering, information technology, and new product or service development projects in a highly flexible and interactive manner.

Autoethnography: like ethnography is a methodology that develops in practice (Pink 2009). It is best defined by Ellis and Bochner (2000) as "an autobiographical genre of writing that displays multiple layers of consciousness, connecting the personal to the cultural". In this case it is my experiences as a design integrator on major hospital projects. It involves qualitative research using narratives.

Auto-interviewing: is a technique for recording one's own views as defined by Boufoy-Bastick (2004) used in conjunction with autoethnography.

Change Control: is a formal process used to ensure that changes to a product or system are introduced in a controlled and coordinated manner. It reduces the possibility that unnecessary changes will be introduced to a project without forethought. The goals of a change control procedure usually include minimal disruption to programme, and cost-effective utilisation of resources involved in implementing change. The client initiates change by making a formal request for something to be changed. The change control team then records and categorises that request. This categorisation would include estimates of importance, impact, and complexity.

Clusters: is the creation of grouped rooms such as operating theatre suites and nurse working areas.

Critical Incidents: are serious events which took place in the case studies which had an impact on the project and used as a means of data collection.

Delivery Model: A common delivery approach combining policies, standard contracts and best practice resources agreed by government and institutions in collaboration with a multi-organizational owner and supplier membership. Delivery models shape structures, relationships, commercial rewards and the activities of project and design management integrators.

Departmental Zoning: is the classification of departments into the following categories: Treatment and Diagnostic, Inpatient and Outpatient Accommodation, Clinical and Non-Clinical Support.

Derogation: is the term used for describing where prescribed requirements (mainly associated with HBNs and HTMs) is not being provided and is authorised by the Trust.

Design Cost Manager: is a quantity surveyor who works with design teams in establishing the project cost estimate and managing the cost control and change control through the design and construction phases.

Design Information Manager: is the person who distributes and gathers the project information to the team using a data management system.

Design Management: the management of people and resources in a multidisciplinary process, performed in a series of iterative steps, to conceive, describe and justify the value of increasingly detailed solutions to meet the needs of stakeholders. It provides the direction, structure and control for the creative and often abductive decision-making process to reconcile stakeholders' project and organisational propositions. Design and design management integrates the process of emergence of design propositions (products and services) with human centred user perception. As such it applies sense-making to build stakeholder competencies around the problem to enable the very best value judgements to be made.

Design Process: managing the design process implementation is the technical delivery of a written brief. Project managers control people and resources to engineer design solutions. They work with architects and/or design managers to facilitate the flow of design information and measure successful delivery of the design process during the conceptual, scheme design, detailed design and construction stages of a project.

Disintegration: describes the temporal period when things started to go wrong, systems start to breakdown, over specialisation fragments relationships and understanding, and standards and guidance have not been updated to reflect advances in practice and technology.

Dynamic Integration: describes the temporal period following disintegration where hopefully lessons have been learnt from the previous periods and the positive outcomes are developed into a new integrated delivery model.

Dysfunctional Integration: describes the temporal period following prescriptive integration when strict regulatory frameworks were abandoned or relaxed giving opportunities for change. This carried out simultaneously with the change from design bid build to design and build created a type of integration which proved dysfunctional where the parties involved were unfamiliar with their roles and responsibilities in an environment where standards and guidance had been relaxed.

Grounded Theory: is a systematic methodology in the social sciences involving the construction of theory through the analysis of data. Grounded theory is a research methodology which operates almost in a reverse fashion from social science research in the positivist tradition. Unlike positivist research, a study using grounded theory is likely to begin with a question, or even just with the collection of qualitative data. This thesis uses grounded theory in conjunction with autoethnography using case studies, action research, workshops and interviews to gather data for grounded theory analysis.

Healthcare Architect: is an architect who specialises in the design of healthcare facilities holistically; planning at departmental and room level, integrating medical technology and mechanical and electrical services infrastructure.

Healthcare Design Integrator: is a systems integrator with a design background who ensures that the design is fully integrated engaging with the client's organisation, the design team and the construction team.

Healthcare Design Management: design management specifically related to healthcare projects.

Hospital Infrastructure Systems: distribution systems such as power, water, drainage, medical gas, major engineering plant together with communication systems such as pneumatic tubes systems and automated guided vehicles.

Integrated Design Management: describes how the different design management roles within the client and delivery partners are brought together by a design integrator. It often applies – BIM, DFMA, etc

Layering: is the design concept of creating primary, secondary and tertiary stages relating to 'Shell and core', internal partitioning and room fit-out.

Integrated Project Delivery: reflects the American Institute of Architects (AIA) model of contract where the client, the architect and the contractor are equal partners.

New Delivery Model: A new delivery model is a somewhat untested new approach to project procurement that is seen by a number of project-supporting organisations and institutions as an industry best practice that may yield efficiency gains, create new employment and industry activity, and make projects more affordable and fundable. New delivery models may be applied over a short, medium or long term period and so their effect on the achievement of integration varies (e.g. alignment of inputs, mechanisms and outcomes).

Positive Integration: events which took place in the case studies which improved project integration, opposite of the critical incidents.

Prescriptive Integration: describes the temporal where healthcare design followed a set of standard layouts, guidance and procedures. Integrated design was inherent in the system and the project governance was easily identifiable.

Private Finance Initiative: form of design, build and operate contract aimed at integrating and improving project outcomes using a payment mechanism to allow NHS providers to afford new and updated facilities.

Problematic integration theory: is a theory of communication that addresses the processes and dynamics of how people receive, evaluate, and respond to information and experiences. The premises of PI are based on the view that message processing, specifically the development of probabilistic and evaluative orientations (our perceptions of something's likelihood of occurring and its value, respectively), is a social and cultural construction. In situations where there is agreement between probabilistic orientation (a person's constructed belief about an object's likelihood, i.e., how likely something is to occur) and evaluative orientation (a person's constructed belief about an object's value), integration is in harmony, i.e., not problematic. However, when there is disagreement between these orientations about an object (i.e., an event, thing, person, idea, outcome, etc.), then integration becomes problematic. This disharmony leads to conflict and discomfort, which can manifest itself as cognitive, communicative, affective, and/or motivational.

Progressive Longitudinal Study: A progression of case studies over the period of an observer's career. In this thesis five temporal periods relate to different case studies all of which are of similar size, type and complexity. Differs from a traditional longitudinal study, where the same study is revisited several times over an extended period.

Project Delivery System: is the term used for the type of contract which exists for the design and construction of a project and the contractual relationships between parties.

Project Healthcare Planner: is a clinical health planner who is employed by the client to prepare the initial project brief, liaising with the strategic healthcare planner and the client's user groups.

Project Phases: are the project stages outlined in the case studies.

Ramblings: form of auto-interviewing used to extract and recall retrospective case study data. The process involves creating a narrative of the project history and afterwards identifying critical incidents and significant developments.

Relaxation: is the term used when circumstances do not permit compliance with the Building Standards Regulations and can only be approved by Building Control Officers

Requirements Crunch Point (RCP): the requirements crunch point occurs at the point in the process when decisions have to be made in order to secure the project and commence construction. It may involve compromise which can result in client dissatisfaction.

Requirements Management: refers to the continuous process of defining, documenting and checking requirements throughout the project cycle.

Retrospective Abduction: is a form of reasoning occurs in the context of ontological, conceptual and theoretical assumptions; the researcher does not start with a blank slate in the manner implied by inductivists. It involves abductive reasoning applied retrospectively making a hypothesis (from literature) which appears to explain what has been observed (in practice); it is observing some phenomenon and then iteratively claiming what it was that gave rise to it based on literature and theoretical framing. In this thesis grounded theory is used to combine ramblings/ auto-interviewing/ auto-ethnography, critical Incidents and temporal periods.

Strategic Healthcare Planning: involves the Department of Health as policy makers in terms of predicting health requirements and establishing standards and guidance.

Substantive Theory: derived from data analysis and rich conceptualisations of specific situations.

Systems of Systems Integration (SI): the delivery of healthcare involves multiple systems in both the wider delivery system and at project level relating to healthcare, design and construction. Each one of these systems having a series of subsystems which requires a process of bringing together the component subsystems into one system and ensuring that the subsystems function together as a system which in turn is a part of a system of system

Temporal Periods: relate to the time frames of each of the five case studies using temporal bracketing as defined by Langley.

Wider Project Delivery: this refers to the delivery of healthcare by the UK Department of Health and Social Care to the National Health Service (NHS

of Health to the National Health Service (NHS)

Chapter 1: Introduction

1.0 Introduction

1.1 Failure to Deliver Client Requirements

Delivery models have changed over the last 30 years to reflect criticisms of the construction industry and the need for improvement as cited in Banwell, (1964), Latham (1994) and Egan (1998). Despite initiatives resulting from these reports there are still failings with project outcomes and disappointed clients. The focus on the iron triangle of time, cost and quality Atkinson (1999) relies on static briefing, something which has proved to be unsuitable for healthcare projects as demonstrated by the demise of the nucleus building programme which was based on static briefing. This thesis looks at the need for a new project delivery model, specifically for major hospitals, which can utilise dynamic briefing to deliver 'state of the art' facilities for when the building comes into operation.

Having worked in the construction industry for 40 years as a principal architect and a design manager for a major construction company I wanted to 'give something back'. The majority of my career has been involved with major hospital building projects and has covered several methods of procurement resulting in a wide range of different experiences. The trigger for the thesis was taking part in a post-occupancy evaluation study of a new major children's hospital surgical unit. This unit was built around the same time as the fourth retrospective case study in this thesis and I was disappointed to discover there were several aspects of the completed project which had failed to meet client/user expectations. The causes of these failures centred around poor stakeholder involvement and problems with project governance which appeared to occur at a particular and defined stage in the project. This led to the idea of a 'requirements crunch point' which, if addressed, could have resulted in a better outcome. This requirements' crunch point is where all the project work streams come together to be integrated into one proposal. The time this takes place can influence the project outcomes, as demonstrated in the case studies, and is achieved through the application of different levels of design management.

Despite a vast quantity of standards, guidance, experts and tools relating to hospital requirements, there are still new hospitals which fail to provide the 'state of the art' facilities required to meet clinical expectations. Particularly when the client's involvement is constrained, and project procurement has become more complicated.

Hospitals are large complex buildings, highly serviced, with expensive equipment which have long design and construction periods. The process of delivering new facilities involves multiple stakeholders and as it is publicly funded is both held to financial account and public sensitivity.

The problem starts with the initial brief, where perhaps stakeholders have not been involved or have had difficulty visualising what is being proposed, where designers have misinterpreted the users' requirements caused by communication problems and the production of a static brief. The resulting issues do not however become apparent until the building is occupied and the problems identified in a post occupancy evaluation. Zeisel (1984) differentiates between paying client and user client, which in this case relates to The NHS Trust as the paying client and the clinicians, staff, patients and visitors as the user clients. He also identifies gaps between the paying and user clients and between user clients and designers. The gaps or conflicts which existed at this stage can be described as problems relating to understanding, communication and visualisation. Whereas these gaps or failures to engage with stakeholders existed in many design projects, the level of standardisation in health buildings and static briefing did not require designers to engage with user stakeholders or for paying clients to consult their users.

Literature in one temporal period often refers to the previous period and with the exception of Denis et al (2001), which involved sequential observations, most of the literature relates to a single project cycle or comparison of projects within the same time frame. By reviewing the literature over the temporal periods, it was possible to establish which authors continued to research their original field or had diversified into other areas. Stephen Emmitt, who has written extensively on design management over a period of more than 20 years, Andrew Davies on systems integration for more than 15 years, Stephen Kendall on open buildings and layering for over 30 years, Goran Lindahl on healthcare architecture over 20 years and Peter Morris, Project Management for over 40 years. Olsson and Hansen (2010), Hansen and Olsson (2011), Bekdik and Thuesen (2016), Svetoft (2005) and Lindahl (2008) together show a layering approach based on the Netherlands Board for Healthcare Institutions (2007) approach. The application of layers provides an important lens with which to investigate the case studies

In the last two years four books, published by architects, have influenced my thinking. Two of them related to healthcare architecture by Kendall (2019) and Singha (2020) and the other two concerned the role of the architect (Samuel, 2018) and that of the lead designer (Sinclair, 2019).

1.2 The Complex Healthcare Setting

Healthcare buildings, particularly hospitals are complex due to the diverse clinical activities, a mixture often of inpatient and outpatient facilities, the supporting services and estates management creating a large number of stakeholders. The hospital structure is in itself a system with a number of sub-systems. The level of technology has increased over the last 30 years and is developing fast. This requires a dynamic approach to not only project briefing but throughout the project cycle to ensure when a hospital building comes into operation it can deliver the services required by patients and staff.

The relationship of functionality (healthcare), structure and building services to create the building form is in alignment with the philosophy of ‘form (ever) follows function’. Louis Sullivan (1896) attributed the core idea to Vitruvius (the Roman architect, engineer and author) who, in his book De architectura (written between 30-15BC), asserted a structure must exhibit three qualities – firmitas, utilitas, venustas – should be solid, useful and beautiful or as often stated ‘firmness, commodity and delight’. The Bauhaus Movement, founded in 1919 by Walter Gropius, followed the principles of ‘form follows function’.

Large hospitals need to be investigated as a separate entity, few public buildings have the high level of engineering services required in healthcare and this study looks at five temporal periods involving major hospital projects and how they have been influenced by status of public procurement during each time frame. Approval for the ultimate funding for all major healthcare public projects for the NHS is the UK Treasury Department.

The installation of major medical equipment and its technological innovation has had and is continuing to have major implications on project outcomes. It not only affects the spatial planning but also introduces additional infrastructure requirements. Due to its separate procurement from the building contract, it has also been developing within its own sphere without consultation with other stakeholder groups, it can become difficult to integrate both its physical and timescale requirements within the building programme. Medical and surgical practices are becoming more integrated especially in the fields of surgical intervention with the merging of disciplines such as surgery and imaging in the same room. Similarly, materials management is changing distribution and storage with the introduction of pneumatic tube systems and automated guided vehicles. All of these different systems need to be integrated at design stage.

1.3 Need for Integrated Delivery

An integrated design approach[1] resulted from the complexities of hospital design (Wilkinson, 2016) which began in 1966. This was an era where the Department of Health and Social Security and the RIBA published guidance and feedback relating to hospital projects. The Scottish Home and Health Department published a series of 'Hospital Design in Use' studies in the 1960s looking at recently completed projects. The format sets out the evaluation method, the operational features to be evaluated, the reactions of clinical and nursing staff and standards and costs, together with plans and photographs it provides a comprehensive report on how the building is functioning, an area where subsequent post occupancy evaluations appear to fail. This type of standardised feedback from projects has the ability to demonstrate objectivity and transparency by the wider delivery system for use on future projects and is available in the public domain.

Another approach in challenging the construction industry's method of hospital delivery is Integrated Project Delivery (IPD). Figure 1 shows integrated design is part of a wider project integration landscape. The definition of IPD used in this thesis relates to that of the American Institute of Architects (AIA) where IPD consists of three parties: the client, the designer and the contractor (Mesa et al, 2016). In IPD the three parties are contracted together with joint responsibilities which enables integrated design to be managed holistically.

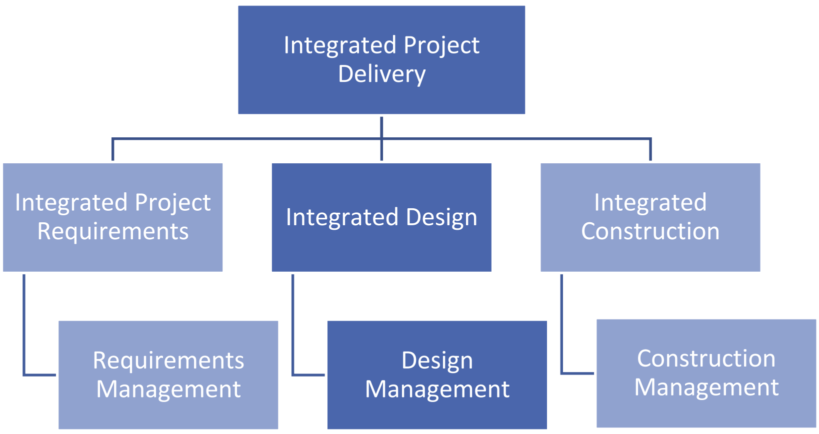

Figure 1 Design Integration

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[1] In June 2016 I presented a paper entitled "Stakeholder Integration and its Relationship with the Requirements Crunch Point in the Design of Major Hospital Projects" at the ID@50 Conference in Bath (Emmitt and Adeyeye, 2016). This conference provided different levels and themes of design integration and explain the history and origins of the joint architecture and civil engineering course at the University of Bath (Wilkinson, 2016).

1.4 Need for Advanced Healthcare-Specific Design Management Research

Kendall (2019) developed a general ‘Open Building Systems’ approach for healthcare infrastructure, while Singha (2020) reported on historical case studies. Both refer to the wider delivery system, but neither are empirically grounded in the process of design and design management. Like, Samuel (2018) who sees the need to advance architectural research, this thesis emphasises the importance of a health-sector specific approach to design management and challenges the industry wide assumption that the lead designer is a subcontractor to a building contractor, unlike the view of Sinclair (2019).

The thesis context relates to Integrated Design Management and the relationship between project-based design management and the wider delivery models in the broadest sense from project conception to occupation or ‘building in use’. It looks at design management as an integrating discipline and not as frequently used as a sub-discipline within project management and construction management which respectively focus on process and product. It looks to integration theory to deliver effective stakeholder management throughout the process to provide an end product which achieves client satisfaction and to systems integration within the construction industry. Investigating an integrated approach, engaging all stakeholders – client, end users, funders, designers, contractors and equipment suppliers to diminish the ‘silo effect’ where different parties work in isolation and when brought together, harsh decisions have to be made which inevitably result in disappointment. This work addresses the concept that in recent complex projects disappointment rather than satisfaction has resulted due to failure to manage stakeholder’s expectations. The study looks at why newly completed hospital projects are failing to deliver the facilities necessary for providing medical care which is current at the time of opening and can cater for foreseeable medical practice. Post occupancy evaluation has not been a project requirement until recently and the introduction of the government’s soft landings focuses on sustainability and energy, both of which are important issues, but there is little or no feedback from user functionality and how this can be addressed.

Current stance is there are a number of Research Challenges which will drive the direction of research and knowledge development: Figure 2.

A - POE is not fit for purpose

B - The complexity of briefing practices are not adequately understood

C - Existing standards are overly static, out-dated and not responsive to innovation

D - Clients lack the relevant experience

E - Procurement and project roles interrupts emerging requirements

Figure 2 Research Challenges

Post occupancy evaluation is a method that enables learning between projects, but its application is often too late to resolve requirement misalignment between project stakeholders. Feedback from Post occupancy evaluations (POE) often highlights a difference between predicted and actual building performance. BSRIA (2019) Soft landings relies on a 'linear framework' and focuses on sustainability and energy not 'user functionality'.

The static approach is common in healthcare projects where traditionally the NHS as 'the informed client' has produced rigorous guidance requirements and fear of the unknown has resulted in NHS Trusts turning this into 'mandatory requirements'.

The combination of these challenges creates the 'Perfect Storm' that may create a crunch point where the requirements do not come together. This is a point in the process where the physical elements are integrated into the design (finalised to allow construction to start), but where the lack of integration and understanding of stakeholder requirements will start to unravel.

There is a need to consider if a more dynamic briefing process exists in other industries which could be developed to create a similar level of agility for the architectural design and construction industries.

There are indicators that this situation may get worse. These include:

- Clients' wanting to contain cost within budget who may start the briefing process with the wider audience but not engaging with the end user stakeholders until it is too late;

- Procurement methods preclude architects establishing a direct relationship with clients;
- Design management roles are fragmented;
- Push for standardisation from government – generic solutions are conceived to provide good facilities rather than very best and most contextually appropriate – this has already been tried and abandoned as in ‘nucleus’;
- Contractors wanting to reduce risk; and,
- No standard ‘skills set’ for Healthcare Planners who often prepare the briefs – many healthcare planners come from the NHS either in project procurement or clinical backgrounds. They are not trained in spatial awareness and often do not understand ‘non NHS speak’ in terms of design and construction. As a result, they rely heavily on existing static and generic briefing material such as ADB rather than creating unique and customised solutions.

1.5 Aim and Objectives

The research aim is to investigate the role of integrated design management during the design and construction phases of major hospital projects and how it impacts on successful outcomes and to further understand how it is affected by the method of delivery at both project and the wider delivery levels. The following objectives and research questions are addressed throughout this thesis: Table 1

Table 1 Research Objectives

	Research Objectives	**Research Questions**	**Chapter**
1	To determine the level of integrated design required and its relationship with integrated project delivery	Does integrated design lead to successful project outcomes? How is it related to project delivery? Who are the project stakeholders and influencers? Who are the systems integrators	1-5
2	To investigate existing projects and their delivery methods	What were the levels of integrated design and who and what influenced them? Did the RCP influence the project outcomes and is it related to project delivery?	6-9
3	To determine the role of Design Management in Integrated Design	How was the design management carried out? Who were the design managers? How does it differ from design information management?	
4	To determine the systems integrator (s)	Who were the systems integrators?	
5	The impact of the wider delivery system on project delivery	What are the controls imposed on project delivery?	

6	To identify and develop an integrated approach for the delivery of major hospital projects which will meet client requirements	How, when and with whom should the client's requirements be agreed? What is the impact of integrated design management? Which delivery model is best suited to deliver state of the art hospitals?	10-11

1.6 'The Journey' to Becoming a Design Systems Integrator

I started my architectural education at the School of Architecture, Edinburgh College of Art, Heriot-Watt University (now transferred to Edinburgh University) and the first milestone was third year which led to RIBA Part 1. This was a very structured year led by Andrew Jackson. Within the school this was always considered to be very exciting and a well taught year, but it was many years later, in 2001, when I discovered just how influential that year had been. 'The Architect's Journal' conducted a poll among its architectural readers asking ''*which tutor had had the most influence in their life*''. A number of tutors with international reputations were named, but at top of the list was the name of Andrew Jackson, of the Edinburgh College of Art (The Herald, 23 April 2001). During that year we were introduced to Eco-system analysis, a design process comprising analysis, exploration and synthesis and something which I now know as 'systems integration'. This latter concept was introduced by analysing the structure, services distributions and circulation systems within in a building, following the teachings of the American architect Louis Khan. Analysis related to the preparation of the client's brief and involved observing how the client operated, interviewing users and searching literature.

The choices for our major project were a sheriff's courthouse, an auction house or a health centre. Ironically, I chose the sheriff's courthouse, as I spent all of my professional career in the healthcare sector albeit major hospitals rather than health centres. It did however prove to be very advantageous, as the health centre was considered to be the easiest project – brief given and fully prepared by the client (an example of static briefing), preparing the brief for a sheriff's courthouse proved to be an extremely important lesson. The process of preparing the brief gave me as a designer a greater understanding of what the client wanted, which also later in my career enabled me to challenge some of the static briefs issued by clients. It was also an introduction to learning how to communicate with users.

After graduation, the practice I joined specialised in health care projects. My first project was a major acute specialist hospital unit (Case Study 0) and as Scotland did not adopt the 'Nucleus Programme', which was being rolled out in England and Wales (a system designed for standardisation and therefore required little client consultation), I was closely involved with the client and the user groups. This was the second milestone in my career being involved with structural engineers, mechanical and electrical engineers and in particular a very experienced quantity surveyor/cost consultant. Working as part of this team emphasised the importance of integrated working. It was a traditional JCT contract where the architect was the client's supervising officer. Unfortunately, this project was cancelled just as it was due to go out for building tender. After that I worked on several small-scale projects before taking charge of a large District General Hospital - Case Study 1. It was towards the end of this project that I decided to study part time for an MSc in Construction Project Management – the third milestone. The reason for doing this was that major procurement changes were taking place – Case Study 1 was the last major hospital to be procured traditionally. The first design and build project was under construction and in England, management contracting had been used for the first time and debates were taking place regarding the adoption of PFI (Private Finance Initiative). Also working onsite with the contractor gave me a different view of how the construction industry operated.

Milestone four occurred when I was involved in the design of a visitors block for a prison. It was traditionally procured, but this time the client appointed an external project manager, who in agreement with the client set up a value management workshop to prepare the brief. Together with visiting other prisons this proved to be extremely valuable and gave an opportunity to carry out the analysis, exploration and synthesis process which I had been taught previously.

The late 1990s saw the first PFI hospitals and Case Study 2 and milestone five. This saw the change from traditional contracting to design and build and role reversals for architects and construction companies. It was difficult for architects to lose direct contact with client/user and have the building contractor as the client. For contractors it was equally difficult as they had to take on different responsibilities and some of the 'hidden aspects' of contract administration carried out by the architect. Some of these 'hidden aspects' will become apparent through the case study findings. The other issue which surfaces is the 'independent' aspect where the client no longer employs a clerk of work to monitor compliance and workmanship on site, this role is instead carried out by the contractor. I worked as an architect on Case Study 2 and on Case Study 3. During Case Study 3 I started another MSc Course – Planning Buildings for Health – milestone six. This course was initially designed for NHS Staff who wanted to become Project Directors, it was led by healthcare architects and the course also attracted a number of architects working in the healthcare sector. After completing the course many people changed their professional direction and towards the end of Case Study 3, I 'changed sides' and went to work for the contractor as a Senior Design Manager – milestone seven. In terms of personal satisfaction, it gave me the opportunity to work on the project to completion. This was something I had been unable to do in Case Study 2 when the role of the architect did not involve site supervision. It also gave me an opportunity to try to ensure what was designed was built and I began to prepare a compliance checking process to ensure this happened.

On Case Study 4 I was the Senior Design Manager and part of the batch core team comprising the Project Director, the Deputy Project Director (Mechanical & Electrical Services) and the Commercial Director. Working as part of the construction team enabled me to introduce additional elements of contract administration gained from experience as 'supervising officer' as in Case Study 1 and at the same time I became involved with one of the Quality Managers in reviewing the Design Management Process in the Company Manual as the Divisional Design Manager.

These retrospective case studies have been organised into five temporal bracketing periods covering:

1. Prescriptive Integration
2. Dysfunctional Integration
3. Adaptive Integration 1
4. Adaptive Integration 2
5. Disintegration

These five periods cover the transition from traditional contracting (Period 1) through the different phases of PFI (Periods 2-4) culminating in the fifth temporal bracket period – Disintegration saw the demise of PFI/PF2, included the study of a major hospital project that was halted due to the financial collapse of the contractor, and the subsequent completion proposal with which I became involved.

1.7 Scope Limitations

As this is a many faceted study where several factors influence project outcomes, certain areas have been excluded, notably how the projects are financed, the use of Building Information Modelling (BIM) and Temporary Project Organisations (TPO).

1.7.1 Project Finance

Three of the case studies are financed through the Private Finance Initiative (PFI), one is from Treasury funding and Case Study 5 started as a PFI project but following the collapse of the PFI consortium is now being Treasury funded. The method of funding does not have a direct relationship on how a hospital is costed and as such does not affect the study method. It is an important issue and one which deserves a separate study

1.7.2 Building Information Modelling (BIM)

Four of the five case studies predate the use of BIM and although Case Study 5 should have incorporated BIM at the time of the project collapse it did not have a working BIM model. Therefore, although BIM can play an important role related to project integration this has not been included in this study. Reference is made however to Coordinated Project Information (CPI) (1987 and 2003) which is the philosophy behind BIM, a computer simulation where to achieve the best results necessitates the 'humans' to understand CPI.

1.7.3 Temporary Project Organisation (TPO)

This has not been discussed in detail and would perhaps make an interesting future study as there are several common denominators between the studies in relation to supply chains and personnel including a client team which was involved with two different trusts. Healthcare provides atypical TPOs in the sense that the wider delivery sets out the structure and with the limited number of major contractors and specialist designers the same TPOs often occurs.

1.8 Outline

The Glossary is presented at the beginning of the thesis to introduce terminology which in many cases only relates to healthcare project delivery and this thesis. The list of abbreviations is also extensive as both the medical and construction professions frequently use acronyms which are not often understood and, in some instances the same initials have different meanings: DDA can mean 'Dangerous Drugs Act' or 'Disability Discrimination Act'.

Chapter 2 sets the scene, the background to the relationship between the wider healthcare delivery system and construction project delivery.

Chapter 3 introduces autoethnography as the primary methodology incorporating retrospective abductive approaches focusing on design management and systems integration theory using case study analysis methods in relation to temporal bracket periods.

Adopting a method where the retrospective case studies were analysed from desk top studies of data previously collected which had been turned into narratives from an autoethnographic perspective from which to extract the critical incidents and positive integration and includes the cultural behaviour of participants in the design and construction industry.

Chapter 4 reviews literature relating to the design process, design management and the integration of stakeholders and project delivery systems.

Chapters 5,6 7, 8 and 9 cover five temporal bracket periods related to my experiences as defined in Section 1.6. The case studies are analysed using critical incidents which occurred during each one and by examples of positive integration. The term 'critical incidents' often implies negative issues and therefore the more positive outcomes are described as 'positive integration'. The case study in Chapter 8 highlights issues with standards and guidance through a quantitative analysis of the Hospital Building Note (HBN) derogations. Case Study 9 analyses the findings across the temporal periods.

Chapter 10 is the Discussion Chapter which involves a 'triangulation' of the findings from the temporal bracket periods and retrospective case studies in chapters 5, 6,7, 8 and 9 and from literature. The final Chapter 11 draws conclusions and demonstrates a contribution to knowledge for the integration of healthcare design management through integrated project delivery. A new approach to the identify levels of integration, by whom and at what time during project lifecycles and its relationship with the wider delivery of hospital projects is proposed.

The Appendices include:

A: Healthcare Studies

B: Evidence of data collected during the retrospective temporal periods used for preparing the ramblings for the case studies

C: The individual case study narratives from which critical incidents and positive integration were extracted for analysis

D: Supplementary Literature

E: Supplementary Case Studies

F: Integrated Healthcare Design Studies and Workshop

Figure 3 is the research map of the study and thesis which is used to sign-post and guide the reader

Chapter 1	Introduction	
Chapter 2	Healthcare and Construction	Background
Chapter 3	Ethnographic Theory and Methodology	Methodology
Chapter 4	Design Management and Integration	Literature
		Phase 1 Framework Development
Chapter 5	Temporal Period 1 Prescriptive Integration	Case Study 1
Chapter 6	Temporal Period 2 Dysfunctional Integration	Case Study 2
Chapter 7	Temporal Periods 3 and 4 Adaptive Integration	Case Studies 3 and 4
Chapter 8	Temporal Period 5 Disintegration	Case Study 5
		Phase 2 Case Study Research
Chapter 9	Longitudinal Outcomes from the Temporal Periods	Case Studies Summary
Chapter 10	Integrating Healthcare Design, Design Management and Delivery	Discussion
Chapter 11	Temporal Period 6 Dynamic Integration	Conclusions and Recommendations
		Phase 3 Findings

Figure 3 The Research Map

1.9 Contribution to Knowledge of the Study

The knowledge contributed by this thesis is the result of a longitudinal study based on temporal periods relating to the progression of major PFI hospital development from its inception to its demise and bench marking it against previous traditional forms of procurement. This migration towards PFI and contractor led design and build not only changed the delivery model but impacted on roles and responsibilities of the people working in the construction industry. At the same time the wider healthcare delivery model was also changing and impacting on the project delivery model. Major hospital design has both technical complexity and difficult space planning and circulation considerations with multiple stakeholders.

This thesis anticipates five parts that combine to form the contribution to knowledge. These are:

1. **Long term learning to integrate wider delivery and project-based efforts** is demonstrated by longitudinal studies to establish patterns and lessons learnt. The absence of post-occupancy and organisational feedback has highlighted the lack of knowledge transfer from both the wider system to the project system and also within the project system. Chapter 10 summarises the learning effect over the case studies. There is no previous evidence of this long-term focus on the outcomes of major hospitals.
2. **The use of systems integration to overcome critical incidents.** Chapters 6-9 analyse the critical incidents in the case studies identifying the systems integrator who resolved the issues. Winch (1998), Brady et al (2005), Barlow and Koberle-Gaiser (2008) and Davies et al (2009) have all defined who they consider to be the systems integrator within the period of a specific delivery model or project but have not analysed this over several projects in different delivery model periods and not in terms of critical incidents.
3. **The wider healthcare systems and project design management.** The effect of the wider delivery system has not previously been investigated. Specifically, the role that healthcare standards and guidance have played at a project level over the temporal periods and what the impact is on design management.
4. **The use of layers to operationalise healthcare design integration.** The use of building layers in the 'Open Building' concept has been adopted in hospital design as discussed by Kendall (2019) and Hansen and Olsson (2011). This reflects the design and constructional issues in relation to future proofing. There is also another framework relating to a zoning system related to clinical functionality and the creation of departmental zones and clusters which is reflected in the case studies and which I developed through modelling a schedule of accommodation which can be used to both aid briefing (Case Study 3) and analyse designs (Case Study 5). Further development of this zoning concept has the ability to link clinical functionality with open building layers.

5. **New integrated healthcare delivery model.** This is the requirement needed to future proof the design and construction of new hospitals adopting alliancing principles involving people with the right skills, at the right time, in the right place.

Chapter 2 Healthcare and Construction

2.0 Healthcare and Construction

2.1 Introduction and Background

This chapter introduces the two main elements of this thesis and how they interact both at project level in the case of individual projects and in the wider field through integrated design management. There is a close synergy between the elements with construction being one of the earliest activities carried out by mankind and in healthcare, the Hippocratic Oath taken by modern doctors coming from Hippocrates (460-370 BC). Different types of healthcare treatment facilities existed in many civilisations including the Roman Empire but following the First Council of Nicea in AD 325 construction of a hospital in every cathedral town was begun, including among the earliest hospitals by Saint Sampson in Constantinople and by Basil, bishop of Ceaesarea in modern-day Turkey.

There are strong links between artists/architects and medicine going back centuries including the Egyptian Imhotep in 2600BC. A master builder or master mason was a central figure leading construction projects in pre-modern times (a precursor to the modern architect and engineer). Historically, the term has generally referred to "the head of a construction project in the Middle Ages or Renaissance period" to become a Master Builder an architect must not only be possessed of the theoretical knowledge of engineering and a knowledge of the details of building construction, but he must become the devisor of methods of construction *Proceedings of the Annual Convention of the American Institute of Architects*, 1926 Volume 59, p. 145. This term was used in connection with the building of the great cathedrals of Europe and many of the early hospitals in the UK were associated with these great churches including hospitals such as St Bartholomew's in London founded in 1123 and St. Thomas's, London in the latter part of the 12th century. The first hospital built in the UK was in the 1070s in Harbledown in Canterbury (Singha, 2020).

This link continued into the 15-16th centuries through polymaths such as Leonardo da Vinci and Michelangelo. The 1871 rebuilding of St. Thomas' was one of the first hospitals to adopt the 'pavilion principles' as outlined by Florence Nightingale following her work in the Crimea 1853-56. This type of ward known as "Nightingale' which contained over 20 beds in a long single room with beds either side became the standard for many hospitals and sanitoria built for over 50 years. The Royal Infirmary of Edinburgh 1879 designed by Sir David Bryce was considered to be largest of this type.

An architectural competition held in 1928-29 for a Sanitorium in Paimio, Finland was won by the architect Alvar Aalto for the treatment of patients with Tuberculosis and was one of the first to be designed with individual patient hand washing facilities as a means of addressing issues with infection control National Board of Antiquities (2005). Aalto was also interested in standardisation and together with his wife they designed a range of standard components and items of furniture.

What these historical examples indicates is the high level of involvement by prominent architects in the design of hospitals and their desire to create them as important civic buildings as well as incorporating functionality, standardisation and addressing infection control.

Moving into the latter part of 20th and the early part pf the 21st centuries this chapter looks at literature in relation to the wider delivery systems and the development of standards and guidance in relation to hospital building. It includes grey literature and press reports.

2.2 Healthcare and Construction Timeline

In this section the timeline (Table 2) sets out the major events which occurred in hospital design and construction through all the temporal periods including the period leading up to Temporal Period 1 to demonstrate how they influence each other and why there is a need for an integrated approach. It starts in 1957 with the introduction of the CLASP prefabricated building system mainly related to schools which lasted until the 1970s just as the Nucleus building programme started. This period highlights a time of considerable architect-led research and development in hospital design by influential architects such as John Weeks, Richard Llewelyn-Davies, Richard Saxon and Sir Alex Gordon who was RIBA President in 1971. It was also during this period that in 1963 the Joint Contracts Tribunal (JCT) introduced the first major revision to their Standard Form of Contract which together with the RIBA Plan of Work in 1964 formed the basis for public procurement in the UK. JCT was set up in 1931 by the RIBA and now includes representative of the RICS, Local Government, the British Property Federation and the Scottish Building Contracts Committee. It does not include ICE which has since developed alternative forms of contract, the most common form being NEC.

Table 2 Healthcare and Construction Timeline

Hospital Design	Year	Construction Procurement
	1957	CLASP (Consortium of Local Authorities Special Programme) Prefabricated School Buildings
Hospitals Buildings Division at the Ministry of Health	1959	

RIBA Hospitals Course Handbook	1960	CLASP awarded a special prize at the Milan Triennale
First Hospital Building Notes	1961	
Hospital Building Programme	1962	
Hospital Design in Use Studies The Falkirk Ward Layout Residential Study Course for Architects, UCL	1963	JCT' 63 First major contract revision since 1939 (Joint Contracts Tribunal), Standard Form of Contract with Quantities (Traditional)
Medical Architecture Research Unit (MARU) established at Southend School of Architecture	1964	First RIBA Plan of Work published
MARU moved to the Polytechnic of North London and the Bartlett School of Architecture, UCL	1965	
Introduction of 'Best Buy' Standard Hospitals	1967	
The Functions of the District General Hospital Introduction of Harness Standard Hospital System	1969	
	1970s	Demise of CLASP
	1971	Sir Alex Gordon, RIBA President 'Long life, loose fit, low energy!'
	1973	Introduction of NBS (National Building Specification)
Temporal Period 1: Prescriptive Integration		
Introduction of Nucleus Standard Hospital System	1975	Adoption of Nucleus in England and Wales not Scotland
	1976	RIBA Plan of Work updated
	1980	JCT '80 Published
	1987	SMM7 (Standard Method of Measurement) RICS, revised and aligned with CAWS (common arrangement of work sections) CPI (Coordinated Project Information) Published by the CCPI JCT' 87 The Standard Form of Management Contract
Chelsea and Westminster Hospital – partial nucleus design	1988	Adoption of JCT'87

NHS Community Care Act	1990	
Removal of Crown Immunity The Patients' Charter First NHS Trust	1991	
Temporal Period 2: Dysfunctional Integration		
Nucleus System abandoned	1992	Introduction of PFI and Contractor led Design and Build
Completion of Chelsea and Westminster	1993	
Better by Design The Scottish Health Service, Common Services Agency Building Division sold to the Private Sector	1994	The Latham Report
Darent Valley, first PFI	1997	
	1998	The Egan Report JCT '98 with Contractors' Design
ProCure 21 Pilot Scheme	2000	NEC2 Adopted
Temporal Period 3: Adaptive Integration 1		
Strategic Health Authorities replaced Regional Health Boards in England	2002	
ProCure 21 National Scheme	2003	
	2005	NEC3 Introduced
Temporal Period 4: Adaptive Integration 2		
ProCure21+ National Scheme	2010	
Last update of HBNs Strategic Health Authorities abolished, and facilities transferred to NHS Property Services	2013	CIOB published 'The Design Manager's Handbook'
Temporal Period 5: Disintegration		
Procure 22 National Scheme	2016	Wall Collapse at an Edinburgh School – Schools PP1 (1998-2005)
	2017	Fire at Grenfell Tower
Liverpool Royal and Midlands Metropolitan Hospitals -work stopped due to Carillion Collapse	2018	Carillion Collapse
Liverpool Royal Recommenced Midlands Metropolitan Hospitals - work recommenced	2019	Management Form of Contract NEC 4 Design and Build form of contract

Royal Hospital for Sick Children opening delayed due to non-compliance with Ventilation HTM		Delays and cost overrun at Crossrail – NEC 3
Coronavirus 19 Outbreak HIP Programme announced	2020	Nightingale Hospitals Grenfell Tower Public Enquiry

The following sections focus on how healthcare is delivered, concepts of healthcare design, how the construction is managed and how it is delivered.

2.3 Healthcare System and National Health Service

This section sets out how the wider delivery system influences the design and construction of hospitals. Healthcare in the UK is mainly provided through the National Health Service (NHS) founded in 1948. For many years NHS Estates was responsible for integrating health delivery requirements with project delivery. All citizens have a national insurance number and are entitled to free healthcare (apart from some charges in primary care for prescriptions and elements of dental care). There are three main levels of care as set out in Figure 4;

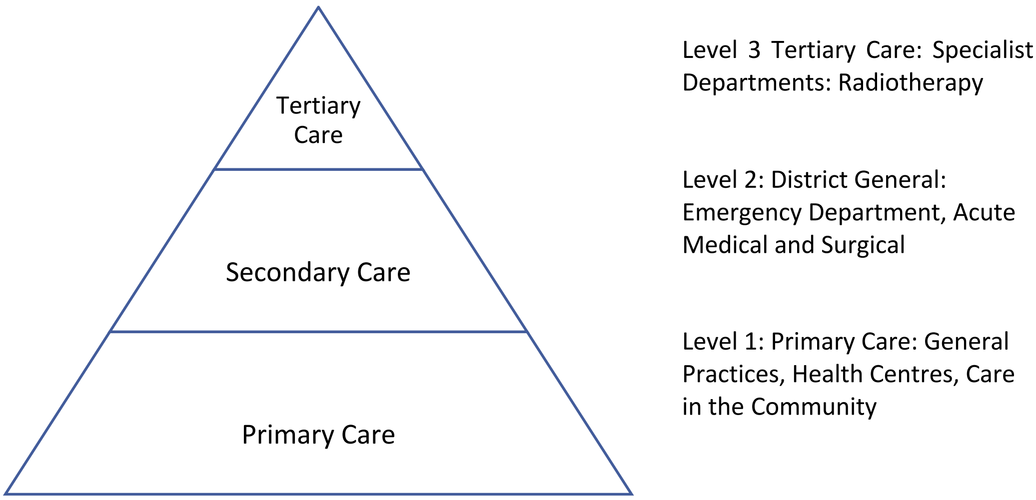


Figure 4 Levels of Care

This model is an example of a vertical system, where the gateway to secondary care; (apart from emergency care) hospital treatment is by referral from general practice (part of primary care). It is part of a rigid system set up in 1948. This thesis focuses on major hospitals, which provide both secondary and tertiary care, the area where complexity occurs, and technological requirements impact on standardisation. They are not stand-alone levels of care but form parts of the overall healthcare system. This level of complexity is also discussed by Zerjav et al (2018) in relation to Terminal 2, Heathrow.

Francis and Glanville (2001), as part of MARU published 'Building a 2020 vision: Future health care environments' following a year-long study involving a steering group from research and practice in health, architecture and construction. This came about as the result of the lack of strategy for the health building to satisfy the needs of the NHS over the next 20 years. The three key principles of the vision were:

- A social model for health;
- Patient centred approaches; and,
- Quality of Design.

Tzortzopoulos et al (2009) investigated the gaps between healthcare service and building design, concluding a more holistic approach is required if healthcare buildings can support the changing requirements of healthcare delivery. This links to open building and the need for certain levels of acuity adaptability. They translate this into three streams: transformation, flow and value.

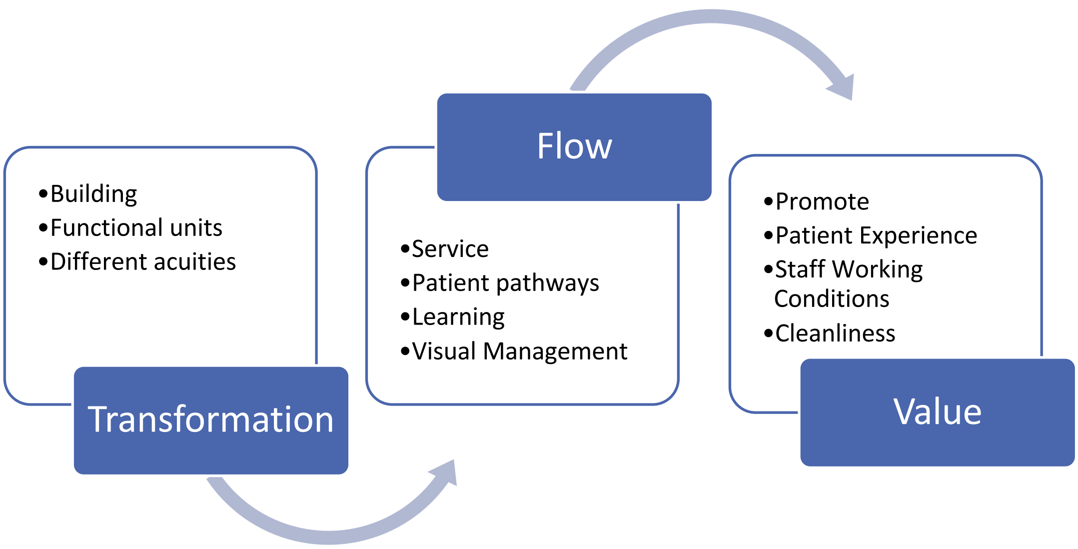


Figure 5 Relationship of Transformation, Flow and Value

Figure 5 above not only demonstrates the linkages and learning from Evidence Based Design, but also highlights staff working conditions - something which is often sacrificed in 'patient focused care' and the highly important aspect of cleanliness, fundamental to infection control. The paper highlights the link between healthcare provision and the facilities in which it takes place. Unfortunately, there appears to be issues with the use of the English language.

Sadler et al (2011) emphasises the need for healthcare designers and service providers to work together to benefit both patients and staff and at the same time reducing costs. Barlow (2015), in a presentation to the EuHPN Brussels Workshop, outlines the need for integrating healthcare systems in order to improve global health sustainability. He focuses on the social aspects of healthcare and the systems required to integrate care at home and outpatient and inpatient hospital care. This follows Chrysanthaki et al (2013) study of the whole system demonstrator programme which was funded by the Department of Health indicating a willingness to address healthcare delivery as a whole and not just in a hospital setting. The current status of the NHS in the UK demonstrates the lack of systems integration by looking at different aspects in silos. During the Nucleus Building Era, the publication of the Hospital Building Notes and Health Technical Memoranda establish a form of systems integration between healthcare requirements and their physical environments.

Huzzard et al (2018) look at how systems integration may be furthered in healthcare and used a one-day dialogue workshop to try to bring together various stakeholders to discuss one common issue.

2.4 Design Integration in Healthcare Facilities

The previous section outlined the wider delivery system of healthcare describing issues which relate to a healthcare estate which comprises of numerous buildings of varying sizes, complexity and age. In this section the focus is on individual projects and how they are designed, why design integration is critical to project delivery and the different aspects which differentiate the design of major hospitals from other projects in the built environment. The integration thread runs through basic design principles, the adoption of a systems approach to the consideration of open building concept with its layering approach. This formal process then needs to incorporate continually changing issues relating to evidence based design, new innovations and advances in medical technology. Healthcare standards and guidance and how these are interpreted by health planners is an additional layer in the preparation of concept and detailed designs.

Trebilcock (2009), cites design methodologists Geoffrey Broadbent and Christopher Alexander, in developing a design process; analysis, synthesis and evaluation (the design method which I was taught by Andrew Jackson) occurring in sequence. Broadbent (1966) Analysis/Synthesis - 4 stages, whereas Hillier, Musgrove and O’Sullivan (1984) consider a model of conjecture/analysis to be more appropriate. Bamford (2002) links this theoretically to Bacon and Descartes. It highlights the difference between alteration and new build projects where in alteration works healthcare delivery often needs to continue and where uncovering the existing construction can lead to design changes. It also raises the question of the difficulties incorporating new equipment and technology. In discussion the main difference between general building design and healthcare concerning design process "is the need of an initial understanding of the whole enterprise, including services and activities of delivering care" (Bamford, 2002).

Two recent publications Kendall (2019) and Singha (2020) consider what is happening in the field of healthcare architecture. Singha (2020), who is UK based, traces the development of healthcare design from its early roots, the processes and funding requirements, current examples of hospital design and looks to the future. It is an excellent overview of healthcare design, but does contain some 'rose-tinted' views on the some of the hospital case studies where healthcare standards have been derogated to satisfy the design, and 'signature' architects' inexperienced in healthcare coupled with design and build contractors have had to rectify healthcare design errors before the hospitals were operational. These comments are made as a result of visiting the said hospitals during the commissioning periods.

2.4.1 A Systems Approach to Design

Symons (2006) investigated Nucleus design (See Appendix A) which was an integrated system and whether its abandonment resulted in "throwing the baby out with bath water" concluding the overarching systems integration was lost, but its rigidity of standardisation was not only unable to provide flexibility but was unsustainable in terms of flexibility. There were also criticisms of the model regarding aesthetics and the importance of environment as outlined in Singha (2020) and Ulrich (2006). Montgomery (2007) defends the Nucleus developments of the 1980s and 1990s which although designed to rigid standards was flexible enough to cater for future developments. Fawcett (2011) concludes there is no evidence to confirm modular room sizing leads to flexibility and activity-space tolerance has a greater impact.

In relation to refurbishment Mills et al (2015) confirm that in such projects, rooms have been compromised in order to provide services. Caixeta and Fabricio (2012) also focuses on reconfiguration of existing health buildings and makes an important contribution to healthcare design although the paper's confusing title and use of the term 'interventions', possibly due to translation from Portuguese (Brazilian paper), reduces its impact.

2.4.2 Open Building Concept

Habraken (1961) first describes ‘open building’ as a form of shell and core where buildings are designed in levels allowing future proofing and adaptability in relation to mass housing, developing the concept of systems and subsystems (Habraken, 2000). Kendall (1987 and 1999) develops this concept of ‘Open Systems’ in building technology and sustainability as open and closed systems and considers that a wider focus is required in terms of integrated building systems. In terms of sustainability, he looks at the three-tier model: base building, interior construction and furnishings, fixtures and equipment and how they can be designed with different life spans to create adaptability for future proofing and sustainability.

Jones (2008) identifies an important factor in healthcare construction as the ability of the infrastructure to support technology to be used. He recognises changes are likely to be required during the course of the building programme and suggests the following examples where cost can be controlled:

- Building unfinished or shelled space in strategic locations or entire floors in a building tower to provide room for expansion in service areas where growth is expected;
- Designing and building acuity-adaptable patient rooms that are easily converted from standard medical/surgical rooms to critical-care rooms; and,
- Building additional capacity into system infrastructure.

Although, not claiming this as open building design, what it is describing equates to this and in the same time frame Kendall has developed the concept of open buildings in healthcare.

Kendall (2007) had previously looked as systems’ building and the US Veterans Administration Building in the 1970s where a similar concept of providing a framework as in Nucleus, but concludes there is little systematic research carried out and lessons learnt resulting in comments such as “we should design column-free spaces, make floor to floor heights greater and don’t bury pipes in concrete”. These are comments which we still hear today. He cites recent examples of loose-fit hospital projects, base architecture and its changing fit out - Erasmus MC University Hospital in Rotterdam and the Inselspital University Hospital INO in Bern which have adopted the three level approach of open building using architectural competition at the different levels and then deciding to award all three stages to one firm by claiming that good design is only possible if top-down control by one architect is maintained. This is not the concept of open building where specialists for the different levels is preferred but considers until the profession (architects) and the academy (US

Institute) embrace reality we will be less able to provide the necessary leadership. Kendall and Ando (2011) conclude open building outlines systems separation where the different levels of construction and fit-out can allow for flexibility and future proofing. Kendall (2015) reflects on the adoption of open buildings in the healthcare sector due to a rapidly evolving healthcare sector following his paper relating to the education of healthcare architects Kendall (2011). Hanitchak (2009) also investigated how open-ended design could be applied to hospitals.

Astley et al (2015b) looks at flexibility in healthcare design and building, the ability to adapt to social and medical changes over the building lifespan. They define five levels: process; hospital complex; building; functional unit; and, individual room. In terms of HBN speak this relates to Estates Planning, individual buildings, departments and rooms. They also describe a good example of adaptability as the PRBB Centre in Barcelona where a research facility was changed into a hospital.

Flexibility in healthcare design is analysed by Olsson and Hansen (2010) analyses the dynamics relating to flexibility in four Norwegian hospital case studies asking three questions:

1. When is flexibility used in the lifecycle of a project?
2. What are the stakeholders' perspectives on project flexibility?
3. What is the nature of interaction between flexibility in the process of a project and flexibility in terms of the characteristics of a building?

They found project owners and users gave flexibility high priority whereas project management teams were less likely to embrace changes and late scope lock-in. Hansen and Olsson (2011) continue with the theme of flexibility, linking it with lean thinking and a layered approach based on open building. They highlight the difference between the design stages and construction in terms of lean thinking and how by adopting a layered approach this not only aids flexibility but can embrace lean thinking into the design.

Hansen and Olsson (2011) describe the three levels and in the Inselspital project as:

- The Primary System: Fixed: building frame designed to last 100 years, which can accommodate different hospital departments;
- The Secondary System: Adaptable: internal fit-out in terms of partitions, services designed to function for a maximum of 20 years; and,

- The Tertiary System: Flexible: room focused, fixtures and fittings and interior design with a useful life of 5-10 years.

It is emphasised the tertiary system should be independent of the primary and secondary systems as far as possible and the secondary system adaptable to the primary system. In this project it is described as ‘systems separation’. This separation allows different architects and construction firms to develop each level. The benefits of this design process are due to the size of these projects it becomes difficult for one firm of architects to have the capacity to carry out all three levels. What is important however is the architects for each of the three levels require to be specialist healthcare designers in order to understand the requirements of the other two levels.

Another Scandinavian paper by Sivunen et al (2014) examines concept of open buildings in hospital projects in Finland and concludes: “The main reasons for the excellent satisfaction levels were the integration of user to design tasks of their interest”. It gives an example of where a new organisation structure may change the main function from a single patient treatment to dynamic group care, resulting in the need to change individual doctor’s offices to group work rooms or back office model.

A report by the Netherlands Board for Healthcare Institutions (2007) outline a Layers Approach to Building Differentiation of Hospitals where it separates the building functions into four categories:

- Hot Floor: high-tech, capital intensive functions specific to hospitals;
- Hotel Accommodation: patient accommodation, nursing care;
- Office: outpatient consultation, offices, staff accommodation, management activities; and,
- Industry: all medical supporting and facilitating functions.

A fifth level of general facilities is added for catering, facilities management and administrative offices. This approach to design is aimed at providing a more efficient business operational model for healthcare where layers can be changed within their typology to reflect new models of care and technologies.

Kendall (2019) focuses on the concept of open building proposed by describing healthcare architecture as infrastructure. It is a collection of studies by different authors focusing on different aspects of healthcare design. In this thesis I have tried to defend why the design and construction of major hospitals is different from infrastructure projects and requires independent research. Kendall (2019) articulates clearly his definition of healthcare as infrastructure, which is similar to the view taken in Symons et al (2016) where the structural and engineering services provide the infrastructure to support the hospital. It is in this respect that there is less evidence of layering adoption of layering suggesting that more research into the integration of spatial planning with structure and engineering services is required.

2.4.3 Evidence Based Design and Innovation

Evidence based design (EBD) is a scientific analysis methodology based on the assumption the built environment can produce significant physical and psychological effects on its users. The leading researcher in healthcare is Professor Roger Ulrich who has published papers over a period of 30 years. Ulrich (1979 and 1981), focuses on the external environment and Ulrich (1984 and 1991) on the internal environment. Ulrich (2003) is specifically written as the result of an NHS workshop and Ulrich et al (2008) is a comprehensive literature review on EBD. Rybowski (2009 and 2017) has linked EBD with lean construction and Target Based Design (TBD) through a case study analysis of healthcare projects including the Cathedral Hill Project concludes that the use of Integrated Project Delivery enables projects to afford EBD and even provide 15-2% cost savings. Van Hoof et al (2015) analysed a design model developed by van Hoof and Verkerk (2013) which brings together healthcare, construction and technology to assess both the results from post occupancy evaluation and evidenced based design concluding that this can be used to support the design process but does not itself generate solutions.

Alfonsi et al (2014) highlights the need for continuous evidence based research and gives examples of how this can be achieved by using simulation techniques in areas where natural methods are not possible, examples such as a 'sky effect on the ceiling' in a MRI scanning room where patients may be in a confined space for a period of time. This leads to the next section where the impact of equipment has on design. Whilst considering EBD for patients and staff, major medical equipment is a major factor in designing activity spaces and departmental planning.

The importance of the physical design of healthcare environments (HCEs) on patient outcomes is highlighted by Ulrich et al (2008) and Elf et al (2015) and revisits evidenced design (EBD) as promoted by Ulrich (2006). Ulrich et al (2010). Elf et al (2015) look at the Planning and Design Process (PDP) and conclude "that a collaborative that is based on integrating evidence and end-users' perspectives will have a profound impact on the quality of healthcare architecture and thus patient health and quality of care." It also describes how the design of new healthcare architecture is a process which involves the mutual exchange of knowledge among various stakeholders and it has a 'two-way' effect; the healthcare organisation is affected by building design but also the environment is affected by the organisational dynamics of the healthcare provider.

2.4.4 Advances in Medical Technology

There have been major advances in medical technology over the temporal periods. Examples of these are contained in Appendix A. Over the last 10 years medical academic papers have recorded the effects of these new technological advances. For designers, It has highlighted the need to understand the implication of integrating them into new and existing hospitals.

Mathews and Pronovost (2011) introduced the concept of human relationships within a vertical system, particularly equipment and technology in Intensive Care Units and Operating Theatres and considered there is a need for a systems integrator in healthcare to collaborate between healthcare professionals, administrators, researchers, human factors and system engineers and industry. Silvis (2014) highlights in a journal article the need for systems integration as a means for accommodating technology and its dependent infrastructure.

Astley et al (2015) examined rapid clinical and technical developments in a major surgical unit and concludes rapid changes in equipment and its building requirements are not necessarily running in parallel and that there is a need for overlapping activities and a more dynamic briefing approach. Symons et al (2016) continues this theme of technology and stakeholder integration and the client dissatisfaction with the completed project.

One common feature of all acute hospitals is an operating theatre department which were largely autonomous. In recent years developments in medical practice have resulted in the creation of hybrid operating rooms, (HOR) where surgical procedures normally taking place in operating theatres, there is now radiodiagnostic equipment to carry out invasive surgery in more complex cases to deliver successful patient outcomes. Combining two different specialties into one space has resulted in new advances in technological design, integrating architectural spaces and major items of medical equipment.

As part of a specialist literature review a total 13 academic papers relating to HORs were reviewed, all of them written since 2009, including Nollert et al (2012), a chapter from a book written by Siemens (major equipment manufacturer) and Schaadt and Landau (2013) a paper for nurses providing a good explanation of how a hybrid theatre works in the absence of any NHS or equivalent published guidance. Several papers were surgically focused on the types of surgery which can be carried out in an HOR, Armstrong (2012), Kaneko and Davidson (2014), Richter et al (2015), Gofrit et al (2016) Cancienne (2016) and Bigot (2016). The earliest paper, Fields (2009), summaries the advantages and disadvantages of this type of theatre following a year-long study into cardiac and vascular surgery at Liverpool Chest Hospital. Perry and Katz (2009) looked at the need to reduce vibration, an issue between imaging and interventional surgery. Andres et al (2017) concludes HORs are safe in terms or radiation protection to staff and patients. Barach and Rostenberg (2015) considered this to be one of the greatest changes to models of care. Cabo et al (2012) discussed the costs of hybrid treatment and demonstrates more research is required and can see the potential financial savings from the collaboration between interventional radiologists and surgical specialists; this was a joint study involving the UK, France and the USA. Lindberg et al (2017) describe the work in HORs as boundary work, as it sees the merging of two medical disciplines, surgery and diagnostic imaging, which demonstrates the emergence of systems integrations within medical procedures

These papers demonstrate the impact that one item of equipment has on medical procedures, space planning and the environmental servicing required. It also indicates the level of stakeholder involvement required to design these facilities. The other issue is that the majority of these papers are written by medical practitioners as part of the wider delivery system and are not shared with project teams and healthcare designers creating a gap which could be avoided by integrating the two systems.

2.4.5 Healthcare Building Standards and Guidance

The NHS has produced a vast amount of information, some mandatory, but largely guidance for the design of hospitals over the last 60 years. These include Hospital Building Notes (HBNs) which give design and requirements guidance originally by department – HBN26 Operating Departing (Ministry of Health 1967), but more recently has focused on generic, care and support groups such as:

- Core Elements HBN 00 Series
- Care Group HBN 01-01 Cardiac facilities (2013)
- Generic Group HBN 04-01 Adult in-patient facilities (2013)
- Support Group HBN 14-01 Pharmacy and Radiopharmacy facilities (2013)

The core elements group now includes the former Hospital Technical Memoranda relating to building components, spatial requirements for core rooms and circulation spaces and most importantly Hospital Facilities Note 30 which is superseded by HBN 00-09: Infection control in the built environment (2013). HBN 00-09 (2013) is not mandatory, which poses dilemmas for designers when different Infection Control Officers interpret it differently. One opportunity was lost in 1991 when Crown Immunity was removed from NHS facilities. A debate in the House of `Commons in 1986 recorded in Hansard (1986) highlighted the dangers relating to infection control in hospitals, whereas fire safety, food hygiene and health and safety were included in statute but not infection control. The HaCIRIC (2010) interim report looked at controlling hospital acquired infection in the ward environment and although prescriptive measures were considered desirable, the following HBN remained guidance only. Glanville et al (2002) produced a research study into NHS guidance which could be used independently of procurement method.

Sir John Cole, when Head of Estates Planning in Northern Ireland was very focused on compliance with HBNs and HTMs. Baldock (2001) writes: "John Cole has achieved what many thought impossible: well-designed PFI hospitals. Now the procurement methods he pioneered in Northern Ireland look set to catch on over here." This referred mainly to his processes which was different from the rest of the UK, and despite the then Prime Minister Tony Blair's comments were not adopted in the second wave PFIs. Compliance with HBNs and HTMs had problems as they were not being updated and both models of care and building components were developing with new technologies.

Hignett and Lu (2008) investigated the use of HBNs by a group of 19 participants: architects, healthcare planners and facilities managers and concluded whereas some participants used the guidance literally and others just as a reference (ignoring the detail) both resulted in a lot of repetition across building projects due to the lack of standardisation. Hignett and Lu (2008) focuses only on the HBNs and not the HTMs. In the HBNs the schedules of accommodation are indicative of typical departments rather than prescriptive in order to reflect individual hospital requirements which following the freedom given to Trusts to decide their own requirements is understandable; but skews Hignett and Lu's (2008) view of the level of duplication and redundancy where they quote LaFratta (2006) "the HBNs offering 1240 different specifications, including 10 different pantry sizes and 6 different utility rooms sizes, with 88% of the rooms less than 40m^2". The figure of 1240 has likely come from the number of rooms on the ADB database reflecting the total number of rooms across all the departments and the size of similar types of rooms will vary by department. Quoting six different types of utility room is a poor example as there are three distinct types of utility: clean, dirty and theatre, multiply this by factors such with or without a macerator and it is quite easy to reach six.

In terms of health standards and guidance the UK has until recently been very active and many other countries have either used or developed this work for their own use. Mills et al (2012) as part of HaCIRIC considered the need for regulation and how this is carried out within the EU and Australia (many of the papers referred to in this thesis are Australian). This paper is written at a time in the UK when the necessity for standards and guidance is questioned. In conclusion, they consider “a type of smarter and integrated regulatory approach that aligns multi-stakeholder and multi-disciplinary decision making” needs to be developed.

Wanigarathna et al (2016), in relation to Standards and Guidance proposes performance-based specifications, with supplementary prescriptive specifications, examines three hospital cases to ascertain whether greater innovation can be achieved using performance-based specifications rather than prescriptive. The issue with this study is that the three case studies are not comparable: one is a £88 million Children’s Unit; another a £90 million Elderly and Mental Health Unit; and, the third is a £10 million Elderly Unit with two of the hospitals being of modular construction. The conclusion is outcomes were generally the same in terms of innovation and there were difficulties in updating guidance, the latter being a known problem with standards and guidance.

Singha (2020) makes reference to HBN and HTM guidance and its development from the systems building programmes of the 1970s and 1980s and revisits this in relation to current requirements. She supports the view of Hignett and Lu (2008) that there are two camps: the first who follow the HBNs and HTMs rigidly in order to avert legal challenges; and, the other who seek derogations to try to innovate. She also quotes Architects for Health (2016) “guidance [health care building] is now increasingly out of date and suffering from lack of investment by the Department of Health”. This statement comes three years after the last HBN was issued. Singha (2020) also recognises the development of standard components through the transition from compendium through to Manufacturers Data Base (MDB), she does not however progress this through the next stages which led to Component Data Base (CDB) which linked to HTMs in relation to building components. There is no mention of the current HTMs which are now focused on engineering services and with their link to CIBSE making them mandatory rather than guidance. Some of the engineering HTMs, especially the provision of medical gases, has always been mandatory. ADB referred to previously as a briefing tool also produces 2D layouts and more recently 3D models as a means of communicating the designs to the users and provide information for construction. Ulrich (2006) promotes the use of PMUs (Physical mock-ups) as this allows users to interact with the proposals but adds time and money. Dunston et al (2009) look at virtual reality modelling as a means of introducing interaction but recognises there may be problems with IP (Intellectual Property) as a result of HUB technology. The use of BIM (Building Information Modelling), which can aid both design and construction with virtual walk-throughs is now mandatory on UK government contracts and links in to design management

NHS standards and guidance has not been updated since 2013 since when major developments have taken place regarding advances in medical technology, new medical practices and no continuous research into evidence-based design. Despite the differences in opinions concerning mandatory compliance, this lack of up to date research and guidance has serious implications for future projects.

2.4.6 Healthcare Planners

Dickson (2015) looks at healthcare planners and their role in briefing projects and interpreting HBNS and HTMs and concludes healthcare planning needs to be recognised as a separate discipline, but due to the diversity of guidance being given, and by people with no specific qualifications, an institute or association needs to be set up which can monitor competencies and accountability and also set out a standard scope of work. She refers to a scope of work in Framework Scotland 2 (2014) which could be adopted. Although there is a framework in place in Scotland there are still no formal qualifications for healthcare planners. Healthcare planning is important in connecting the wider delivery system to project delivery and needs to be fully integrated within the design process, whether it is to set out prescriptive standards or to interpret individual output specifications. There is a need therefore to establish regulated training and qualifications for healthcare planners.

2.4.7 Summary

This section has demonstrated the different components in developing the concept design to a stage where construction becomes involved depending upon the type of procurement. It highlights the need for a more integrated approach in terms of both design and design management where the interfaces between building elements and components is often the weak link, addressing the issues separately results in fragmentation.

2.5 How Construction Management Influences Healthcare Delivery

This section leads on from design and into the construction phase where issues relating to innovation can cause uncertainty, attempts have been made to introduce lean construction and concerns exist in construction management in relation to the competencies and capabilities.

In terms of project failure and success there is no mention of time lag, memory fades faster relating to time and cost than with quality and performance. Client dissatisfaction with poor quality and performance remains long after any increased cost or project delay. Griffith et al (2001) conclude the greater the project preplanning effort the greater the chance for project success. Using case study methodology involving industrial construction projects ten critical alignment issues are identified:

1. Stakeholders are appropriately represented on the project team;
2. Project leadership is defined, effective and accountable;
3. The priority between cost, schedule and required project features is clear;
4. Communication within the team and with stakeholders is open and effective;
5. Team meetings are timely and productive;
6. The team culture fosters trust, honesty, and shared values;
7. The pre-project planning process includes sufficient funding, schedule and scope to meet objectives;
8. The reward and recognition system promote meeting project objectives;
9. Team building programs are effective; and,
10. Planning tools (checklists, simulations, and workflow diagrams) are effectively used.

It is suggested that further research should be carried out into different areas of construction

Baiden et al (2006) investigated nine projects using different types of procurement in relation to team integration within construction teams and concludes further research is required from design and build contracts to determine how effectively teams can be integrated where structural barriers to collaborative working are mitigated. The influence of the client's efficacy of collaborative work practices also needs to be investigated. Bogus et al (2006) look at concurrent engineering within the design process as a logical approach to reducing project delivery time in a fast track environment and acknowledges that this needs to be approached in a systematic manner to reduce costs and risks as there is a tendency to overdesign and increase standardisation. Both of these papers are written at a time when design and build is still being established, particularly in more complex projects and the level of integration has still to be identified.

Schieg (2009) sets out a model for integrated construction project management including stakeholders being involved in design and realisation but does not discuss their management or integration. It does note the leadership role of the project manager and refers to Baker et al (1983) regarding client satisfaction. His reference is to traditional design bid build and construction management where the architect always has a direct relationship with the client, which was prevalent at the time, but in conclusion it mentions stakeholders contributing to success. Pinto and Mantel (1990) carried out an investigation into project failures, studying 53 projects, 29 of which were construction projects looking at three contingency variables:

1. The way in which project failure was defined;
2. The type of project being implemented;
3. The stage in the cycle occupied by the project;

and, concluded that further research was required. Many of the project managers involved considered project failures were unique occurrences and the cause of failure was idiosyncratic to the firm, perhaps the project.

Winch (2013) articulates the conceptual framework of Shapira (2011) organising the project field around three domains – the temporary project/programme organisation and the two permanent organisations of owner and occupier and project-based firm and the need for further research between the interfaces of the three domains, particularly those relating to governance and resourcing. Edkins et al (2013) looks at the front end of project management and considers this area is not as well documented in literature. The paper concludes it is at the front end where there is the greatest chance of errors and faults becoming in-built, or value being enhanced. It looks at the roles, attributes and competencies of project sponsors and the management of internal and external stakeholders. Ireland (1992) concludes that is the project manager's role is to manage their expectations and requirements and satisfy what he describes as "customer satisfaction" including quality. He describes the customers as not only the 'Buyer Customer' but includes co-partners, the contractor, senior management, suppliers and users and criticises project managers for failing to manage all expectations. It also reflects an attitude within construction companies who tend to describe the 'client', the term used in professionally led projects, as "customers". It was written at a period in time when the procurement of major hospitals changed from architect-led to contractor-led. He also identifies the skills needed to deliver "customer satisfaction".

These papers look at different aspects of project planning, but indicate further research is required. Although there are various aspects being addressed and suggestions made as to how project planning could be improved, no integrated approach is demonstrated and there is a lack of recent research.

2.5.1 Effect of Innovation and Uncertainty

This section looks at literature relating to innovation within the construction industry in relation to the use of new products, prefabrication, the issues which cause uncertainty and the introduction of BIM. Hippel 1988 and Slaughter 1998 emphasised the role of contractors, suppliers and manufacturers as the primary sources of construction innovation. Innovation in the architectural, engineering and construction (AEC) industry encompasses a large number of different actors from different disciplines within a ‘product system’ (Marceau et al, 1999). The move towards design and build was seen as an opportunity for contractors to input into innovation.

Hobday (1998) defines complex product systems (construction is characterised as this by Winch (1998) and Manley (2001)) as “any high cost, engineering-intensive product, sub-system, system or construct supplied by a unit of production (be it a single firm, a production unit, a group of firms or a temporary project-based organisation (TPO)”. Quantity of tailored components and sub-systems, the way they are integrated, and the degree of technological novelty are considered as the indicators of product complexity. The shift of several manufacturing or component sectors towards ‘total solution provision’ Foote et al. (2001) state by redefining the scope the way the firm and its identity (and capabilities) are defined, is a case in point. It considered how value chain structure affects participants, and how in turn participants reshape the value chain. It also looked at how firms try to change the transactional environment on the basis of their capabilities, displaying ‘institutional entrepreneurship’. The methodology involved ‘appreciative theorising’ the focus being the development of new insights or constructs through iterations between theory and evidence (Eisenhardt 1989; Yin 2014). Bogus et al (2006) looked at strategies for overlapping dependent design activities but did not include complex architectural design.

Wolter and Veloso (2007) investigated the effects of innovation and technical uncertainty in vertical integration and demonstrated technological uncertainty, which exists in innovative environments, always raises transaction costs whereas integration will save on transaction costs due to uncertainty.

Gil et al (2008) study the link between early design and fit-out referring to Habraken (2000) and open buildings and how uncertainty affects the initial design. They define the need to upstream as well as downstream and how this can be achieved by creating mock-ups during the briefing stage, how this informs the decision-making process which ultimately leads to better project management and by facing uncertainty early in the process leads to better outcomes.

Rutten and Halman (2008) consider this to be the case in traditional design-bid-build procurement and acknowledges designers may also take part in a project from inception to completion. The idea innovation takes place in the construction phases is also questioned as much innovation comes from the design. If the traditional procurement route is adopted there is little scope for innovation in construction as theoretically all the construction detailing is complete.

Fischer and Varga (2009) “technological innovations are less and less the outcome of isolated efforts of the individual firm”. An example would be the development of ‘bathroom pods’ where “Saniflex” created a joint venture between an architect and a plumber. Acknowledging the ‘dynamic’ nature of innovation games and the complexity of relationships between associated players this paper, with a narrower focus, questions the role and ability of architectural designers as system integrators.

In relation to the human systems integration requirements outlined in Endsley (2015), where the requirements form the driver for the design of new technologies, these are often instigated by users. Koppenjan and Klijn (2004) defines the role of the “entangler”, as adopting and managing uncertainty to bring and keep stakeholders together to learn about each other's perceptions, objectives and resources, and to discover mutually beneficial opportunities and create courses of action. Ward and Chapman (2008) also focused attention on uncertainty related to the multiple silos created by the integration of wider stakeholders in healthcare specifically (e.g. clinical users, facilities management).

This thesis does not focus on BIM as it was not used in any of the case studies, with the exception of Case Study 5, where BIM was not implemented properly, as it was not a government requirement at the time of the projects. Although the concept of BIM as a tool had been established since the 1970s, and Coordinated Project Information (CPI) promoted by the RIBA, standards have only been introduced in the UK since 2007. In relation to innovation, however, reference is made to Rekola et al (2010) who carried out a qualitative case study of a Finnish project looking at BIM as a means of integrating design and delivery solutions. They conclude to be effective the project network needs to be integrated from the beginning, the whole design team, cost estimators and the expertise from the contractor’s perspective. Krystallis et al (2015) looked at future proofing delivery and BIM in a healthcare setting concluding that BIM could be used to drive future proofing and healthcare projects which have greater complexity, criticality and uncertainty would benefit. There are still issues with delivery models which need to be adapted to suit BIM principles relating to model ownership and relationships.

2.5.2 Introducing the Concept of Lean Construction

Morgan and Liker (2006) define the basis of lean product development at Toyota as a mutually supporting system composed by process, skilled people, and tools and technology. In the process element a Chief Engineer (CE) is appointed to guide the team. The definition of this person is someone who before they begin on the project has “walked in the customers’ shoes to gain a deep understanding of their needs”. This puts an emphasis on the importance of being involved at the start of a project and as Morgan and Liker (2006) state “plan carefully and execute exactly”. In terms of skilled people, the mantra is “Right person, right work, right time” and with tools and technology it relies upon the integration with people and processes throughout the project delivery system.

Applying Lean Product Development Concepts to architectural engineering and construction (AEC). Koskela (1997) saw that “the management of design and engineering is one of the most neglected areas in construction projects with research findings indicating that planning and control are substituted by chaos and improvising in design”. More recently Emmitt and Ruikar (2013) and Tzortzopoulos et al (2002) report on design management developments around 2000 and more recently Hamzeh et al (2009) have questioned it’s use in design. The Last Planner System (LPS) is also developed to manage construction site activities during this period (Ballard & Howell, 1994) and Howell (1999). As Ballard (2008) points out site activities which are linear in nature are in “sharp contrast to activities developed as part of the design process which are often interdependent and have constraints that cannot be resolved in an isolated fashion”.

Jorgensen and Emmitt (2008) explored the transfer of lean manufacturing/production from the Japanese (Toyota) car manufacturing industry to the construction sector and takes the form of a literature review. The concept of lean techniques has been driven following the criticisms of the Egan Report but some of the negative aspects of lean have been ignored despite repetition by Green (1999, 2000, 2002) and Green and May (2005). The main difference between the manufacturing industry and construction is volume production. Manufacturing has high volume, high repetition and standardisation – issues which are not prevalent in construction - apart from housing possibly but unlikely in complex major hospital developments. The literature reviews highlighted some of the negative effects which indicate “that lean production procedures have come with a very high price for Japanese industrial workers who work under very hard and stressful conditions and enjoy rights inferior to those of workers in western industrial countries”. This is indicated from empirical studies by Dohse et al (1984), Briggs (1988), Sullivan (1992), Williams et al (1995).

They do however consider that there are common elements such as:

- Focusing on eliminating/reducing waste;
- End customer preference is adopted as the reference for determining what is to be considered value and what is waste;
- Management of production and supply chain from a (customer) demand pull approach;
- Approaching production management through focus on processes and flows of processes; and,
- An (at least to some degree) application of a system’s perspective for approaching issues of waste elimination/reduction.

The subject was first discussed by Koskela (1992 and 1997) and there are many references to his work and to Ballard (1993 and 2008) and to papers involving Koskela et al (2002).

Jorgensen and Emmitt (2008) summarise three themes:

1. Production planning, control and management;
2. Production system design and construction project design; and,
3. Implementation and application.

The first theme is dominated by the last planner system (LPS) related to workflow scheduling and management, the second which is related to the first introduces supply chain management and Winch (2006) and the third theme looks at the tools and their application where the common feature appears to be the adoption of a project structure as the organisational basis for designing and making. Hansen and Olsson (2011) make a clear distinction between design and construction by describing design as an iterative process unlike construction which is sequential and therefore easier to adopt lean principles. Further empirical research is needed to further support the implementation of lean in design and construction.

2.5.3 Competencies and Capabilities

Hillebrandt (1984) stated “the builder had a poor public image and, in general, until shortly after the Second World War, most directors of building companies had worked their way up from the crafts. The obvious source of well-educated persons for building contracting – the architects and quantity surveyors – were not permitted to participate in commercial activities and, very often, after building increased in complexity and size in the post-war period, the man in charge of a building firm or the building part of a large contracting firm was a civil engineer by training”. This was definitely the case on all the major hospital projects in which I was involved.

Building sites were described by Cicmil and Marshall (2005) and Ness (2010) as “chaotic, complex and in constant flux, constituting ‘ad hoc environments’ that undergo rapid temporal and spatial changes, they are therefore often probe to unpredictable configurations”. Lowstedt (2014) in an ethnography study of construction workers gives an insight into how the manual workers behave on site and how they perceive the information provided by the professional to be resulting at times in “improvisations which would be impossible to incorporate in the formal documents”. Baiden et al (2006) looked at team integration within construction recommending further investigation should be carried out for effective team operations or the construction sector must overcome significant organisational and behavioural barriers if the benefits of integration are to be fully realised in the future. These papers are all written during the temporal periods when contractors are directing projects. At the same time Cohen et al (2005) in a study of architects working in the East Midlands focused on creativity and lack of control by architects and paints a very depressing reflection of architects’ competencies but does not mention the architect’s role in helping to prepare a brief or understanding of stakeholders. The title reflects the use of ‘RIBA’ Remember I’m the Bloody Architect!

Smyth (2005) presents an interesting paper around relationships and the effects of trust on a project and refers to Thomson (1998) particularly regarding the role of QS/Cost consultant. Dillenberger (2010) discusses how contractors frequently upset the architects at the start of a project by saying “We are going to be doing this project differently to meet the project costs”. This not only upsets the architect but also the client who has spent time preparing his project to achieve his desired outcomes and fears it will be hijacked by the contractor and changed to suit his vision of its construction. This paper is written after the design and build contract has been the preferred method for over 10 years indicating that this method of procurement was not producing the expected outcomes. The research was based on interviews with several architects and contractors with the conclusion it was important to be a team player, it is not to your firm’s detriment but indicates willingness to achieve the project’s outcome. One of the architects considered the move towards BIM and Integrated

Project Delivery would reduce the adversarial nature of architect-contractor relationship in a change for the better. Rooij et al (2019) looked at developments in interdisciplinary education within architecture and built environment design education at TU Delft which has the potential for increasing integrated design.

Akintoye and Main (2007) investigated collaborative relationships in construction from the UK contractors' perception. The common theme of Latham (1994) and Egan (1998) was that improvements in the construction industry could be made "through greater teamwork not only at site level and organisational level but also with clients and suppliers". This has led to an increasing use of collaborative arrangements such as partnering, public private partnerships, prime contracting and supply chain management. The study sample was divided into two categories: SMEs (Small and medium-sized enterprises) and large contractors. It was found large contractors were more likely to engage in collaborative partnerships, possibly as a part of size and complexity of the projects. Successful collaboration was thought to result from high levels of commitment and trust, sharing risk, responding to client needs, good communications, sufficient resources, improved efficiency and understanding individual roles of the partners. Unsuccessful factors involve the collaborating partners' failure to contribute to the partnership needs, goals and objectives, with lack of trust rated as the second highest failure. Poor design consultation/management was cited as another factor, together with undefined roles and responsibilities. Behavioural issues were suggested as being the cause of some of these failures and they considered the construction industry needs to address these failure issues as on the positive side there are major advantages from collaboration.

Law (2018), setting out the differences between professionalism and commercialism which have led to recent failures and catastrophes in construction: failure of Edinburgh Schools PFI, the collapse of Carillion and the fire at Grenfell Tower. He differentiates the professional roles of architects with the commercialism of contractors and whilst acknowledging the rights of contractors to take a commercial approach to projects considers that there is also a need for a professional approach. This indicates that team integration suggested by Baiden et al (2006) has not happened.

Davies and Brady (2016) addressed theory and empirical research into project capabilities and the relationship with project success. They previously looked at this in terms of dynamic capabilities in teams Davies and Brady (2000) and acknowledges Morris (2013) as well as emphasising the need for specialised knowledge skills and capabilities of organisational teams and this also applies to individuals. Previously Winter (2003) focused on dynamic capabilities as being associated with change and flexibility both elements which can be applied to project briefing and the capabilities within construction teams.

Durso et al (2015) looked at human systems integration (HSI) from a psychological perspective. One aspect of HSI is to refer to people interacting with technology or to the scientific or engineering issues focused tightly on that particular interaction. They state human factor professionals know calamities could have been prevented or efficiencies enjoyed had human factors issues been considered early in development. It also involves people who are part of teams that are embedded in organisations. Kowalski (2015) also focused on teams and team integration and cites examples from the military and fire brigades which involves individuals and teams. Endsley (2015) linked HSI with requirements analysis and concludes that establishing detailed, accurate, and robust HSI requirements is a critical step in the development of systems.

Javidan (1998) tried to explain the differences between competencies and capabilities with 'capability' described as "the corporation's ability to exploit its resources, which are functional based" and 'competency' as " a cross-functional integration and co-ordination of capabilities", with 'resources' as the building block of competencies. Woodin and Wade (2007) amplified competencies further by saying they need to include organisational factors and not just focus on knowledge, skills and capabilities of professional. The service-led relationship proposed by Razmdoost and Mills (2016) gave recommendations as to how this can be achieved by construction project-based firms being flexible with resources rather than just exploiting with existing resources and developing capabilities.

Literature recognises the issues with capabilities and competencies and acknowledges initiatives have been taken to try to improve the situation, but Law (2018) indicates there are still major issues with capabilities and competencies within the construction.

2.6 The Effect of Construction Delivery Models on Healthcare Projects

This section looks at different construction delivery models, some of which have been used on healthcare projects and their outcomes.The construction sector contributes to 6% of the UK economy according to Rhodes (2019) with hospitals and schools forming part of the Commercial and Social Sector (45% of construction) larger than either the residential sector (40%) or infrastructure (15%). Rowlinson and McDermott (1999) and Turner (1990) outline three different forms of procurement which existed in Temporal Period 1 as:

- Traditional – Design-bid-build

- Design and Build
- Management

All three types of procurement used different forms of JCT (Joint Contracts Tribunal) contracts.

In Temporal Periods 2-5, following the introduction of PFI, the form of building contract adopted was JCT Design and Build rather than the traditional with quantities form. NEC 3 was introduced for smaller P21 and P22 projects and in Temporal Period 5 NEC4 appeared as a means of completing an abandoned PFI project.

Alternative models have been used in other construction sectors and these are investigated together with issues relating to innovation and uncertainty, competencies and capabilities and attempts at integration.

2.6.1. Delivery Models used by the Department of Health

Symons (1993) compared seven case studies all completed within the time frame of Case Study 1. Six of the seven hospitals were for the NHS. Two of the hospitals were traditional design-bid-build, the last of their era, two were the first contractor design and build, and two were management contracting. The seventh case study was a private hospital in Scotland built for a Middle Eastern client to an American design using Design, Manage and Construct with a Guaranteed Maximum Price (GMP). The delivery architects and engineers were all Scottish including an independent Project Management firm. The study concluded in terms of cost and quality traditional provided the best solution, whereas in terms of time design and build proved to be the best solution. The management projects had advantages and disadvantages of both, cost being an issue, but one project was in the Western Isles which was always going to present a cost problem and the other was as a result of the financial crisis at the time. This latter project however was the Chelsea and Westminster Project which was designed and built in the shortest time frame in comparison with future PFI projects of a similar size and complexity.

2.6.1.1 The Move Away from Design, Bid, Build

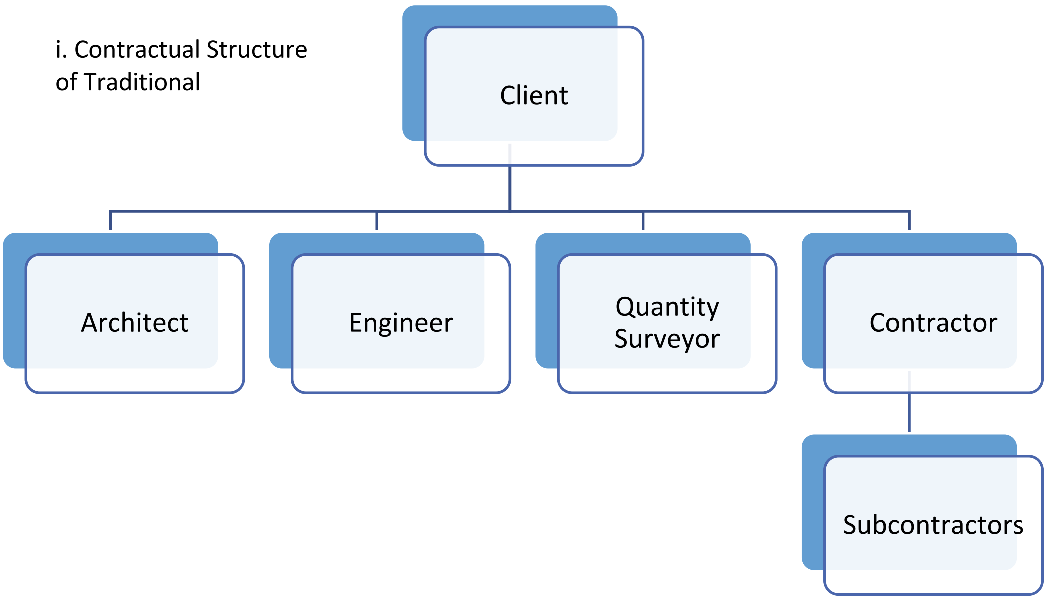
The Latham Report (1994) carried out a review of the British Construction Industry looking at the evolution of the British construction industry from the late 1880s when the vertical structure of the sector stabilised and remained largely until the 1970s referencing studies to Hillebrand, Gann, Winch in the 1980s and 1990s. Following the Fairclough Review (2002), Saxon (2002), Chairman of the Reading Construction Forum, supported the idea of systems integration and integrated solutions but considered the industry needs “rebirth” but in a different form as there is still no clear direction in the construction since the Latham Report (1994).

Cacciatori and Jacobides (2005) looked at the development of an inductive framework to explain why after a long period of vertical specialisation the British building industry is shifting to vertical reintegration. They describe 'Traditional' procurement' as 'disintegrated' compared with design and build where a single contract exists with the client. They highlight issues such as the deinstitutionalization of professions allowing changes to take place and where reintegration is advanced by firms seeking to protect their position; enter new, related markets; or find new ways of leveraging their capabilities.

This paper is written at a time when the first wave PFI projects, using the JCT Design and Build form of contract as used in Temporal Period 1 as described by Symons (1993) was adopted and the was used through Temporal Periods 2-5.

This comparison of the two forms of contract is well illustrated in Figure 6 (i and ii), the paper however does not explain how the contract affects the design team relationships with both the client and each other as developed here to show the influences on design delivery. Figure 7 (i and ii) shows the potential disintegration (rather than integration that would be expected).

i. Contractual Structure of Traditional



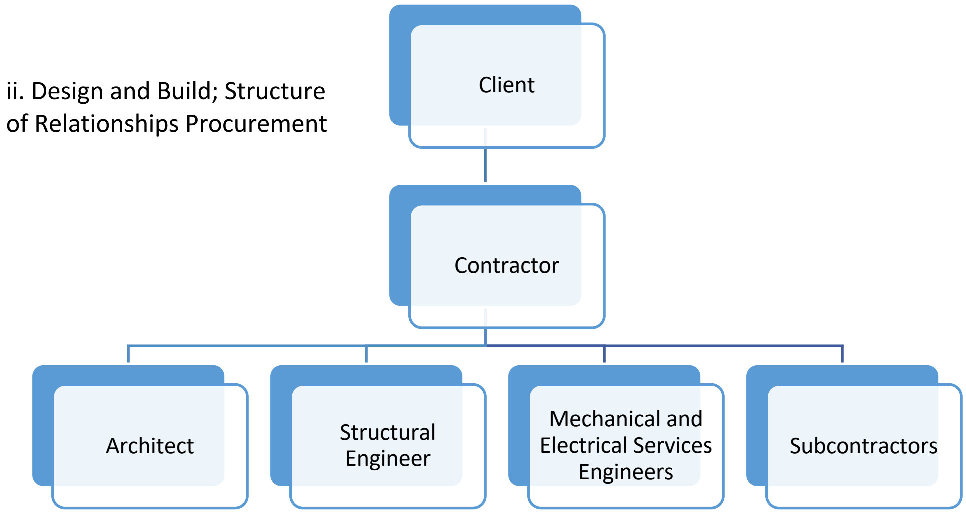


Figure 6 Comparison of Contract Forms, Cacciatori and Jacobides (2005)

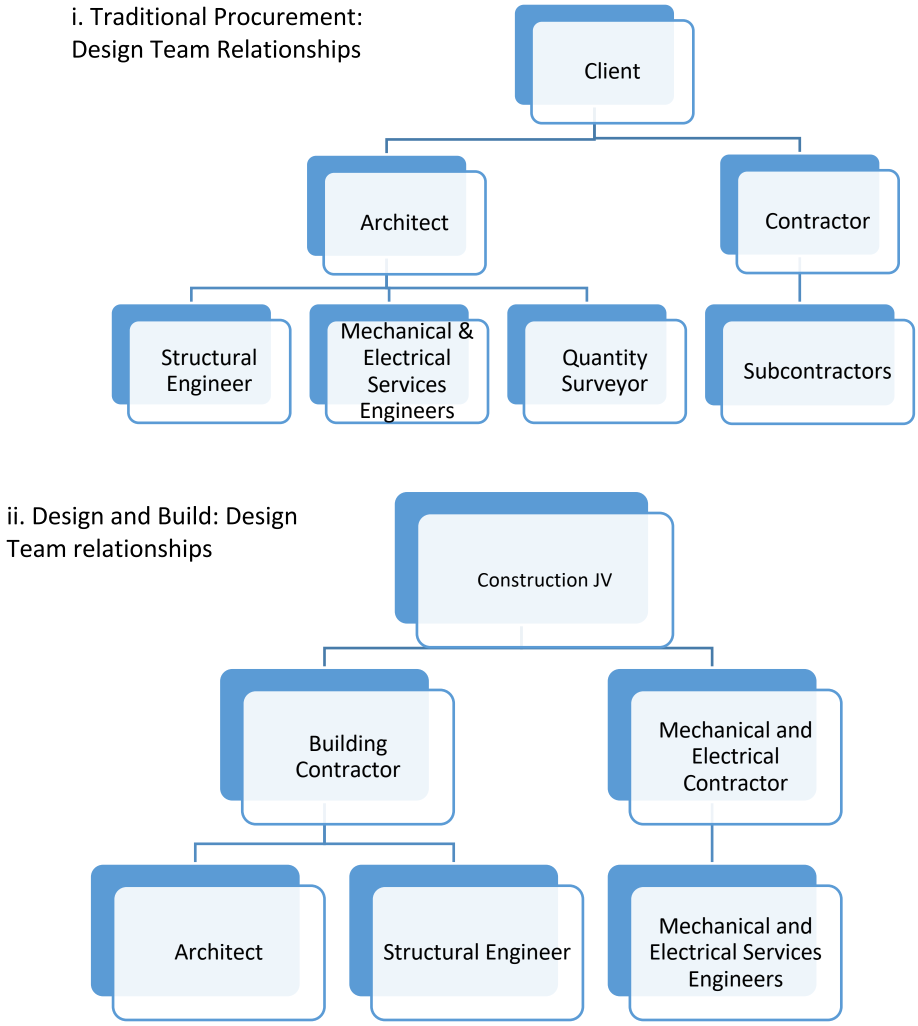


Figure 7 Comparison of Design Team Relationships

In major hospital projects, where the JV consists of a building company and an engineering services company, the design team relationships are split as a result of the building contractor engaging the architect and the structural engineer and the engineering services contractor engaging the services engineering consultant. The paper does highlight differences between architects and services engineers related to the level of design during the project stages, but the impact of this disintegration is not investigated.

2.6.1.2 The Introduction of the Private Finance Initiative

The first PFI hospital procured by the NHS was Darent Valley, Dartford where financial close was achieved in 1997. That same year Gaffney and Pollock (1997) in a report for the BMA questioning whether the NHS can afford PFI concluded that PFI placed greater demands on public revenue than on public sector recruitment but PFI favours greenfield sites rather than developing existing estates. It also raises the question of using the Public Sector Comparator (PSC) as a means of testing value for money. They also conclude that "affordability, like value for money should be determined at national level by the Department of Health and decisions on how projects are to be financed should be made after appraisal of the various options".

Fischbacher and Beaumont (2003) examine a qualitative research case study carried out by an NHS manager into one of the first wave PFI hospitals concentrating on stakeholder involvement and concludes "the PFI decision making process has been shown to be potentially dysfunctional and inefficient". They consider this to be partly due to the design of the PFI scheme in a system which already tends to separate strategy from implementation and has the capacity to accentuate this separation rather than integrate the process. They also suggest it not only prolongated the process but distracts staff and human resources from carrying out their core business. Li et al (2004) investigated 18 potential critical success factors relating to PFP/PFI of which the top three were: a strong and good private consortium; appropriate allocation of risk; and available financial market. The least successful factor was social support, and this perhaps reflects user satisfaction, as the paper is focused on economic success and hospitals were only one out of ten project types.

Gesler et al (2004) evaluated the UK hospital building programme following the adoption of PFI design, build, finance and operate, in terms of therapeutic design and concludes there is little evidence of the new ideas achieving their goals following the introduction by the NHS of AEDET to review the designs. This would reflect the completion of the first wave of PFI projects. They quote Purves (1998) who considered PFI provides the opportunity for architects to work directly with clients, doctors etc, something which had the reverse effect. Gesler et al (2004) also refer to Spring (2001) and the influence of the Chelsea and Westminster Hospital (completed in 1993 using construction management) as having "broke the mould for an NHS facility and was a precursor to the current drive towards patient-friendly design" and evidence based design.

Smyth and Edkins (2006) examined the management of the projects delivered by PFI and PPP where the primary relationships are between the public sector client and the SPV (Special Purpose Vehicle) whose members essentially belong to same operating company as the construction contractor. Private sector management was evidenced as reactive rather than proactive in managing relationships and the public sector weak in managing the interface with the private sector.

The concept of Smarter PFI was promoted by the RIBA (2007) during the third wave PFI period whereby the Client's design advisors prepare a concept design model following in depth consultation with users as a means of reducing time and bid costs within the PFI process. This was again promoted by Tucker (2012) as part of the reform of the current PFI model which had been adopted by the North Bristol NHS Trust at Southmead also referenced by Schwarz (2012). This method is seen as being not dissimilar to earlier procurement, where standard layouts are provided – nucleus for example. It is however a static approach and does not germinate an understanding of requirements between the users and the ultimate designers of the project. It is also negative in terms of lean design principles by duplicating design teams and processes.

Caldwell et al (2009) compared the procuring of complex performance in construction through two examples – London Heathrow Terminal 5 and a PFI Hospital. In terms of CoPS (complex product systems) –the PFI hospital was considered high in relation to performance complexity and low in relation to infrastructure complexity in comparison to Terminal 5. It was found to have many stakeholders, and although design and build contract but was still traditional in its approach to managing risk. Complexities of integrating equipment and major services distribution were not investigated which may have changed the view on infrastructure complexity and this again raises the question of the definition of 'infrastructure' in comparison with airport design.

Tillmann et al (2010) related the need for integration as a result of poor requirements management, lack of collaboration among different stakeholders and suggests that healthcare building should look at successful examples of integrated solutions in industry. Tillmann et al (2010) also support Gesler et al (2004) who suggest due to contractual arrangements which removes the direct link between the architect and the client that risk allocation is raised.

Kamara (2012), is a PFI case study related to fire stations and as with his other papers focuses on the aspect of knowledge transfer, Kamara et al (2002), again it is a non-typical project and it is difficult to see how the findings might apply to other building types. The use of atypical acronyms and US referencing reduces the impact of comparisons with peer papers.

Considering over 60 hospitals have been procured using PFI/PF2 over a period of 25 years there is a gap in literature to evaluate them following early research into the first and second wave schemes. An important issue highlighted by Fischbacher and Beaumont (2003) concerning first wave PFI about the unproductive time involvement by NHS staff and design teams has not been addressed in subsequent waves and no evidence demonstrated from the RIBA (2007) proposal.

2.6.1.3 The Move Towards Frameworks

Shen et al (2010) described the "current period" as a time of rapid change in technology, demographics, business and the economy and for the construction industry where systems integration becomes an important prerequisite to achieve efficient and effective collaboration although not a new topic, further research into systems integration will be active for 5-10 years. Previously, Jones (2008) had looked at a different approach to project procurement which was to use an integrated project delivery approach where the entire team of designers, builders and key design sub-contractors are directly appointed by the client. This approach has not as yet been adopted for the procurement of major hospitals.

2.6.2 Alternative Delivery Models

Management Contracting has been used in a few instances, in exceptional circumstances. The Chelsea and Westminster Hospital which Morris and Hough (1987) would classify as a "positive failure' where the sale of the existing hospital resulted in negative equity but the building itself proved to be successful. The Western Isles Hospital in Stornaway presented difficulties due to its location and the ability to engage subcontractors and more recently the Royal Liverpool Hospital where the contractor went into liquidation three months before completion. The perceived difficulty with this method is delivering within cost. It is now 30 years since this method was considered as a first choice, but it may be that it is time to think again.

2.6.2.1 Partnering and Alliancing Models

Leading on from PFI and its current demise in the UK for the hospital building programme this section looks at other ways of integrating through collaboration and alliancing. The UK

Cabinet Office (2014a) published; 'New Models of Construction Procurement: Introduction to the Guidance for Cost Led Procurement, Integrated Project Insurance and Two Stage Open Book, HMSO' described as three models of construction procurement. The first part relates to the method of procurement in terms of seeking a collaborative way of working and the concept of frameworks and supply chains to achieve cost reductions on subsequent projects. The second concerns UK Cabinet Office (2014b), of 'Project Insurance' something which is used in Europe and where one policy covers all parties' insurances and professional indemnities and helps to avoid transfer of risk between parties which can be detrimental to project success. The two-stage open book sees the client invite prospective team members to bid for a project based on an outline brief and cost benchmark. Following selection of the successful bidder the client and their chosen team then work up a proposal on the basis of open book costs that meets the client's stated outcomes and cost benchmark. Examples of this type of approach are the P21 and P22 hospital procurement programmes which use NEC 3 and 4 contracts. Recently NEC 4 has been adopted as a means of completing a failed PFI as design risk can be transferred to the contractor, Figure 8.

Figure 8 NEC 4 Relationships

In NEC2 and 3 used in P21 and P22 which are two-stage open book methods, the designers are still second tier consultants as in the JCT Design and Build contracts, NEC 4 can however accommodate an alliancing model where the consultants are 'first tier' participants along with a building contractor and the client.

Project 13 related to NEC4 was also developed by ICE and introduces an integrator to connect the key supplier and key advisor with the supplier and advisor. This model designed for major engineering infrastructure does not reflect the different levels of design and complexities involved in major hospitals projects, Figure 9.

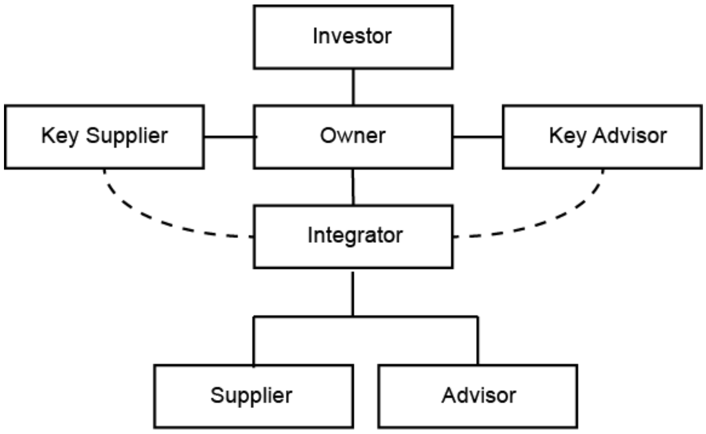


Figure 9 Project 13 Relationships

Bresnen and Marshall (2011) follows on from an earlier review and critique of literature on partnering which they carried out in 2000 (Bresnen and Marshall, 2000). It specifically looks at client-contractor relationships and covers nine cases studies – three of which relate to building construction projects which use three different types of contract: design-bid-build, design and build and construction management. All three are in the hotel/commercial sector and are therefore difficult to compare with complex projects such as hospitals. Interestingly the use of the alliancing contracts as such as NEC are related to the civil engineering case studies. There are however findings from this research which are pertinent to hospital design and construction. One of which is the lack of involvement of key designers and subcontractors in the alliance. This issue of 'tier two' contractors inhibits the ability to fully integrate teams. They also identified there was a lack of clear demarcations of roles, responsibilities and authority, especially in the early project stages when the contractor's input into the design was high.

There were issues with incorporating user requirements into the designs and in some cases (namely with contracts pertaining to the Institute of Chemical Engineering) a 'no-changes' culture was explicitly promoted. Any alliancing/partnering contract involving healthcare would need to understand the need for potential changes as no-one wants to open a new facility with out-dated equipment or technology. The open book approach to cost proved to be successful. In conclusion, they consider one of the key project processes is design-construct integration, which includes not only time and cost but quality and is still proving a major problem. They also conclude that "people and their relationships" are key to project success and how knowledge is transferred referring to Nonaka (1994) and Nonaka and Takeuchi (1995) whose work involves at organisational knowledge creation.

Lloyd-Walker et al (2014) looks at alliancing and how a no-blame culture enables construction innovation. They define innovation as “the outcome of people with different skills, knowledge, experience and perspectives collaborating to find new ways to solve problems or to reflect on current methods to find more efficient and effective ways to goal accomplishment”. Alliancing is one of a new form of procurement which Meng (2012) describes as where “mutual objectives, gain and pain sharing, trust, no-blame culture, joint working, communication, problem-solving and risk allocation” where the most important indicators of strong supply chain relationships in the construction industry. Lloyd-Walker et al (2014) used examples in Australia and what makes it relevant to this study is how it is considered to provide a good project procurement method for complex projects. They also consider it to be best suited for high risk/ high uncertainty projects. They also introduce the term ‘non-owner participants’ (NOPs) which can describe designers and contractors and their relationship with the facility owner/client. Using an alliancing contract enables an open book approach, a fair commercial where cost expenditures are agreed through a target out-turn cost (TOC) model is rigorously validated through reference benchmarking by independent cost consultants. The contract balances the right of NOPSs to make a reasonable profit with the rights and obligations of the project owner to ensure that value for money is competitively achieved. One of the case studies in the paper outlines the stages in the alliance project starting with government announces the alliance, then appoints the architect to the alliance nine months later and finally the head contractor a further six months later with the alliance completed four years from the pre-planning stage. The ability for sharing ‘lessons learnt’ is also easier due to the no-blame culture and it also highlights a required change in leadership style from a command and control, often found in the construction to one which is more authentic and emphasises the change in ontological stance from ‘being’ to ‘becoming’. It also highlights the benefits of project insurance- something which is common in France and is also being considered in the UK as part of Integrated Project Insurance.

Matinheikki et al (2019) involves an infrastructure case study – a tunnel project and what they describe as temporary hybridisation combining the state, corporate market and multiple professions within a temporary project alliance organisation and define project alliance as “an integrated project organisation consisting of representatives of multiple independent organisations uniting their efforts for what is often termed *best-for-project.* They think that further research in this field is required to understand the dynamics and roles within hybrid organisations

Zerjav (2015) in a study on project leadership, relating to an engineering infrastructure project, proposes upstream integration can be achieved "by devising strategies of alternative resource allocation and collaborative problem-solving to mitigate the potentially adverse impact of design boundary dynamics that are likely to occur on infrastructure projects".

2.6.2.2 Integrated Project Delivery (IPD)

The Term Integrated Project Delivery (IPD) was first used by Matthews and Howell (2005) with a form of contract described by Lichtig (2005) being developed by the AIA in 2001. Hall and Scott (2019) reviewed the IPD process in relation to Sutter Health and found IPD was advantageous where there was a high repetition of projects for the same client (in comparison to design-bid-build procurement). The time of its development during the early 2000s coincides with the adoption of contractor-led design and build in the UK, but unlike the design and build model, IPD has grown out of projects relating to healthcare and is now extending into other building types.

Fleming and Koppelman (1996) had previously looked at integrated project development teams concluding it was an existing concept and when properly implemented will deliver successful results by shortening the time from project concept to a tangible asset. One important aspect was the co-location of the project members in order to create a cohesive project team.

Lichtig (2010) looks at how Sutter Health set out to deliver its capital healthcare programme adopting lean construction methods and developed a new form of contract its "Integrated Form of Agreement" where risks and rewards are shared which is signed by the architect, the construction manager/general contractor and the owner requiring teams to start working together very early in the project.

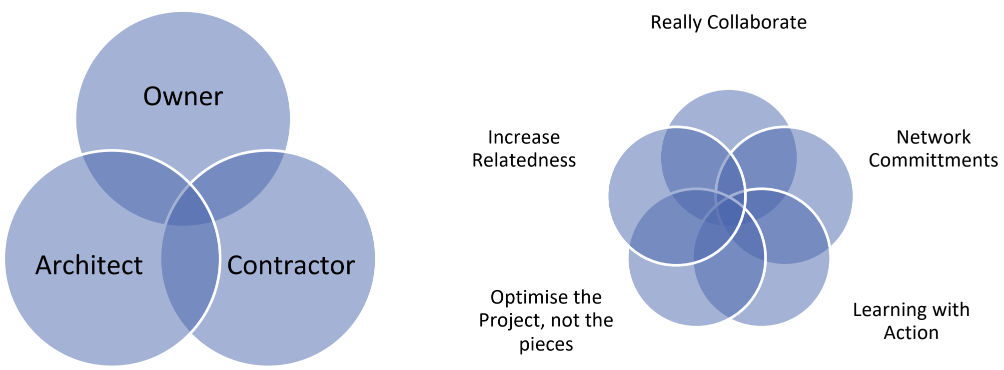


Figure 10 The Five Big Ideas

It is described as overlapping circles as in Figure 10 rather than three separate entities. The core group acts as the decision makers, similar to a steering group to achieve “the five big ideas” of Lean Project Delivery. The project cost is either a guaranteed maximum price (GMP) or an estimated maximum price (EMP) where pain/gain share operates. The main difference between this US model and most UK models of collaborative working is that it is not a design and build contract where one party takes total responsibility.

The Cohen (2010) case study of the pilot IPD project for Sutter Health was based on the AIA form of contract. Very few change orders were initiated by the client and the project was delivered on time and within budget. The team considered this type of arrangement was suited to larger projects.

Lostuvali et al (2014) involves an IPD case study for the Cathedral Hill Hospital Project in San Francisco, California which also uses the AIA form of contract, a true alliancing form involving the client, designers and contractor. It also looks at the principles related to lean product development at Toyota. It acknowledges “the management of the product development process differs from the management of manufacturing in many different ways, which must be addressed when one tries to apply Lean concepts originated in manufacturing to design.” A literature review was carried out as part of the study which concluded “literature lacks a clear definition of what design management means” and cites Emmitt (2010) in reviewing the emerging design management field and the need for a well-defined and agreed discipline.

This project was the first to use a full-fledged IFOA and may not have been repeated. One of the essential requirements is to have a strong leader, someone who has “in-depth experience of the problem areas, as well as hands on experience in the different phases of design, engineering, manufacturing and construction.” Whilst this is possible in the car industry, Lostuvali et al (2014) states “this well-versed leader profile might not exist (yet) in the construction industry, which is much broader in its range of products than the manufacturing industry.” Morgan & Liker (2006) developed a system based on the Toyota principles which included “Develop a Chief Engineer (CE) System to Integrate Development from Start to Finish” this principle they describe as “work in process”. Hickethier et al (2013) considers having leaders who understand the complexity of the project and see the whole is crucial to define how the information is coordinated and distributed within the team. As a result of the CHH project two elements were identified as being at the core of Lean Product Development System (LPDS:) role of leadership during the transformation to a lean enterprise and the effective management of the information flow. One aspect of lessons learnt which contributed to good team integration was the long preconstruction period and another positive outcome was the frequent collaboration meetings resulting in issues being resolved by participants during the meetings instead of through requests for information (RFIs).

Mesa et al (2016) in exploring performance of their integrated project delivery process on complex building projects selects a hospital project of 430,000 sq.ft (40,000sq.m) costing $160 million(£120 million)and a 24 month construction period. A hospital was selected as it was an example of a project which could be completed using the four forms of delivery (DBB, DB, CMR and IPD) and also due to its level of complexity. They define integrated project delivery as being where the owner, designer and constructor sign one contract. Traditionally the risk allocation is split and the owner, the designer and the contractor individually manage risks. The owner transfers risk to the designer and the constructor through the contract. In this case the risk is shared: the owner, the designer and the contractor collectively manage and appropriately share risks, frequently through a shared contingency pool. This is similar to the P21 model, but in P21 it is only between the owner and the contractor.

Mesa et al (2016) created a General Performance Model (GPM) as a conceptual model as it provides insights into how project delivery systems impact project performance at the supply chain level. The matrix in Table 3 below is extracted from the paper:

Table 3 Matrix Extract from Mesa et al (2016)

Project Organisational Structure	**Supply Chain Relationship Factors**							
	Alignment of interest and objectives	Gain and Pain Sharing	Trust	No-blame culture	Team working	Communication	Conflict resolution	Continuous improvement
Design-Bid-Build (DBB)	N	NN	NN	N	N	NN	NN	O
Construction Management at Risk (CMR)	O	NN	O	N	O	O	N	O
Design-Build (DB)	O	O	O	N	O	O	N	O
Integrated Project Delivery (IPD)	P	PP	P	P	P	P	P	P
Matrix of the impact of project organisational structure on SCRs factors, H.A. Mesa et al (2016)								

Key: NN High Negative, N Negative, O No Effect, P Positive, PP High Positive

For the complex healthcare project IPD outperformed DBB, CMR and DB. The analysis showed that project outcomes were very sensitive to communication, alignment of interest and objectives, team working, trust and gain/pain sharing. Comparable is the need for both experience and professional qualifications and the importance of IPD removing team fragmentation.

Chambers (2010) outlines the Sutter Health Prototype Initiative (2010) where charettes are used to explore and develop new ideas and cites the example of creating a “universal care unit” where activities can be flexed in accordance with demand. This type of activity, which takes place during the project lifecycle and because of the integrated form of contract, enables value management to aid dynamic briefing and adopt the more holistic healthcare design approaches related to open building and EBD.

A UK reference to IPD and in particular for use in healthcare projects is contained in a blog from E+I Engineering (2017). Promoting the use of IPD is particularly interesting as I+E Engineering are the largest providers of Electrical Switchgears in the UK and Ireland and the installation of switchboards in hospital design frequently results in design changes due to the issue of installation drawings taking place well into the construction phase. Final electrical loadings can be difficult to assess and due to its essential nature spatial design changes have to be made.

2.7 Reflections

The literature focus in this chapter related to how healthcare is delivered and the integration of the wider construction industry and how they impact on the delivery of individual projects.

The conclusions that can be drawn from this chapter are:

- The delivery method is selected at government level but can be influenced by the major stakeholders, contractors and institutions as demonstrated by the change from design-bid-build to design and build and more recently from the introduction of ICE forms of contract, that are perhaps replacing JCT contracts in the delivery of hospital projects. This supports the case for treating the hospital procurement differently from other government projects and investigating a form of contract which can accommodate the complexities and specialties involved.
- There is an absence of literature relating to the 20 years of the construction of 60 major PFI hospitals both in terms of procurement and functionality performance demonstrates the lack of long-term learning which is valuable for the transfer of knowledge for both avoiding replicating mistakes and implementing successful outcomes.

- The literature also highlights areas of weakness between the wider delivery and project delivery systems.
- Integrated project delivery appears to offer the opportunity to integrate design management and a greater level of understanding of the discipline, particularly in major hospital projects as demonstrated by Lostuvali et al (2014).

Chapter 3 Ethnographic Theory and Methodology

3.0 Ethnographic Theory and Methodology

3.1 Introduction

This chapter describes the research philosophy, design and methods adopted to achieve the research aims and objectives as outlined in Chapter 1 which were to determine the level of integrated design management and its effect on project outcomes in major hospital developments and to determine the type of project delivery route best suited to achieving client expectations.

This is a longitudinal study spanning 40 years and is a reflection of four major hospital case studies in which I had significant roles and a current case study in which I also participated but in a different role, giving me the opportunity to observe what had happened and what was happening. Samuel (2018) highlights the difficulties in perception about research into architectural practice and quotes Schweber (2015) as requiring "architectural research to be more reflective, more critical and ultimately more useful", to create what Duffy (2008) calls "a powerful and concentrated intellectual searchlight which can be used to illuminate masses of empirically driven data which otherwise would remain obscure, entangled, scattered and meaningless". As reflective research this thesis has therefore developed a methodology which can deliver a contribution to knowledge in the field of integrated design management spanning architectural design and construction management in both project delivery and the wider delivery system.

This auto-ethnographic thesis used qualitative methods relating to substantive theory, involving post-positivism in the form of critical realism. The proposal was to use an auto-ethnographical method in relation to retrospective case studies, and potentially action research, in the form workshops, observation and interviews to gather data for grounded theory analysis. Pettigrew (2000) proposed the combination of grounded theory and ethnography which had the potential to offer a detailed understanding of consumption as experienced by consumers when relating to client satisfaction. I have described this thesis as a progressive longitudinal study; it is longitudinal in the sense of taking place over a long period of time and it did involve revisiting some of the earlier case studies; unlike a true longitudinal study where the same case studies are reviewed using the same criteria at given periods. It is progressive as it followed the procurement routes of five major hospitals of similar complexity through my experiences as a design integrator. A retrospective abductive reasoning approach was taken. The case studies were used to demonstrate the different levels of integrated design and design management. Figure 11 below sets out the research structure.

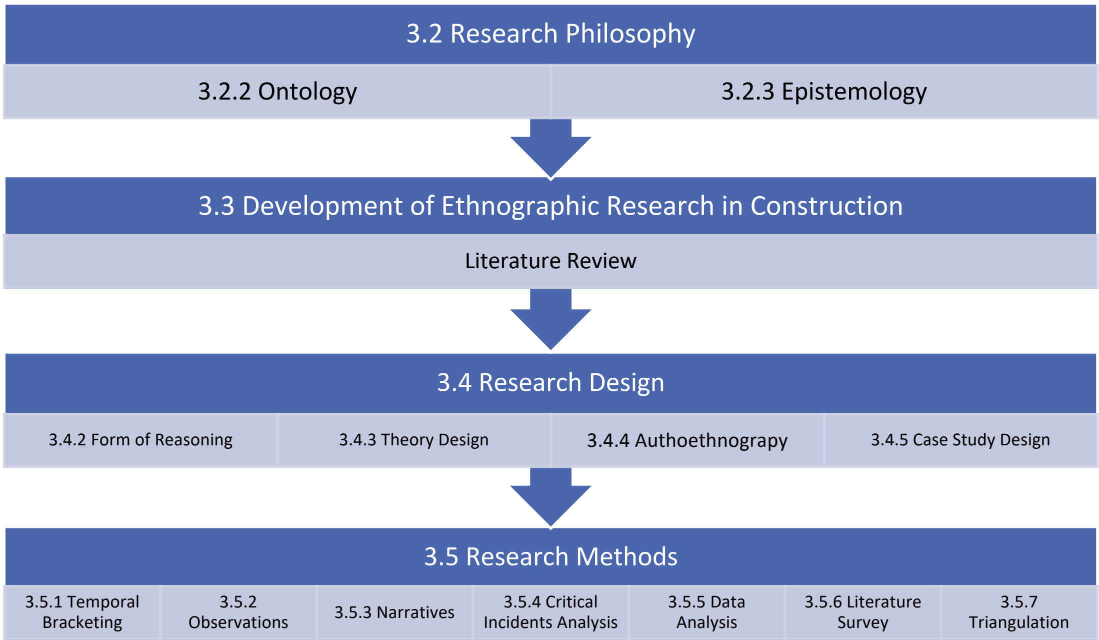


Figure 11 Research Structure

Howell (2013) gives some very clear definitions of methodology being “defined as the research strategy that outlines the way one goes about undertaking a research project, whereas methods identify means or modes of data collection”. Ontology is defined as the nature of knowledge with ontological perspectives being conceptualisations of truth or reality, with epistemology the relationship between the observer and the observed and between humanity and knowledge.

3.2 Research Philosophy

3.2.1 Introduction

According to Kuhn (1962) research is inherently subjective and needs to be carried out within a conceptual framework as quoted by Suppe (1974). Burgess-Limerick et al (1994) state that a researcher’s own world view will determine what questions are “legitimate, how answers may be obtained, what are counted as facts and what significance is attached to these facts”. This is important in relation to this thesis due to use of auto-ethnography which could be viewed as biased or subjective. Table Theory incorporates a “set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena” (Strauss and Corbin, 1998).

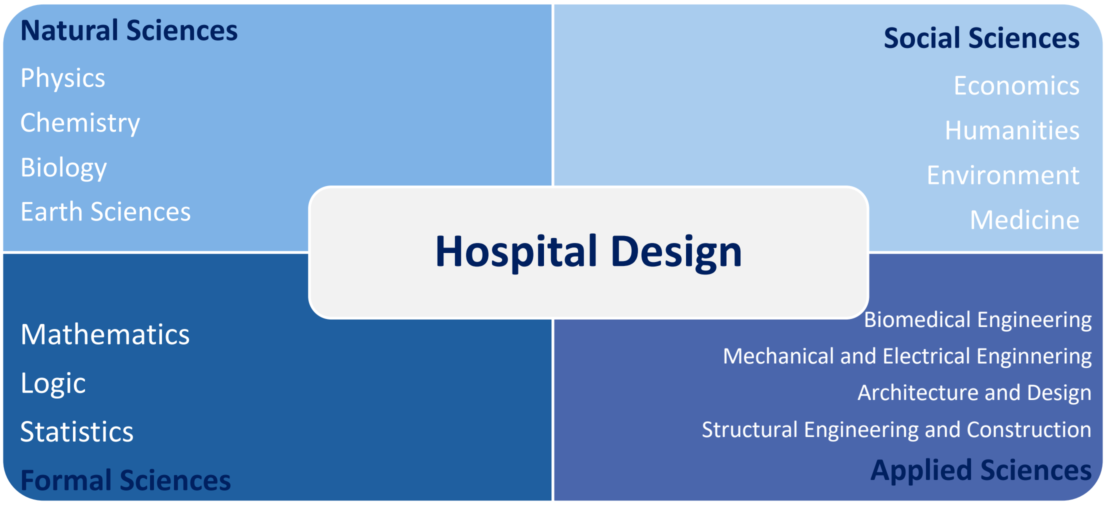


Figure 12 Relationship of Hospital Design to Theory

Figure 12 demonstrates how hospital design relates to the difference branches of philosophy and how it draws from all four branches. The bias is towards the social and applied sciences as it involves people (patients and staff) and their environment, evidenced based-design medicine and economics. It also involves architectural and engineering design and construction and with advances in medical technology and biomedical engineering the integration of medical infrastructure into building infrastructure. It also embodies aspects of the natural sciences in terms of building materials and need to understand infection control and in the formal sciences the use of statistics to predict facility requirements and capacity planning. The understanding of this straddling of the sciences helps to explain the complexity involved in delivering hospital projects and why different theories are involved bringing with them both quantitative and qualitative methods of analysis. Traditional construction research is associated with quantitative methods, positivism and the natural sciences but the use of ethnography in construction has the ability to research more diverse areas related to the social sciences.

This describes the relationship between integrated design and healthcare which is also confirmed by Duffy (2008) who explains that no one discipline can possibly comprehend the totality of the built environment and notes the lack of research by practitioners. The framework for designing hospitals was for many years the responsibility of NHS Estates who developed standards and guidance through research and development. This approach has been diluted over the years and has not been carried out for over five years. By contrast, the medical profession maintains the tradition of linking practice, research and teaching. In architecture and the other construction professions, research and teaching are mostly carried out by research institutes such as the British Research Establishment (BRE) or the universities. Currently there is a lost opportunity to feedback vital user experiences into design and construction.

Methodologies providing the means for interpretive theories include grounded theory, ethnography, hermeneutical and action research. Interpretative theories are based on ontological positions that are relativist and subjective. In this case auto-ethnography is the primary methodology being adopted with elements of grounded theory.

Table 4 Types of Theory/Source: Howell (2013)

Personal theorising	Reflection regarding individual experience in relation to wider notions and rationales
Substantive theory	Derived from data analysis, rich conceptualisations of specific situations
Models	Simplified perspectives of phenomenon
Meso theory	Middle-range theories that draw on substantiated substantive theories and models
Grand theory and philosophical positions	Sweeping abstract explanations of phenomenon and existence

This thesis looks towards a substantive theory as in Table 4, with personal theorising reflecting from involvement in retrospective case study analysis.

Table 5 sets out paradigms of inquiry, which are explored further in the following sections;

Table 5 Paradigms of Inquiry Source: adapted from Lincoln and Guba (2000) and Heron and Reason (1997)

Item	**Positivism**	**Post-positivism**	**Critical theory**	**Constructivist and participatory**
Ontology – the form of reality	**Naïve realism** Reality exists and it can be discovered	**Critical realism** Reality exists but humans unable to totally understand it	**Historical realism** Shaped by history Clear distinction between ontology and epistemology	**Relative realism** Based on experience Clear distinction between ontology and epistemology
Epistemology – the relationship between the investigator and what can be discovered	Investigator and investigation totally separate **Truth** is a possibility	Abandonment of total separation. **Objectivity** still pursued.	Investigator and investigation are linked. Influenced by historical values Results **subjective**	As critical theory, however findings are created as the investigation proceeds
Methodology- how does the investigator go about finding out what they believe can be discovered	Scientific experiments based on hypothesis – usually **quantitative**	Pursues falsification of hypothesis; may include **qualitative** methods	Needs dialogue between the investigator and subject. Structures may be changeable	Consensus Participatory – primarily **action research**

3.2.2 Ontology – Rationale for the Selection of a Critical Realism Position

Ontology is or should be the starting point of research - that is, what is out there to know about, followed by one's epistemological - that is, what and how can we know about it and methodological - that is, how can we get to know about it? Grix (2002) "if we as researchers, are unclear about the ontological and epistemological basis of a piece of work, we may end of criticising a colleague for not taking into account a factor which his/her ontological position does not allow for."

3.2.2.1 Interaction of Ontological Entities

Ontology appears in different forms depending upon the paradigms of inquiry relating to positivism and phenomenology. Positivism is expressed as: naïve realism and critical realism; and historical and relative realism as phenomenology. In naïve realism the belief is that things are objective, what they see is reality and is common sense. In critical realism, reality is acknowledged to exist but not fully understood by humans. This was developed in the 1970s by Bhaskar (1975) and includes theory on cause and effect. Historical realism is concerned with the recording of events which took place in the past and is subjective. It is open to interpretation and the accuracy of its recording. In contrast relative realism is based on experience and takes the theoretical stance that denies the possibility of objective truth.

Relativism and rationalism in ontology are divergent ontological perspectives; the first denies the possibility of objective truth. According to Baghramian (2004) relativist arguments vary from perceptual (everyone experiences the world differently), to moral (my good might be your evil), aesthetic (beauty is in the eye of beholder – something which is very relevant in architecture where different stakeholders have different perceptions), cognitive (it is true for you but not true for me) and cultural (when in Rome, do as the Romans do). Rationalism sees pre-existing hard, tangible structures independent of an individual's cognition. As a result, logic will always prevail through rules and procedures that form guiding principles to which people adhere, something which can be demonstrated through the temporal periods of this thesis.

3.2.2.2 Ontological Perspective Taken in this Thesis

This thesis is located in the middle ground between relative realism and rationalism – this is a critical realism ontological position. There is an element of historical realism as the result of it being a longitudinal study over a period of 40 years. Critical realism defines the generative nature of mechanisms and ongoing improvement in both social and physical worlds which sits well in relation to social sciences where the integration of different systems blends architectural design with human activity through stakeholder engagement highlighting the need for human beings to be able to communicate, express their requirements, understand what is being offered and to make decisions. Edwards et al (2014a) explains how ethnographic enquiry can be strengthened through recourse to the ontological assumptions of critical realism. “The retrospective abductive research strategy and design contrasts with the deductive form of positivism and the inductive form typical of constructionism and postmodernism with the objective being to explain – rather than predict, describe, or deconstruct – social behaviour. Applied to the study of work organisations, for example the key is to uncover why it is that certain persistent relations or features of the organisations have certain effects or observable outcomes in some settings and not others and what the factors are- for example, management strategy, employee resistance, sector, nation – that may explain this”. Edwards et al (2014a) also state: “It highlights the value of comparative case studies, which can uncover the varying and complex ways in which combination of structural, historical, and operational contingencies interact”. This thesis consists of comparable case studies of a historical nature, within large temporary organisations all working for a major government department whose participants also demonstrate different social behaviours, reinforcing critical realism as the form of ontology.

Ontological assumptions in the field of project management are concerned with what Gauthier and Ika (2012) believe constitutes project reality and seek to explicitly address the ontological question in the expanding domain of project management suggesting a specific project ontological analysis without which they doubt the epistemological and methodological project management endeavour will succeed. Gauthier and Ika (2012), consider that although Smyth and Morris (2007) address the epistemology and methodological underpinnings of project (management) research less effort has been made to question project ontologies.

Table 6 shows a six-facet ontological framework in project management. The ontological approach taken in this study is a becoming /virtualist ontology as described by Blomquist & Lundin (2010), which aligns with the retrospective abductive auto-ethnographic research design.

Table 6 Ontological Framework

	Realist Ontology	**Nominalist Ontology**	**Virtualist**
Being	Project reality as a concrete and universal structure:	Project reality as seemingly stable and universal convention that is the fruit of regulation and	Project reality as a seemingly stable and universal construction of human spirit that is the fruit

	Project="out there' structures (Pinto & Slevin, 1988)	institutionalisation by powerful Stakeholders: Project= conventions about structure (Larson & Gobeli, 1985)	of reproduction and institutionalisation: Project= invented structures (Lindgren & Packendorff, 2006)
Becoming	Project as a concrete process: Project= project management processes Pinto & Slevin, 1988)	Project reality as a changing convention, due to conflict between powerful stakeholders: Project= conventions about project management processes (Nysten-Haarala, Lee & Lehto, 2010	Project reality as an ever-changing construction of human spirit due to the constant negotiation with oneself and others: Project= invented project management processes (Blomquist & Lundin,2010)

According to Abbasi and Jaafari (2018) project management, after many years, has become recognised as a true scientific discipline and is arguably governed by the CIOB Code of Practice (2014), BS 8534:2011 and the PMBOK Guide 2017. Design management however has no formal governance and is trying to establish itself as a separate discipline. Even at the point where project management has become established; dissatisfaction, cost overruns and delays appear to be the rule rather than the exception. Defining design management theory is more difficult than project management as the players have different roles and responsibilities depending upon what type of organisation they work for, equally design management can be viewed as being project management as integrated design management does not start or end when constructors get involved. Rather, it is a continuous process integral to project success and, as such, a similar ontological approach to that of project management is justified.

Design management involves the interaction of people over a period of time providing a service in the creation of a built product. The key elements are the people involved, stakeholders - decision makers, the implementors and the building users. The processes - briefing, design and construction and the transformation of components into buildings. They interact in different ways throughout the process, displaying different skills and capabilities. Understanding how this happens is important in order to ensure that completed buildings deliver clients' requirements. A balance needs to be achieved between a process which is highly prescriptive to the extent that it loses the ability to deliver differences in requirements and one which is deregulated and is open to interpretation.

3.2.3 Epistemology – Rationale for the Selection of a Constructivist Perspective

3.2.3.1 Epistemological Positivism and Interpretivism

Epistemology is concerned with the study of nature of knowledge, asking questions such as "How do we know what we know?" and "what is known?". Epistemology looks at the relationship between the investigator and the investigated and where there is not total separation the results are likely to be objective. Where the investigator and the investigated are linked subjectivity occurs and this also occurs in constructivist and participatory paradigms where findings are created as the investigation proceeds (Lincoln and Guba, 2000; Heron and Reason, 1997).

Positivism and objectivism are based on the idea knowledge is dictated and gained through logic. Positivism in social research should aim to be as scientific as possible, whereas interpretivism and subjectivism do not hold the position of universal truths and instead research findings emerge from the interaction between researcher and the research situation, Figure 13:

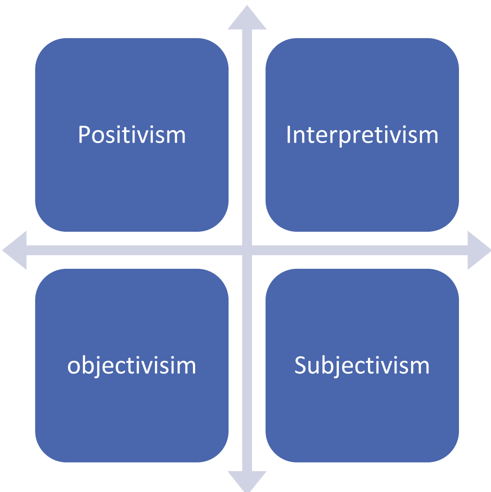


Figure 13 Epistemological Relationships

Smyth and Morris (2007) address methodological issues that have yet to be fully resolved in research in projects and their management and evaluates how these issues have a direct and indirect impact upon research and practice. They conclude "if the epistemological base of our research is weak, then it must be the case that progress in developing the knowledge base for research and practice in the field is also weak". It looks at applying positivism and empiricism, being closely aligned, with positivism being dominant historically in research on projects and underpinning the PMBOK Guide (2017). Contrastingly critical realism's "strength is its ability to engage with causality and complexity in context". It does however align with the working environments of projects as it recognises the value-laden nature of all science and the interpretative nature of scientific endeavour (Bashkar, 1978); incorporates a normative viewpoint (Packendorff, 1995); and for optimising and addressing critical factors (Soderlund, 2002). Smyth and Morris (2007) identify the following related to contextual conditions:

- General events that are not always replicated
- General events with particular features according to context
- Particular events that are not replicated

3.2.3.2 Epistemological Constructivism Perspective Taken in this Thesis

This thesis looks at five major hospital projects of similar size and complexity, but unlike the nucleus hospitals the designs, construction and methods of procurement differ making empirical comparisons difficult. It does however relate to the three contextual conditions identified by Smyth and Morris (2007). Their review of methodology used in 68 IJPM articles identified only positivist and empiricist paradigms concluding “It is relatively easy to apply positivist and empiricist methods mechanically once learned”. This may explain why these methods are prevalent in construction project management research (and to some extent design management) where processes and frameworks tend to be controlled in order to measure performance and may not adapt to individual situations. Critical realism can however encourage critical evaluation and reflection which can be utilised in case study analysis related to ‘lessons learnt’. In this case phenomenology consisting of a combination of critical realist and constructivist theories exists as the researcher (the investigator) and the investigation are linked.

Constructivism, according to Charmaz (2014) is “a social scientific perspective addressing how realties are made. This perspective brings subjectivity into view and assumes that people, including researchers, construct the realities in which they participate. Constructive inquiry starts with the experience and asks how members construct it. To the best of their ability, constructivists enter the phenomenon, gain multiple views of it, and locate it in its web of connections and constraints. Constructivists acknowledge that their interpretation of the studied phenomenon is itself a construction.”

The use of auto-ethnographic retrospective case studies attempted to achieve objectivity, which although by nature was subjective, to describe what took place over a series of linked case studies, linked both by my involvement and the changes in procurement methods for similar project profiles. This combined with the findings from supplementary information, literature and grey literature which developed as the research proceeded resulted in this, thesis adopting a constructivist epistemology.

3.3 Development of Ethnographic Research in Construction

Autoethnography is related to ethnography meaning the study of people; ethnos is a Greek term for people and graphic involves making something clear and /or the study of certain phenomenon (Howell, 2013 p.120) and as such there is similarly in approach. Ethnography is a systematic study of peoples and culture normally associated with anthropology. Certain analysts, including Silverman (1985) argue even though an emphasis on empirical observation exists, ethnographers always use some form of theoretical framework to ensure some form of distance between the researcher and the researched. Ethnographic research methods are not widely used in construction research (mainly associated with cultural behaviour). There is a link to nursing where ethnography is widely used and the different healthcare requirements in the cases studies reflecting culture in terms of endemic diseases which occur in different areas and regional differences relating to urban and rural requirements.

Pink et al (2010) take an ethnographic approach to looking at the behaviour of construction workers on site and conclude that ethnographic methods are compatible with both the nature of the material and social contexts of the construction site and Howell (2013) describes three types of ethnography:

- Positivist; which incorporates positivist, ontological and epistemological perspectives:
- Critical; drawing on critical theory, engaging with analysis and including ethical considerations; and,
- Constructivist: which requires a foundation-less detachment in terms of phenomenological stream of becoming and the world continually shifting in relation to this becoming.

Ethnographic research within the construction industry has developed considerably within the last 10 years as demonstrated by Oswald and Dainty (2020) in their review of 57 studies which adopted varying ethnographic approaches such as autoethnography, quasi-ethnography, ethnographic-action research, retrospective ethnography, and ethnographic interviewing. Traditional construction research is associated with quantitative methods, positivism and the natural sciences but the use of ethnography in construction has the ability to research more diverse areas related to the social sciences. The tendency is to look at the behavioural characteristics of construction site manual workers, Lowstedt (2015), Pink et al (2012) and Dingsdag et al (2008) whereas the emphasis here is on the behavioural characteristics of the management and professional teams. Tutt and Pink (2019) summarise issues relating to construction management research and the importance of adopting ethnographic methodologies.

Areas which examine the impact of the introduction of information management systems, Hartmann et al (2009), communication issues with foreign workers, Tutt et al (2013), evidence of bullying and gender biased career prospects, Dainty et al, (2000), and issues with the industry's claim culture, Rooke et al (2004). Auto-ethnography was used by Grosse (2018) to describe his relationship as construction building company owner with the architect on a particular project and Kanjanabootra and Corbitt (2016) study which uses reflexive theory to look at how construction knowledge and expertise is reproduced. Self-reflexivity accordingly to Oswald and Dainty (2020) becomes more important as the researchers adopt roles which involve more than observation having the potential to influence the natural setting. Demain and Fruchter (2006) studied knowledge transfer relating to design within a construction concluding that construction managers do not appear to consider it to be a pertinent issue and focus more on generating paperwork transferring items to other members of the team. Shipton et al (2014) which is an example related to a hospital project highlights an important aspect of the use and understanding of language. The researcher who had a background in healthcare construction was familiar with the basic culture of the industry and able to observe, participate and record discussions being familiar with the specific construction and healthcare terminology used on a daily basis. In this case the ethnographer did not need to learn a new language. Acronyms are used extensively in both construction and healthcare which is why there is a long list at the beginning of this thesis. Shipton et al (2014) focuses on change management and its relationship with design and commercial management in connection with contract requirements. The form of NEC contract is described in what appears to be a Procure 21/22 setting. Long term observational studies are defined as being greater than six months It is an approach which had its roots in the social sciences aspects of construction looking at the behaviour of construction workers and problems related to stress, issues of alcohol and drug abuse and suicide. Hampton et al (2019) findings showed the pivotal importance of interpersonal relationships in coping with uncertainty of working conditions, the coordination of teamwork and managing responsibilities and power interactions. The researcher involved was a psychologist who had to obtain a CSCS (2018) card in order to be allowed onto the construction sites as part of the strict health and safety measures required. The issue of health and safety was itself highlighted through ethnographic studies which has led to construction sites being much safer workplaces. The observations, unstructured and semi-structured interviews and colloquial dialogues and discussions involved four managerial staff and 12 site operatives. Issues relating to the ability to get on with each applied to both the site management teams and the subcontract workers teams. The paper highlights two other aspects still associated with the construction industry one where career progression used to start from the bottom – working in building trades. This is still prevalent in the small to medium construction companies but in the larger construction companies, site management and leadership are now undertaken by university graduates which sometimes changes the team dynamics. The other issue is that of working long hours and the requirement for working away from home on major projects.

3.4 Research Design

3.4.1 Rationale for Taking a Retrospective Abductive Auto-ethnographic Approach

Ethnography and in particular auto-ethnography has not been extensively used in construction research until recently. It did however appear to be the logical choice for this thesis as it primarily focuses on my experiences and observations. It is in the field of design management and although it does not appear to have been used in this area of research is part of the greater field of construction project management.

Construction management according to Chan and Raisanen (2009) involves people drawing upon social science which involves understanding interactions between people as individuals and as groups. The study of architecture in many UK universities is associated with social science faculties causing a separation from many of the construction disciplines and this study aims to demonstrate the role and integration of design management through the architectural design and construction phases.

This study is a predominately retrospective autoethnographic research of four major hospital projects in a longitudinal study over a series of temporal periods. The fifth study combines the more traditional concept of ethnographic research as it involves participation for a period of eight months with a quantitative study of HBN standards. It uses ethnographic case study methods outlined by Ball and Ormerod (2000) including the analysis of critical incidents, which have been determined by creating a series of narratives or ramblings for each of the retrospective projects with reference to artefacts such as meeting notes, minutes, drawings and schedules. Each case study represents a temporal period, is of a similar size and complexity and reflects my role as either a project architect or design manager.

3.4.2 Form of Reasoning (Deductive, Inductive and Abductive Research Design)

There is much debate amongst authors on the selection of reasoning to take in research design. For Eisenhardt and Graebner (2007) in case study research, the cases are the basis to which the theory can be developed inductively but then state: "the popularity and relevance of theory building from case studies is one of the best of the bridges from rich qualitative to mainstream deductive research".

Gioia et al (2012) describe the "Gioia Methodology" as a method for achieving rigour in qualitative inductive research. In relation to sensemaking they make a valuable point relating to assumption and terminology in the example they give, what they describe as "threats and opportunities" is seen by the interviewees as "strategic and political". It is an "assumption of *their* sensemaking by imposing *our* preordained understandings on their experiences". This is an important issue when dealing with user stakeholders in the early briefing and design phases of a major hospital project. Gioia et al (2012) emphasise the need for carrying out a thorough methodology process and also employ research methods such as multiple data sources (archives, field observation, media documentation etc.) but for them the semi-structured interview is at the heart of research. They also consider that as with Langley (1999) that the inductive approach moves towards abduction "as knowing the literature intimately too early puts blinders and leads to prior hypothesis basis". The Gioia induction approach makes a point of not knowing the literature in great detail before commencing data gathering.

Deductive reasoning according to Southern and Devlin (2010) is "top down logic" and is the opposite of inductive reasoning – "bottom up logic". Southern and Devlin (2010) also state: "Grounded theory provides an accessible method for bridging the gap' between inductive and deductive forms of both qualitative and quantitative reasoning and knowledge development". In the diagram below the interaction in the abductive reasoning, the theoretical stages 1,3 and 4 are indicated in green and the empirical stages 2 and 5 in blue as in Figure 14 below:

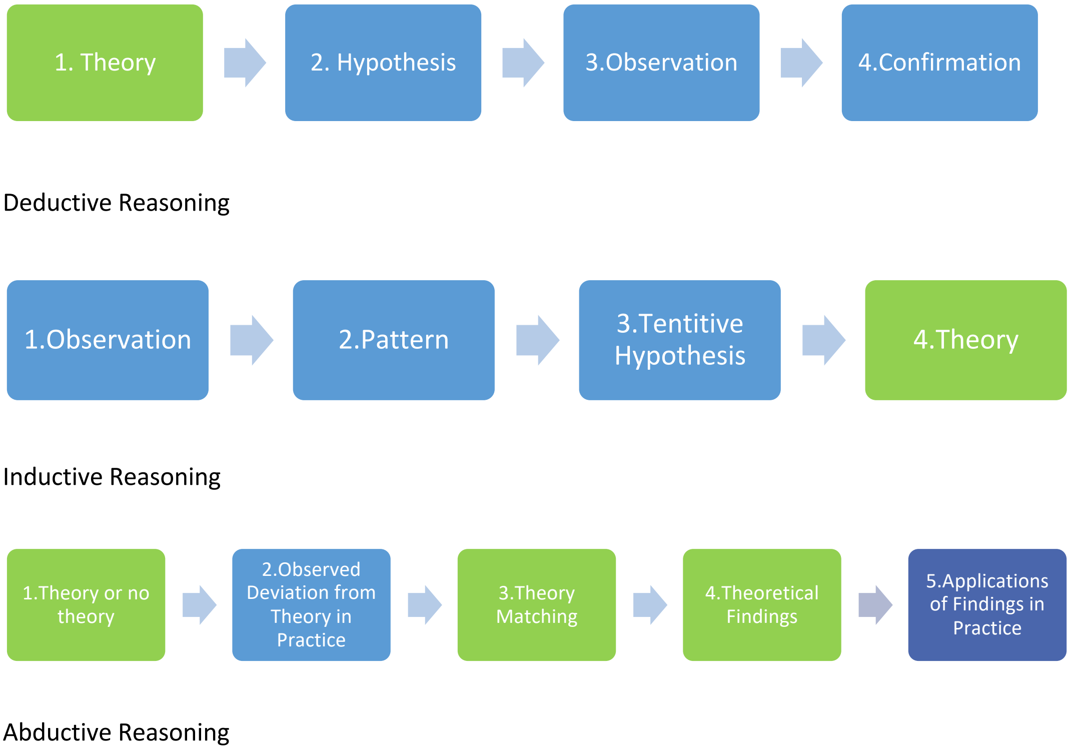


Figure 14 Theoretical Approach

Although the abductive approach is described in relation to grounded theory Charmaz (2014) acknowledges the use of grounded theory methods in ethnography and the creation of rich data through observation. This started with a 'rough' theory about what was causing clients and users to be dissatisfied with new facilities, particularly in association with functionality. The focus is on functionality as this is the issue which affects the daily lives of both medical and non-medical staff. The time taken to complete new facilities does not affect them once they have moved in. In terms of cost, there are two elements: capital cost and running costs and again capital cost is historic, the only factor affecting them is running costs associated with functionality. There is no point installing the latest technology if you cannot afford to run it.

The abductive approach allows the theoretical knowledge and the empirical practice to continually review and refine the study by introducing different theories to be introduced. In this case the initial design management theory has evolved through requirements management and stakeholder theory into systems integration as an integrated design management theory which can encompass all of them.

Gehman et al (2018) compares three different qualitative approaches to theory building at a symposium where three prominent scholars: Denny Gioia, Kathy Eisenhardt and Ann Langley discussed their different approaches; Gioia (induction), Eisenhardt (deduction) and Langley (abduction) and concludes there are similarities with them and the researcher needs to customise the method to suit the research content.

3.4.3 Theory Design (General versus Middle Range)

3.4.3.1 Theory Development in Construction

Theory building in relation to the construction industry is not easy as it is diverse; large scale to small scale, complex to simple and the term infrastructure interpreted in different ways influencing how we think about and apply new theories with the result that relationship between theory and practice is incompatible. The hypothesis that in traditional construction, architectural led projects resulted in escalated costs and time overruns, may have been justified in some sectors but was not the case in all hospital building projects which had a strong framework with cost control as demonstrated in Case Study 1. In despite of this, the hospital building programme was included in the new 'Private Finance Initiative' using contractor led design and build. Instead of a general theory, Green and Schweber (2008) discuss the importance of middle-range theory, which "provides a form of theorising that lies between abstract grand theorising and a theoretical local description" and draws upon Schon's (1983) idea of continuously reflective practice to combat complacency and routinising and the need to "... explicitly embrace the complex and dynamic relationship between theory, empirical research and professional practice". It is this reflective approach that is used in this thesis. Stakeholder perspectives- often based on fear and uncertainty – how and what do we want to build are also key (Rabeneck, 2008).

Sutton and Staw (1995) considered there was more agreement on what theory is not and describe a number of misconceived ideas of what theory is including:

- Reference lists with no understanding of the casual relationships that underpin them;
- Empirical data, unless they describe why patterns were observed;
- Lists of variables or constructs, without explanation of construct connections or why they come to be connected;
- Diagrams that do not have underlying relationships clearly justified to combine visual and verbal connections, and,
- Hypotheses which should not be biased towards a particular outcome, only a statement of what causal relationship is expected.

According to Sutton and Staw (1995) "… theory is the answer to queries of why" and "connections among phenomena". It also emphasises the nature of casual relationships, identifying what comes first as well as the timing of such events …". "A good theory explains, predicts and delights". Weick (1995) for whom the act of theorising "… consists of activities of abstracting, generalising, relating, selecting, explaining, synthesising and idealising". It involves critical thinking about the content or problem, and the structuring and restructuring of a problem or solution with a new understanding.

3.4.3.2 Middle-Range Theories

Middle-range theory was developed by Merton (1968) in the field of sociology, aimed at integrating theory and empirical research. Middle-range theorising is a multi-disciplinary and multi-role research approach that begins from a specific local-level problem on the ground and tries to understand the underlying grounding dynamic. According to Green and Schweber (2008) its success is dependent upon the researcher's ability to "… draw on a range of different grand theories …" and to look for a range of "… mechanisms or small discrete processes that might account for what can be observed' such as "linguistic, psychological and organisational mechanisms" to communicate and agree.

In Figure 15 below, adapted from Southern and Devlin (2010), abductive reasoning is demonstrated where the middle-range theories are the "glue" that creates a binding relationship between theory and practice.

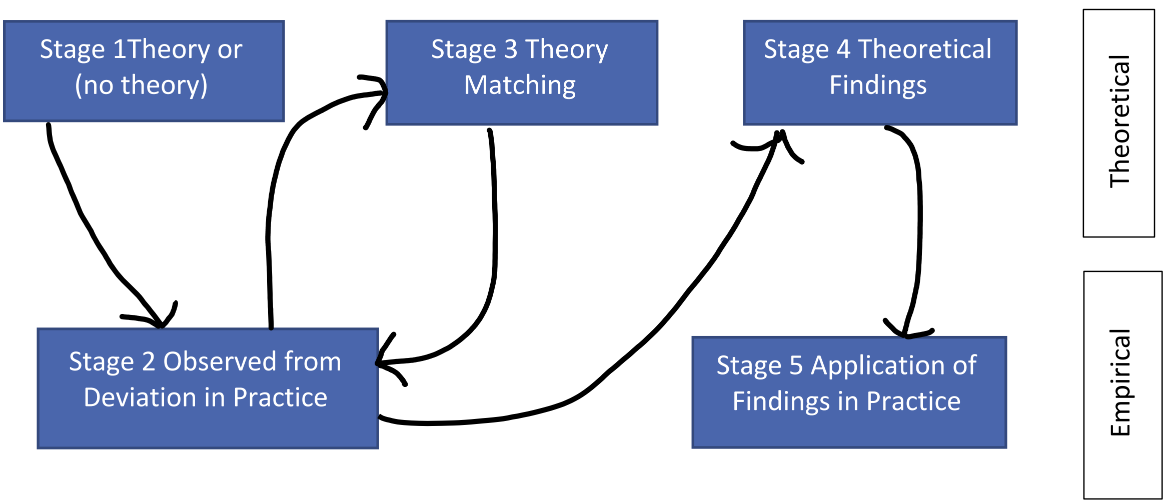


Figure 15 Middle Range Theory (adapted from Southern and Devlin, 2010)

3.4.3.3 Thesis Theory Development Position

This thesis investigates design management at project level in relation to the delivery methods and client outcomes over five temporal bracketing periods; and investigates the parallel design activities in the wider delivery system relating to NHS guidance, standards and procurement systems which govern project delivery. The research design is retrospective abductive autoethnographic using grounded theory research methods in four of the five periods. The fifth period is also autoethnographic, but this time period also involves action research.

A middle-range theory of integrated design management is more achievable than the development of a new general theory in construction, as the ontological and epistemological context of design management theory is so dependent on context, the sector (healthcare) and stakeholders.

3.4.4 Autoethnography Research Design

Autoethnography is a research method that uses personal experience to describe and interpret cultural texts, experiences, beliefs and practices (Adams et al, 2017). Autoethnography developed in the latter part of the twentieth century with the work of Hayano (1979) where he describes autoethnography as "anthropologists as people studying themselves". He also describes a major type of autoethnography as "work that is written by researchers who have acquired an intimate familiarity with certain subcultural, recreational or occupational groups". Anderson (2006) in response to Hayano (1979) addresses some of the paradigmatic problems associated with group relationships, role of the researcher and their level of subject matter knowledge and issues of subjectivity by setting out five key features in what he describes as "Analytical Autoethnography".

1. Complete member researcher
2. Analytical reflexivity
3. Narrative visibility of the researcher's self
4. Dialogue with informants beyond the self
5. Commitment to theoretical analysis

Giorgio (2013) looks at memory, the re-living and re-imaging what happened, in a form of storytelling using a short story method, something which I have adopted in the "ramblings". She defines autoethnography as, question "How do you begin to write autoethnography?", to which she replies, "By closing your eyes and remembering". Jarzabkowski et al (2014) examine various techniques for presenting ethnographic evidence, with particular reference to vignettes, built up through rich storytelling.

Doloriet and Sambrook (2012), writing in a higher education organisation of the increasing popularity of autoethnography refer to different streams of organisational autoethnography, one of them being within “previous/other life” organisations where the data is formed from recollection which they suggest could be less rigorous, although this defended by Bochner (2000). Hamilton et al (2008), also writing in an education setting, looks at the differences between narrative, self-study and autoethnography, with autoethnography looking at “self within a larger context”. In my case this would be how I was able to influence systems integration within each case study. Hamilton et al (2008) consider Ellis and Bochner as being important researchers in this field and how they developed Hayano (1979) description of autoethnography to refer to stories that feature self or include the researcher as a character. Hamilton et al (2008) also state that in addition to the various research strategies such note taking, memory work, narrative writing, observation and interview, a study cannot be called autoethnography without an easily identifiable cultural content. In this thesis the setting is the architectural design and construction of major hospitals. Chang (2013) suggests three characteristics of autoethnography:

- Uses the researcher’s personal experiences as primary data;
- Intends to expand the understanding of social phenomena; and,
- Processes can vary and result in different writing products.

3.4.4.1 Data Collection and Critical Events in Autoethnography

Chang (2013) also states that “Autoethnographic data can be gathered in a variety of ways: recalling, collecting artefacts and documents, interviewing others, analysing self, observing self and reflecting on issues pertaining to the research topic. Recalling is a free-spirited way of bringing out memories about critical events, people, place, behaviours, talks, thoughts, perspectives, opinions and emotions pertaining to the research topic”. Observation is a key method of gathering data in both autoethnography and ethnography, along with the less formal interviewing techniques, talking to people in their working environment as they go about their tasks can provide an important insight into how things work, what might appear as a trivial item to them can be an indication of something much more important. Another technique is auto interviewing, Grosse (2016) describes his method of auto-interviewing in ‘An insider’s point of view – auto-ethnography in the construction industry’. This is a single case study relating to a critical incident and he uses field notes, initially voice recording whilst driving after the event and then later in the evening sitting down and writing longer descriptions of his experiences and subsequently reflecting on them. This study involves the relationship between architect and contractor. Gross (2018) also concludes "there is an almost total lack of autoethnography in construction management, compared to its prominence in other fields."

3.4.4.2 Critical Incidents Technique and Auto-Interviewing

Boufoy-Bastic (2004) introduces the critical incident technique as well as auto-interviewing as methodological techniques into introspective qualitative methodology. She uses the term critical cultural incident as "a vignette illustrating my educational principles" as part of critical incident methodology and also draws attention to the difficulties with interpretive analytical techniques providing an etic rationalisation for emic experiences. Emic reporting is subjective and as she was the only source of data and its interpretation triangulation was unreliable. Peterson (2015), in proposing the use of autoethnography in the nursing field, discusses autoethnography based on the assumption that reality is multi-faceted, and the role of culture and context is crucial in understanding human experiences. The reader is engaged through the evocation of emotion and stimulation of reflection. Both these fields are related to social sciences and as stated earlier although construction is deemed to be an 'engineering' subject, the behaviours within the industry and the integration of design and stakeholder involvement strongly relate it to social sciences. Lowstedt (2015) describes his study of carrying out his research on a construction site as "self-reflexive" ethnography a term also referred to by Ellis & Bochner (2006).

3.4.4.3 Thesis Approach to Autoethnography and its relationships with Grounded Theory and Action Research

Grounded theory builds theory through data collection and analysis in relation to pre-existing theory and practice. It allows the direction of the research and analysis of the data to be guided by the researcher. It is used in many different subject areas including business, nursing and social sciences.

Pettigrew (2000) considers a marriage of ethnography and grounded theory have the potential to offer a detailed understanding as experienced by consumers. Both involve qualitative methods. Similarly, Phelps and Horman (2010) examines a Children's hospital using ethnographic data collection methods including artifacts, critical incidents and general observation and grounded theory coding and interviewing for analysing the data.

Ethnographic research is emic in design in that it attempts to describe occurrences as they are experienced by the subject (Arnould and Wallendorf, 1994). Pettigrew (1999) conducted a study looking at beer consumption in Australia using ethnographic methods of interviews, observations and participant observations. The data obtained was analysed using the principles of the grounded theory method with the outcome that it not only provided a description of the way beer was consumed but it made a contribution to consumer behaviour theory.

This study can also be aligned with consumer theory as it seeks to determine what creates a successful project in the eyes of the owners and users of the building. Construction, in ethnographic terms, can also be seen as having a culture. Grounded theory relates specifically to the analysis phase of research (Glaser, 1992) although it can refer to data collection and therefore in this case the marriage of ethnography and grounded theory relates to ethnographic data collection from the case studies and the adoption of grounded theory for analysis. The sensemaking process is for Orton (1997) critical to organisational research and positions iterative grounded theory between inductive and deductive methodologies. This thesis looks at sensemaking in terms of understanding and communicating between parties and adopts abduction being the intertwining of inductive and deductive methods.

According to Herr and Anderson (2014) autoethnography is a form of action research in which the researcher explores a field and describes its insights. The definition of Action Research is "a participatory, democratic process concerned with developing practical knowledge in the pursuit of worthwhile human purposes… It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities" (Reason and Bradbury, 2001). Greenwood and Levin (2007) define action research as social research which includes a professional researcher and members of an organisation seeking to improve a situation, the final temporal phase gave me the opportunity to use elements of action research. Kemmis and Taggart (1988) developed an iterative model of the Action Research Process, in which in each cycle has four steps: Plan, Act, Observe and Reflect. Although not strictly action research as it was retrospective, this cycle was inherent in the first four case studies as:

- Involvement in Project Planning
- Taking part and observing what took place
- Reflecting on what happened in terms of the project outcomes

This fifth temporal phase involves how to rescue a failing project and trying to incorporate lessons learnt.

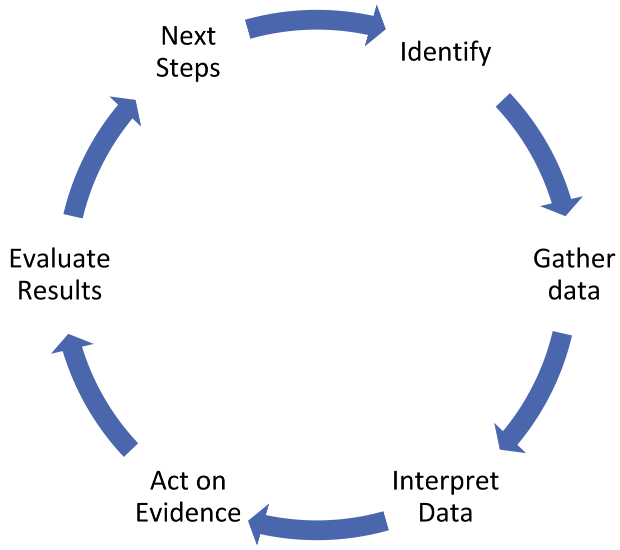


Figure 16 Ferrance's Model for Action Research

Ferrance (2000) developed a six-stage action research model – Figure 16 for use in education which could be adapted for construction. As part of the 'rescue plan' the existing design had to be validated and a due diligence exercise carried out before construction work could recommence with a new design and build contractor. The six stages therefore reflect the stages carried out in Case Study 5 as in Table 7 where the data is interpreted differently rather than additional data collected.

Table 7 Ferrance's Model Adapted for Case Study 5

Stage	**Design**	**Construction**
Identify	Areas of design requiring validation	Compliance of construction works
Gather Data	Desk top design study	Survey existing construction works
Interpret Data	Due diligence exercise	Analyse survey results
Act on Evidence	Make proposals to the Client	Estimate time and cost to rectify
Evaluate Results	Agreement on how to proceed	Agree time and cost
Next Steps	Proceed with validated design	Recommence construction

Another area where action research is widely used is in nursing and Hockley et al (2013) considers action research in a palliative care setting in relation to critical theory in social sciences and looking at reflection as part of action research and critical theory as a reflexive methodology. Alvesson and Skoldberg (2000) interpret critical reflection as uncovering the "unconscious processes, ideologies, power relations and other expressions of dominance that entail the privileging of certain interests over others". This interpretation of critical reflection can easily be applied to construction and the behavioural attitudes of the major players depending upon the different methods of project delivery.

3.4.5 Case Study Design

According to Yin (2014) case study research has classically been considered as a "soft" form of research compared for example with experimental. It is more common in the social sciences and ethnography which is why the intention was to use it for this study. He describes the challenge of case study as "hard" as it does need to be carried out rigorously, it needs to avoid confusion with teaching cases, being able to know how to arrive at generalised conclusions if required, carefully managing the level of effort required and understanding the comparative advantage of case study research. He defines five components of research design:

1. A case study's questions;
2. Its propositions, if any;
3. Its unit(s) of analysis;
4. The logic linking the data to the propositions; and
5. The criteria for interpreting the findings.

For Yin (2014) there are three types of research;

- Exploratory - the investigation of unknown subjects to find unidentified variables
- Descriptive- directed towards specific known characteristics
- Explanatory – finds causes and effect relationships among the variables

This according to Yin (2014) contributes to knowledge of complex individual, organisational and political phenomena using multiple sources of evidence (p.47) related to data collection to construct validity.

Yin (2014) suggests you consider an adaptive design to allow additional information to be included in the final analysis. He also states that using mixed methods research forces the methods to share the same research questions, to collect complementary data and to conduct counterpart analyses. He considers using a mixed method, although more difficult, can enable broader and more complicated research questions to be investigated.

Yin (2014) outlines four basic types of case study design based on a simple matrix consisting of single and multiple cases studies with either a single unit of analysis or multiple units of analysis. Regarding the issue of single or multiple case studies, there is criticism of single case studies as they are vulnerable not only by putting all your efforts into the study of one project, but the findings may only be typical to that particular project. By carrying out multiple case studies comparisons can be made and emerging themes can be demonstrated. It is important therefore in studying multiple case studies that the reference to rigour in the research is carried out in order to achieve meaningful outcomes. The size and nature of the case studies needs to be comparable.

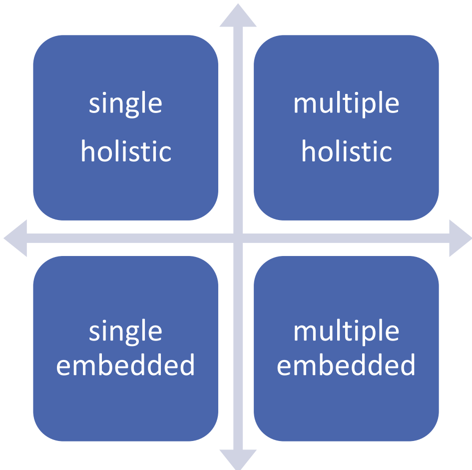


Figure 17 Yin's Case Study Matrices and Design Yin (2014)

In Yin's multiple-case study procedure he defines three stages:

- Stage 1. Define and design where firstly the theory is developed, the case studies are developed, and the design data collection is produced.
- Stage 2. Prepare, collect and analyse where each case study is carried out and the individual studies and
- Stage 3. Draw cross-case conclusions, modify theory, develop policy implications and finally write the cross-case report.

The case study design used in this thesis is a multiple-case study (embedded) Figure 18 as defined by Yin (2014) as it involves five case studies each with multiple units of analysis. It is however a longitudinal study with each case study situated within sequential temporal periods. Yin (2014) includes longitudinal as a rationale for selecting a single case study where the case study is revisited more than once over an agreed timescale. For Orum et al (1991) case studies can combine longitudinal and historical research and create multiple data sources, techniques and outcomes. In this case the examples are all similar but constructed at different times. Ensuring the same units of analysis are applied allows both a comparison of outcomes and an insight into changes taking place in design and construction of major hospitals and how they are influenced by the development of design management in the relation to the level of integration achieved. They are all acute hospitals, built over a period of 40 years, from the 1980s to 2020, of a similar size and complexity. The case studies track the development and changes from traditional procurement through three phases of the private finance initiative. The hospitals all have the departments where major medical equipment and installed with the exception of Case Study 4 where the operating theatres were in a separate building connected by a bridge link directly to the Critical Care Unit as set out in Table 8;

Table 8 Comparable Hospital Departments

Department	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5
Emergency	X	X	X	X	X
Radiology	X	X	X	X	X
Critical Care	X	X	X	X	X
Operating Theatres	X	X	X	-	X

Edwards et al (2014b) compare case studies in a multi-level study in healthcare, the same field as this thesis, stating “for the critical realist, the choice of more than one case helps to identify cross-cutting patterns or demi-regularities, while at the same time signalling possible causes and the opportunity to follow them up through deeper analysis”.

3.4.6 Theoretical Sample Design Selection

Sampling design is a key consideration before carrying out any form of research and is related to the nature of the research questions. According to Lemeshow et al (1990) and Wright (1997) two classes of samples exist:

- Probability samples, which ensure that every element in the population has a known probability of being included in the sample;
- Non-probability samples, which do not use probabilities in the selection process

. Probability sampling has three main forms: random (the purest form); systematic which is a structured selection; and, stratified where sub-sets or strata are defined that have common characteristics from which random selections are made. Non-probability sampling techniques include strategic and purposive sampling where the sample is subjectively selected by the researcher according to the objectives of the study, convenience sampling where the researcher selects the most convenient people to be part of the sample and self - selecting where respondents area asked to volunteer themselves to take part in the survey.

What is important is justifying the selection of the sampling methods used. In this case random sampling associated with quantitative research is not used. The approach taken is non-probability sampling where strategic and purposive sampling has been adopted in terms of selecting case studies which are all comparable in terms of type, size and complexity and there is also convenience sampling as all the case studies are autoethnographic.

In grounded theory there is a third approach which is theoretical sampling, which sees emergence and theoretical completeness as the purpose. Tesch (1991) identified three categories of approach to the analysis of qualitative data:

- Language based – focuses on how language is used and what it means, understanding 'symbols' -gestures in the environment
- Descriptive or interpretative – attempts to develop a coherent and comprehensive view of the subject material from the perspective of those who are being researched
- Theory-building – seeks to develop theory out of the data collected during the study with grounded theory as the best-known example of this approach.

This study looks to adopt this third category, using the data from the case studies to develop a theory in relation to successful project outcomes in terms of client satisfaction with the functionality of the end product.

In qualitative research, the number of samples tends to be small but studied in depth. According to Miles, Huberman and Saldana (2014) sampling in this field requires actions which sometimes pull in two different directions: firstly the need to set boundaries to define aspects of the case studies and secondly to create a conceptual frame to help to uncover, confirm or qualify the basic processes or constructs that underpin the study. Qualitative sampling is often decidedly theory driven, either "up front" or progressively, as in grounded theory mode. Patton (2002,2008) states that there is a wide range of sampling strategies available to qualitative researchers within a complex case or across cases.

3.5 Research Methods

3.5.1 Temporal Bracketing

This thesis uses two levels of temporal bracketing, the first describes the temporal periods in which the case studies occurred and the second describes the design management stages in the case studies. The use of interviews and surveys is not appropriate for this thesis due to its retrospective longitudinal nature. Many of the people who were involved have retired and unless the same representation for each case study could be included it would be difficult to analyse data obtained. The POE study in Appendix A used both structured interviews; semi-structured interviews and a questionnaire but the results from this data were not as rich as from the observation studies and unstructured interviews in the form of unsolicited conversations.

Temporal Bracketing according to Langley (1999) is one of the seven types of process research strategy that applies sense-making. Langley (1999) considers “Process data are messy. Making sense of them is a constant challenge” and describes seven types of process research that apply sense-making as follows:

- Quantification strategies: systematic, rational, mathematical evidence and coded predetermined incidence, that apply data reduction and statistics to understand variations, similarities and sequence to deal with complexity;
- Alternate templates: complex multi-analysis, multi-dimensional, multi-paradigm and multi-perspective approach to understanding dynamic and adaptable situations, requires careful consideration of combination and generalisation;
- Grounded theory: systematic, constant and cross-comparison of small units of emergent data. Langley (1999) contributes an inductive view of grounded theory as proposed by Glaser and Strauss (1967), however collective strategies contribute to today’s views of grounded theory as an abductive and iterative approach to theorising;
- Visual mapping: the integrated and simultaneous manipulation and organisation of words, numbers, matrix and graphical forms, providing multi-dimensional interpretations of decision making as in organisational process re-engineering and quality management approaches;
- Temporal bracketing: structure that describes events, structure constraints, shapes actions and influences future structures, labelling continuity, levels of influence between processes, adjacency, change and discontinuity; and,
- Synthetic: a whole process, monolithic and global principle that measures outcomes and describes detailed events. This approach assumes regular principles and measures that can predict outcome delivery and allow comparison.

The use of narrative strategies retains richness, complexity and avoids excessive data reduction. Suffers however in that it prohibits the gathering of large sample data, unless as in this case the data has been collected over a long period of time.

3.5.2 Narrative Approach and Temporal Bracketing

Shapira (2011) is concerned about the misuse of the term 'Theory" and to clarify the status of theory reviews three modes of research formulation: theories, models and conceptual frameworks and discusses two research languages: mathematics which is precision and narratives which provides rich data. Shapira (2011) concludes that all of them are required for a contribution to knowledge. the use of narratives in ethnographic research is its ability to richly convey the study context as narrative analysis means a very orderly and precise analysis of the word, a process whose intent is to extract meaning from text.

This study uses narrative strategies to collect data, the raw data for each case study has been gathered by a process of creating 'ramblings' to describe my role during each of the projects. Critical incidents and positive developments were then identified within these ramblings and set against a temporal bracketing framework related to the design stages. Temporal bracketing is also used as a means of identifying the project phases of each of the major case studies which spans from the introduction of the private finance initiative (PFI) in the 1990s to its demise in 2018. The temporal bracketing period, Figure 18 also include supplementary information from projects, frameworks and issues of regulation and deregulation during each period.

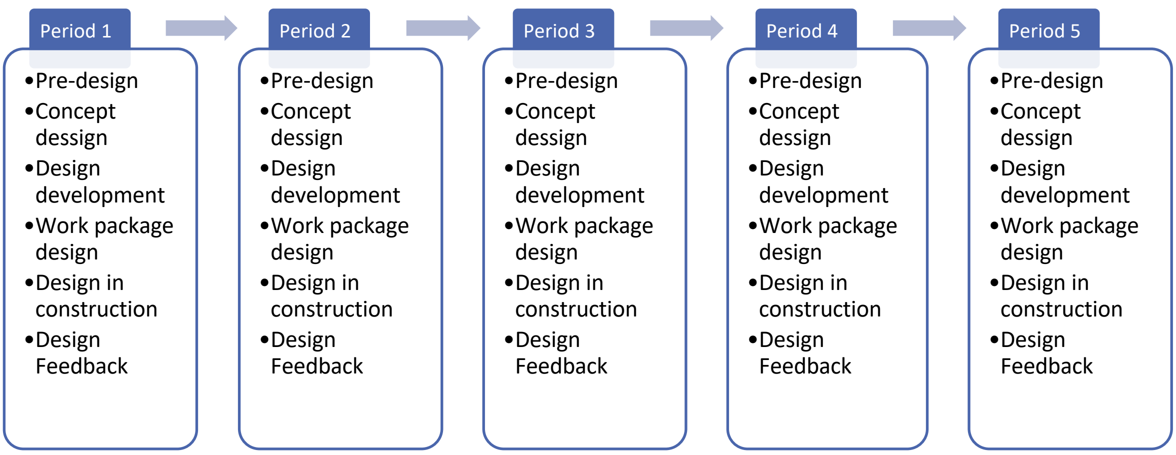


Figure 18 Temporal Bracketing Periods

Over the years I have collected a large amount of data as in Appendix B, carried out lessons learnt and tried to address things that did not go well and build on successful practices. However, a large percentage of my experiences were not recorded at the time in a research format. I did keep examples for future use as personal lessons learnt and therefore the challenge was to search and find a method of data collection which would address this and allow case study analysis and comparisons to be undertaken to determine the existence of the requirements crunch point and its effect. Giorgio (2013) describes examples of "memory data" as stories, secrets, artefacts such as photographs, letters objects, transcripts (minutes of meetings) – all items which I have collected over the years, together with observations, diaries and recalling conversations – recalling words said, voices, tones and facial expressions.

The difficulty was how to collect data from these case studies which could be comparable. I investigated the idea of "auto-interviewing" and developed a procedure for how this could be carried out. A trial session was carried out with my supervisor, but this did not prove to be very successful as it did not draw out all the issues. Instead I wrote down all my thoughts and recollections of what happened on these projects. This was similar to the "note taking" method used by Grosse (2016) in his auto-ethnographic study.

These 'ramblings' (Appendix C) as we called them described each project in essay form. They related what had happened on the project, going through the stages, making observations and explaining my role in the project and referring to notes and documents which I had retained. They reflect changes in my career from project architect and supervising officer to senior design manager with a contractor during the transition from traditional procurement to contractor-led design and build.

The next stage was how to collect the data from these ramblings with the perceived weakness being subjectivity and reliance on memory. Part of the documentation in Appendix B contains the development of personal "lessons learnt" through the case studies. I tried to distance myself subjectively by reviewing the case study essays by going through each one with a highlighter and marking up the critical incidents and positive developments with no preconceived ideas as to how many there were of each or category.

3.5.3 Critical Incidents Analysis

The use of 'critical incidents' is seen as an alternative method of collecting data from surveys for events which are believed to have a major consequence (such as the evaluation of tenders), (Fellow and Liu, 2015; Flanagan, 1954). The word critical implies crisis and something which is severe as in a 'Critical Care Unit' where the episode is triggered by something which has gone wrong or has complications. A number of the events have not resulted from something which went wrong but have looked at innovation and new developments to simplify situations and as such I have described these as examples of positive integration.

The critical incidents and positive integration have been categorised against six 'temporal bracketing' design phases. The six design phases being:

1. Pre-design
2. Concept Design
3. Design Development
4. Work Package Design
5. Design in Construction
6. Design feedback

The critical incidents and positive developments were then tabulated with a different terminology reflecting the positive and negatives outcomes, and comments listed under four headings in each case as in Table 9.

Table 9 Critical Incidents and Positive Integration Descriptions

Critical Incidents	**Positive Integration**
Cause	Reason rather than cause
Effect	Consequence rather than effect
Resolution	Beneficiaries replace resolution
Lessons Learnt	Adoption on future projects reflects lessons learnt

On most projects the negative aspects tend to be remembered and are the subject of lessons learnt workshops. If things go well there is often a failure to record success, this is not intentional – lessons learnt exercises always emphasise that there is a need to take forward good ideas and things that worked well. However quite often if things do work well people are not instinctively aware of processes which have made a positive effect on a project which is why I have separated out the as examples of positive integration as unlike critical incidents it has a more positive attitude rather than 'cause and effect'.

3.5.4 Observations

Observations form a large part of the data source for this thesis and ethnography is particular uses field notes. Although considered to be a time consuming and resultantly costly method, it does provide an effective means of understanding behaviour. It is used in post occupancy evaluations (POEs) and having carried out several POEs looking at the layout and use of facilities as well as observing how people work can give clear indications of how the facility is being used. This can be illustrated in the POE study referred to in Temporal Period 4, where without asking questions it can be seen that a Store Room is being used as a Sister's Office and deduce that the operational requirements are different from the brief. This is just one small example but demonstrates the power of observation. In addition, whilst carrying out observation studies, the members of staff often ask what the observer is doing and will divulge information which they might not do if they are asked to fill in survey questionnaires or take part in semi-structured interviews.

Kelleheare (1993) outlines a simple method which includes defining interest, sample selection, recoding approach, recording device, planning and observations. The taking of photographs provides a good method of comparison as well as a visual record which can be continuously checked. In the case of the POE study mentioned a series of photographs relating to the same type of room can easily be compared. In terms of architectural and construction data collection visual recording is not only important but is a medium which is easily understood by participants and for the clients who commission POE reports.

3.5.5 Data Analysis Methods

According to Yin (2014) there are three strategies for data analysis:

1. Theoretical proposition: establishing a conceptual framework and concepts;
2. Rival explanations: testing different perspectives of similar frameworks;
3. Case Descriptions: developing a description of a framework with live case study data

Within these strategies there are several analytical techniques including: pattern matching, where empirical patterns are compared to a hypothesis; explanation building, where the case study data is analysed by building an explanation of what took place, looking at the how and why, it is a broad and descriptive analysis; time-series analysis looks at repeated occurrences of a pattern; logic models are especially useful in case study evaluations with repeated cause-effect-cause-effect patterns, matching empirical cause and effects to theory; the fifth technique – cross-case synthesis (which can only be used across multiple case studies) is the aggregation of findings across a series of cases.

3.5.5.1 Theoretical Coding

For Charmaz (2014) "theoretical coding is a sophisticated level of coding …", to integrate codes into emergent theory and specify the possible relationships between categories that have been developed out of initial coding. Glaser (1978) presents a series of theoretical coding families that include analytical categories such as the “six Cs: causes, contexts, contingencies, consequences, covariances and conditions” (p. 74). Chamaz (2014) also states that there is a need to “… guard against forcing our preconceptions on the data we code” which is why the case study essays were completed before the critical incidents and positive developments were identified in an to attempt not to prejudge what had happened.

Pandit (1995) identifies three types of coding: open, axial and selective and states that; “These are analytic types and it does not necessarily follow that the researcher moves from axial to selective coding in a strict consecutive manner”. This thesis uses selective/theoretical coding as it utilises the most significant and frequent initial codes to sort, synthesise, integrate and organise the data.

3.5.5.2 Axial Coding

Strauss (1987) and Strauss and Corbin (1998) define axial coding as a strategy for bringing back data together in a coherent whole answering the questions; “when, where, who, how and with what consequences” p.125. relating categories to subcategories and creating “texture” whereas Charmaz (2014) states axial coding “specifies the properties and dimensions of a category”. Strauss and Corbin (1998) in their axial coding apply a set of scientific terms to make category links visible, grouping participants statements into components or an organising scheme to answer the following questions:

1. Conditions: the circumstances or situations that form the structure of phenomena - these answer the “why, where, how come and when questions?”
2. Actions/interactions: the routine or strategic participant responses to issues, events or problems – the “who and how questions?”
3. Consequences, outcomes or actions/interactions – “with what consequences?”

For Charmaz (2014) the axial coding frame “… may extend or limit the vision, depending on the subject matter and ability to tolerate ambiguity” (p.61) and so a flexible and emergent scheme is preferable. This thesis used a flexible coding method as having identified the critical incidents and significant developments within their project phases different categories started to appear with differing consequences. This early data was separated, sorted and synthesised through qualitative coding, labelling areas to distil data and establish a means for making comparisons. Preliminary analytical notes were made which led to reorganisation of data and creating additional fields as a result of asking the questions raised by Strauss (1987) relating to ‘How, where, when etc”.

This study uses constant comparison related to the critical incidents and the significant developments which occurred during the case studies and similar issues which are still merging in the construction industry at present.

3.5.5.3 Thesis Theoretical Sampling, Saturation and Sorting Approach

Theoretical sampling focuses on the emergence of a concept which is dependent upon the analytical problem under investigation and the ideas, gaps, uncertainties and questions which have arisen. Charmaz (2014) defines it as "seeking pertinent data to elaborate and refine categories in your emergent theory". This involves conducting theoretical sampling by developing "… properties of category(ies) until no new properties emerge. Thus, you saturate your categories with data and subsequently sort and/or diagram them to integrate your emergent theory". Yin (2014) considers that if using a multiple case study design a replication logic rather than a sampling logic should be used and the researcher must choose the case studies carefully. In Yin's example (p.58) he outlines Szanton's (1981) book "Not well advised" eight case studies which he considers sufficient ''replications" to convince the reader of a general phenomenon. This study, although it involves multiple case studies, relates to sequential projects rather than replicated studies.

Charmaz (2014) considers that theoretical sampling improves the study by specifying relevant properties, increasing category precision, moving from description to analysis (the method used in this study to interrogate the ramblings), making analysis more abstract and generalisable, grounding conjecture, explicating links; and increasing the robustness of theoretical statements. Sampling enables researchers to "… check, qualify and elaborate the boundaries of … categories and specify the relationships among categories". Saturation determines when you stop gathering data and "when gathering fresh data no longer sparks new theoretical insights ... " (Charmaz, 2014 p. 213). The following criteria are defined by Charmaz (2014) as a means to assess when a study has reached theoretical saturation:

- Which data comparisons are made within and between categories?
- What sense is made of the comparison and where does it lead?
- How do comparisons illuminate theoretical categories?
- What other directions does the comparison take?
- What new conceptual relations, if any might be seen?

In this study the initial separation of the critical incidents and the positive developments, negative and positive elements sometimes repeated themselves within the case studies, some only appeared once and some "corrected and avoided" similar instances happening in the future. The resulting developments through the chronological studies also led to refining analysis categories as saturation was reached.

According to Miles, Huberman and Saldana (2014) qualitative data analysis is seen as three concurrent flows of activity:

1. Data Condensation which refers to the process of selecting, focusing, simplifying, abstracting and or transforming data;
2. Data Display is how the data is presented: matrices, graphs, charts and networks;
3. Drawing and Verifying Conclusions which even in the early stages start to appear and are refined until the final data has been analysed

This study uses a mixture of qualitative data analysis methods including cross-case synthesis. In order that this research is valid the definition and selection of cases, units of analysis and embedded units must be fully justified. The three levels are illustrated in Table 10 below.

Table 10 Units of Analysis and Embedded Units

Levels of Analysis	**Specific Units of Analysis**	**Justification**
Cases	• Completed major hospital projects • Study covers comparable temporal periods • Similar levels of complexity • Author has a significant role on the project	• Varying levels of client satisfaction with project outcomes • Standardised hospital project framework abandoned by NHS • Different procurement methods introduced • Case studies cover the whole period from pre PFI to the demise of PFI
Units of Analysis	• Design Management • Design Communication • Equipment • Roles and Responsibilities • Procurement • Integration	• Introduction of Design Management as a separate discipline • Relationship with user stakeholders • Regulation and Compliance • Advances in technology and medical equipment • Changes in roles and responsibilities • Changes in methods of procurement • Level of integration
Embedded Units	• Project Roles (Sponsors, Designers and Contractors) • Project requirements • Alternative methods of project delivery	• Relationships between parties • Process for developing and monitoring project requirements • Success levels of project delivery • Opportunities for improving project delivery

3.5.6 Literature Survey

A literature review is the most accessible and efficient means of gathering information. A search of the existing academic and practitioner literature defined the baseline knowledge that was applied as part of the retrospective abductive, auto-ethnographical theory approach. The literature developed as the findings from the temporal periods emerged introducing different aspects. The starting point of design and project management in the initial phase of the literature review was to search for the 'requirements' crunch point'' looking at specific stages within the RIBA Plan of Works, relating to Project Briefing and Post Occupancy Evaluation (POE) – the beginning and ending of the process but also interlinked with the intention that POE and Lessons Learnt should influence future Project Briefing. It also included communication both visual (pictorial) written and oral, trying to understand common language. This first phase of the literature review was carried out during the same period as the recording of the ramblings and before the extraction of data for analysis.

The second phase following the ramblings widened the scope to investigate systems integration and stakeholder involvement. Following the data analysis, a third literature review phase took place focusing on three distinct areas:

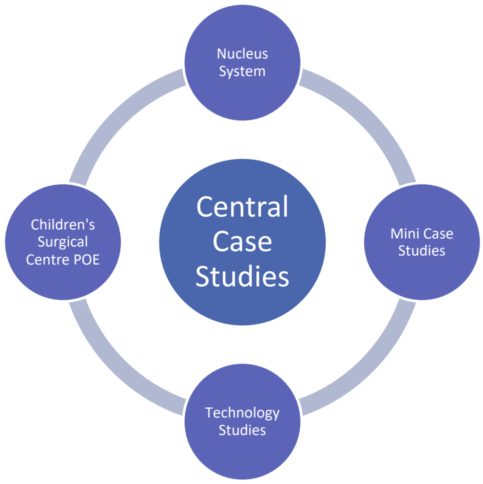
- Project Delivery as the process which could influence project outcomes
- Behavioural characteristics of the people involved in the process who could influence project outcomes
- Wider system in relation to the delivery of healthcare

Table 11 Influential Literature

Phase	Literature	Typical Authors
1	• Design Management • Project Management • Project Briefing • Post Occupancy Evaluation	• Emmett, Enyon. Edkins, Mills • Winch, Brady, Davies, Morris • Blyth & Worthington, Chandra, Loosemore • Brand, Bordass, Leaman, Hay
2	• Systems Integration • Stakeholder theory	• Davies, Barlow, Cacciatori, Jacobides • Langley, Davis, Olander
3	• Types of Project Delivery • Behaviourial Attitudes in Construction • Wider System in Relation to Healthcare Delivery	• Ballard, Emmitt, Lichtig, Hall, Scott, Mesa, Lostuvali • Hillebrandt, Cicmil, Marshall, Endsley, Pink • Glanville, Caixeta, Fabricio, Ulrich, Kendall, Singha, Fawcett, Hignett, Lu, Price, Mills

3.5.6.1 Supplementary Data and Grey Literature

As well as collecting data from the five major hospital projects I have included information in the form of technical studies, literature articles and data from other sources relating to the temporal bracketing periods to help put the case studies in context with other occurrences and issues relating to legislation and frameworks during that period and these are contained in the appendices.



Supplementary Data

Children’s Surgical Centre Post Occupancy Evaluation (Appendix A)

Technology Studies (Appendix A)

Nucleus Building System Appendix (A)

Mini Case Studies (Appendix E)

Figure 19 Supplementary Data

3.5.7 Triangulation

Triangulation in qualitative research is to increase the validity and reliability of complex results with richness, balance and cross-checking from a number of stand points. According to Denzin (2006) there are four basic types of triangulation:

- Data: empirically cross-comparing results
- Investigator: multiple researchers
- Theory: more than one theoretical scheme
- Methodological: more than one method to gather data

This thesis applies data and methodological methods of triangulation. Eisenhardt (1989) states that triangulation in case study research can use qualitative data, quantitative data or a mixture of both and that the use of multiple data sources can enhance construct validity and reliability. The analysis method used in the case studies takes qualitative data and extracts quantitative data in order to empirically cross-compare results.

As previously stated, the research topic developed from a desire to reflect on my experiences as an architect and design manager working on major hospital projects and try to analyse how successful client outcomes were or could have been achieved to aid future projects. The projects formed the basis of the first four temporal bracketing periods and were all retrospective. They were all drawn from practice and therefore it was necessary to carry out a literature review in order to relate theory and practice. As such this was a retrospective abductive period in the research. The four case studies were chronological and covered the period from the use of traditional design-bid-build contracts through three phases of design and build PFI projects.

Phase 1 looked at the case studies and set out the temporal periods

Phase 2 involved a critical review of literature relating to stages within the project cycle: briefing, stakeholder involvement, design and project management, the construction period and post occupancy evaluation. This phase also involved establishing a method with which to analyse the data which I had already collected.

Phase 3 reviewed the case studies in relation to the literature which instigated a further literature search into systems integration, project delivery and the behavioural issues within the construction industry.

Phase 4 during the process of writing up the findings, several major incidents occurred in the construction industry, two of which involved major hospital buildings on which construction ceased due to the collapse of the contractor and which led to the demise of PFI. I was fortunate to be asked to join one the bidders for the completion one of these hospitals, Case Study 5 This has enabled me to carry out another auto-ethnographical study using action research and one which closed out the PFI process and was able to validate some of the findings from the previous studies.

3.6 Generalisation, Repeatability, Validity and Reliability

The use of case study design risks the threat of bias, and with autoethnography this is even more likely, therefore the research design must be valid (Yin, 2014). Construct validity is the accuracy with which a case study's measures reflect the concepts being studied, internal validity is the strength of a cause-effect link made by a case study, in part determined by showing the absence of spurious relationships and the rejection of rival hypothesis and external validity is the extent to which the findings from a case study can be analytically generalised to other situations that were not part of the original study. A fourth test is reliability where the consistency and repeatability of the research procedures are used in a case study. Yin (2014) sets out 'Six Sources of Evidence: Strengths and Weaknesses' in Figure 4.1 p. 106, as extract in Table 12:

Table 12 Extract from Yin's Six Sources of Evidence

Source of Evidence	Strengths	Weaknesses
Documentation*	• Stable • Unobtrusive • Specific • Broad	• Retrievability • Biased selectivity • Reporting bias • Access
Archival records	• As documentation • Precise and quantitative	• As documentation • Accessibility due to privacy reasons
Interviews	• Targeted • Insightful	• Bias – poor questions • Response bias • Inaccuracies – poor recall • Reflexivity – interviewee gives what the interviewer wants to hear
Direct Observations	• Immediacy • Contextual	• Time-consuming • Selectivity • Reflexivity • Cost – hours needed by human observers
Participant-observation	• As direct observation • Insightful into interpersonal behaviour	• As direct observation • Bias due to participant-observer's manipulation of events
Physical artefacts	• Insightful into cultural features • Insightful into technical operations	• Selectivity • Availability

*Documentation includes:

- letters, memoranda, emails, diaries and notes;
- agendas, announcements, minutes of meetings, and other written reports of events
- administrative documents, proposals, progress reports and other internal records
- formal studies or evaluation related to the case study
- news clippings and other articles appearing in the mass media

This study uses documentation, direct and participant observation and physical artefacts as the principal sources of evidence. Its strengths are in these areas as I am using my own records – no issues with access and retrievability, in connection with observation, this is either retrospective or as a participant so cost and time are not relevant. This also applies to artefacts. Originally my intention was to interview people who had been involved in the projects but recognised the weaknesses stated relating to inaccuracies due to poor recall over a long time period and decided not to use this source.

Table 13 below sets out my approach taken to ensure validity.

Table 13 Approach Taken to Ensure Validity, adapted from Winter (1989)

Origin of Case Study Tactic	Approach Taken in this Thesis
Multiple sources of evidence, Yin (2014); Eisenhardt (1989)	• Multiple sources of evidence were used with each case study using the same types
Establish key chain of evidence, Yin (2014)	• Case Study 'ramblings' were written down electronically and the relative multiple evidence sources collated with each study. Sources relating to case study documentation.
External validity, Yin (2014)	• Evidence drawn from other projects which confirm the findings
Reliability, Yin (2014), Glaser (1978 and (1998)	• Development of a framework to demonstrate consistency and repeatability of the research

3.7 Case Study Methodology and Structure

The previous sections in this chapter have outlined different types of case study analysis and methods of gathering data, reference has been made to the fact that this was a longitudinal multiple-case study with multiple units of analysis using temporal bracketing, narratives and critical incidents as methods of data collection, the following description outlines the process taken in collecting the data and the chapter format. This format was consistent over the retrospective case studies in Chapters 5, 6 and 7. Chapter 8 had a slightly different format as it was a live project. As this was a longitudinal study the findings from each of the temporal period chapters were analysed as a whole in Chapter 9 before triangulating with the literature in the discussion Chapter 10.

3.7.1 Chapter Format

Each chapter represents a temporal period and consists of one or more case studies. The introduction outlines the events taking place in the wider delivery period followed by the case study. There is a brief description of the case study, followed by an analysis of the critical incidents and positive development and their level of project integration. The occurrence of a requirements' crunch point (RCP) is also assessed in relation to the success or otherwise in terms of achieving client requirements. Findings from minor case studies are also included. The chapters concluded with a summary of findings from the analysis with the aim of achieving objectivity followed by reflections which are subjective and my personal experiences.

3.7.2 *Data Collection and Analysis Process*

As stated previously I had accumulated a considerable amount of information over the years but with no express intention of undertaking a PhD, therefore I had to construct a methodology of translating it into a format which could be turned into data for analysis. The following process was adopted:

Phase 1: Produce a narrative “ramblings’ for each case study

Phase 2: Mark up and code the ramblings highlighting critical incidents (CI) and significant developments (SD) renamed examples of positive integration

Phase 3: Allocate the CIs and SDs into five temporal bracketing periods relating to the project phases

Phase 4: Establish the occurrence of an RCP

Phase 5: Identify the cause and effects of the CIs

Phase 6: Establish who was responsible for integration

The ramblings are contained in the appendices and the following table sets out the roles and responsibilities of project team organisations and personnel involved in the four case studies to demonstrate overlaps and continuity. In Table 14 AE represents myself as auto-ethnographer.

Table 14 Roles and Responsibilities in Case Studies

	Case Study 1 **Traditional**	**Case Study 2** **PFI**	**Case Study 3** **PFI**	**Case Study 4** **PFI**
Client - Organisations	**NHS Health Board**	**NHS Trust 1**	**NHS Trust 2**	**NHS Trust 3**
Client - Individuals				
Project Sponsor (PS)	PS1	PS2	PS3	PS3
Project Manager (PM)	PM1	PM2	PM3	PM3
SPV - Organisations	-	**SPV1**	**SPV1**	**SPV1**
SPV – Individuals	-	DP1	DP2	DP3
Project Director (DP)				
Design Team				
Project Architect (PA)	**AE**	PA1/**AE**	PA1/**AE**	PA2

Structural Engineer (SE)	SE1	SE2	SE3	SE3
Mechanical & Electrical Engineer (M&E)	M&E1	M&E2	M&E2	M&E2
Quantity Surveyor (PQS)	PQS1	-	-	-
Contracting Organisations	**Contractor 1**	**Contractor 2**	**Contractor 2**	**Contractor 2**
Contractor - Individuals Project Director (PD)	PD1	PD2	PD3	
Project Manager (MP)	MP1	MP2	MP3	MP3
Design Manager (DM)	-	DM1	DM1/DM2/**AE**	**AE/**DM3
Cost Manager (CM)	-	CM1	CM1	-
Commercial Manager (QS)	QS1	QS2	QS3	QS3/QS4
Services Contractor (MES)	MES1	MES2	MES2	MES2

I have tried to distinguish between Project Managers and Project Directors to give clear definitions of the roles they undertake. One observation from carrying out the literature review was often the term Project Manager was not clearly defined. On a major hospital project there may be dozens of people with the title 'Project Manager'. In the case of the client organisation this may be the person charged with managing the project on a 'day to day' basis within their organisation. In a construction company 'Project Manager' is seen as a 'rank' as in the army (many large construction companies adopt a military or hierarchical style of management) with a major site being managed by a Project Director and a small site by an 'agent'. Each sub-contractor tends to have a project manager and in some architects' offices there is also a project manager who is not the project architect but someone who organises resources and ensures that information is issued on time.

The definitions I have used are as follows:

> **Project Sponsor (PS):** person within the Client organisation who is responsible for the project, this may not be a full-time role
>
> **Project Manager (PM):** person within the Client organisation who is responsible for the day to day running of the project, liaising with the contractor organisation
>
> **Project Director (DP):** person within the SPV (Special Purpose Vehicle) which in the case of PFI can also be seen as 'the owner' of the building who is responsible for the project as opposed to:

Project Director (PD): person in the contracting organisation who is responsible for delivering the project and **Project Manager** (MP) to differentiate from the Client's PM

Design Manager (DM): person within the contracting organisation responsible for ensuring that the compliant design can be delivered

Cost Manager (CM) and **Commercial Manager (QS)** are two different roles within the contracting organisation with the cost manager looking at project costs and the commercial manager dealing with the procurement of subcontractors

The **Services Subcontractor (MES)** Mechanical and Electrical subcontractors also have their own project managers.

The design team comprises: **Project Architect (PA):** usually appointed lead consultant, **Structural Engineer (SE)**, the **Mechanical and Electrical Engineers (M&E)** and the **Quantity Surveyor (PQS)**.

Fellow and Liu (2015) state that "all studies involving people are influenced by cultures". They also refer to the construction industry where casual observations of behaviour suggest that it has "a macho culture" and also "a culture of conflict". This thesis sets out to look at the frameworks, forms of contract and processes within the industry and their effect on project outcomes but during the course of data analysis the effects of cultural behaviour became evident.

3.8 Reflections

This chapter has outlined the methodology and the research methods which have been adopted and has made the case for taking a critical auto-ethnography approach. The study is based on the analysis of five case studies over five temporal bracketing periods with supplementary data and triangulating it with the literature review (Chapters 2 and 4). The approach in this study is post-positivist related to critical realism and adopts critical theory in relation to phenomenology as the investigator and investigation are linked.

The fact that the units of analysis used in this embedded multiple-case study approach and longitudinal are robust demonstrates that they can be repeated on future case studies.

The use of ethnography in its different forms: retrospective autoethnography related to the four major case studies, ethnographic-action research in relation to Case Study 5 and an ethnographic observation POE creates a cohesive methodology from which to carry out research in design management. There are very few ethnographic studies relating to auto-ethnography, Oswald and Dainty (2020) the examples which do exist are both related to professional relations in construction but not in major hospital projects and not in the UK. This study is over a considerable period of time which is also unusual, a previous study by Ness (2012) looked back over a period of 30 years but is related to the role of women in construction and as such the combination of the retrospective and self-reflexive aspects of auto-ethnography in the field of design management could be considered to be a unique approach. This approach can be adapted for shorter timescales as a means of transferring knowledge within the construction industry.

Chapter 4 Design Integration and Management

4.0 Design Integration and Management

4.1 Introduction

The theory relates to integrated design management with the focus on healthcare therefore, the literature review includes references to health technology, complexity related to medical planning and the high level of stakeholder involvement. Literature specifically related to the design and construction of major hospitals is limited, possibly due to lengthy timescales and a reluctance from the design and construction sectors to carry out research. This can be seen by the lack of evidence of post occupancy evaluations in the literature search, partly due to a fear of recrimination towards designers or contractors from clients as discussed in Hay et al (2018).

Project-based delivery relates to temporary project organisations (TPO) set up to deliver specific projects, in this case major hospital projects, with the focus on design management. It could be argued that design management is the function of the project manager and this used to be the case when projects were traditionally led by architects.

The following sections discuss design management in terms of the design process and the stages set out in Chapter 3, design education and training and the influence of product design processes on lean design management. Additional literature to requirements management, value management and systems integration is included in Appendix D.

4.2 Design Management, System Theory and Project Management

Design management is defined as: “a field of inquiry that uses project management, design, strategy, and supply chain techniques to control a creative process, support a culture of creativity, and build a structure and organization for design” according to Wikipedia (2020). This definition relates to all types of design, initially related to product design where the term was first used by Farr (1966) introducing system theory and project management to create a framework for dealing with design as a business function at the corporate management level by providing the language and methodology for effective management. All three terms are now used in Design and Construction Industry and although some of the practices may have been adopted it is not until the early 2000s, when the change in project leadership to contractor-led design and build projects led to the introduction of a ‘new’ discipline relating specifically to design management leading to an emerging theoretical field of study.

4.2.1 Design Management in Construction

Sun et al (2011) trace the concept of design management as a separate discipline emerging in the 1970s. Design management began in product design rather than in architecture and construction, which differs in that it is project-based and often involves a unique product delivered through a participatory process.

Emmitt (2007) looks at design management for architects including how design is managed within offices as well as on site and Enyon (2013) whose Handbook on Design Management provides a reference manual for practitioners, mainly within construction companies. Both Emmitt and Enyon are architects, one of whom looks at design management from an academic perspective and the other, who like me, moved from architectural practice into a contracting organisation. Emmitt and Ruikar (2013) published 'Collaborative Design Management', a significant textbook for university design management courses. These publications are nearly 15 years since the birth of design management, although Emmitt in particular has been publishing related papers since 1997 and states that the design manager role first appeared in the 1960's, Emmitt (2007). The 1960s relates to the introduction of CLASP (Chapter 2) when design and build first appeared in public buildings, notably schools. There are different definitions of design management in terms of when it occurs during the project cycle and the roles and responsibilities involved. Unlike project management which is recognised as a theory in its own right, is subject to the CIOB Code of Practice 2014, has a recognised professional body in the form of the Association of Project Managers (APM), recognised undergraduate and post graduate university courses, design management has no code of practice, no recognised professional body and very few bespoke university courses. The CSC organise a one-day course 'A practical guide for design managers' based on Enyon (2013).

4.2.2 System Theory in Relation to Design

Giurgola and Mehta, (1976) defines Louis Khan's Richards Medical Centre (1960) as a turning point in contemporary architecture as it articulates the building form and contents in terms of integrated systems, separating servant (support areas) and served spaces. It integrates spatial, structural and utility (heating, ventilation, water, drainage, gases and electrical distribution) services. The authors conclude however that although Louis Khan's, Richards Medical Centre evolved the concept of integrating the structure and mechanical and electrical services into the design of the building creating risers and stair/lift cores for vertical communication and ceiling zones horizontally for services distribution was successful, the resulting facility did not provide client satisfaction as a result of failure to integrate the human stakeholder systems.

It did however contribute to the following architectural design process which had been driven by Gropius et al at the Bauhaus in 1919:

- Analysis - working out the client requirements;
- Exploration -investigation of the relationships between rooms/areas both horizontally and vertically; and,
- Synthesis - development of the building concept, taking into account how the building fits into its environment in terms of creating a footplate and its relationship to surrounding buildings.

This process ensures the building form is driven by the functionality and not by an arbitrary form and structural design. The arbitrary approach may be appropriate for open plan office buildings, galleries with large open spaces creating iconic architectural buildings such as the Pompidou Centre or the Shard. It does not however translate into complex hospital buildings where room and departmental relationships are critical to the building operation.

4.2.3 Project Management and its Relationship with Design Management

The Project Management mantra of time, cost and quality Atkinson (1999) developed following Latham (1994) and Egan (1998) into the state of the UK Construction Industry led to the development of design and build procurement where major contractors were seen as having the project management capabilities to deliver projects on time, cost and quality. The ability to deliver on time was led by the construction delivery teams adopting programming techniques such as Critical Path Analysis developed by DuPont (1957) and commercial management teams controlling costs through supply chain management. The structure of constructure companies undertaking work in the hospital sector did not employ inhouse designers and therefore did not have design management teams. Whereas project management may achieve project efficiency according to Shenhar et al (1997) and Shenhar and Dvir (2007); project success requires the meeting of the wider business and enterprise needs as defined by key stakeholders. This relationship between project efficiency and project success is further investigated by Serrador and Turner (2015) and concludes that although project efficiency is necessary for project success, project managers must properly engage with stakeholders to achieve success. Stakeholder engagement being an essential part of design management.

4.3 Activities, Roles and Stages in Design Management

The design process does not necessarily follow the project process as the project process may have the ability to overlap activities. The first recognised Plan of Work outline the design and construction process was the RIBA Plan of Work 1964 which reflected the method of procurement at that time all design and construction information being completed before construction commences. NBS (National Building Specification) was launched in 1974 which set out materials, standards and workmanship related to individual work packages cross referenced to drawing notation and the common arrangement of clauses in SMM. The theory being that if all the documentation was completed at tender stage, the architect’s role in the construction phase was purely to administer the contract and ensure that resultant building complied with original specification. The issue of architect’s instructions should only reflect changes requested by the client, the resolution of anomalies within the contract documents and contractors’ errors (including poor workmanship). Cacciatori and Jacobides (2005) looking at vertical integration in construction contracts highlights the differences between the development of architectural and structural drawings and those of the mechanical and electrical engineers, where in the former the potential is for 100% construction information and in the latter where the mechanical and electrical services drawings are schematics and the fabrication and installation drawings are prepared by the subcontractors. Despite the introduction of BIM which can address this anomaly the subsequent RIBA Plans of Work (1976, 2007, 2013 and 2020) still do not take account of it as seen in Figures 20 and 21.

In the 2020 version Stage 3 Developed Design has been changed to Spatial Coordination and Stage 5 Construction to Manufacturing and Construction. The 2020 version attempts to accommodate different methods of procurement and delivery.

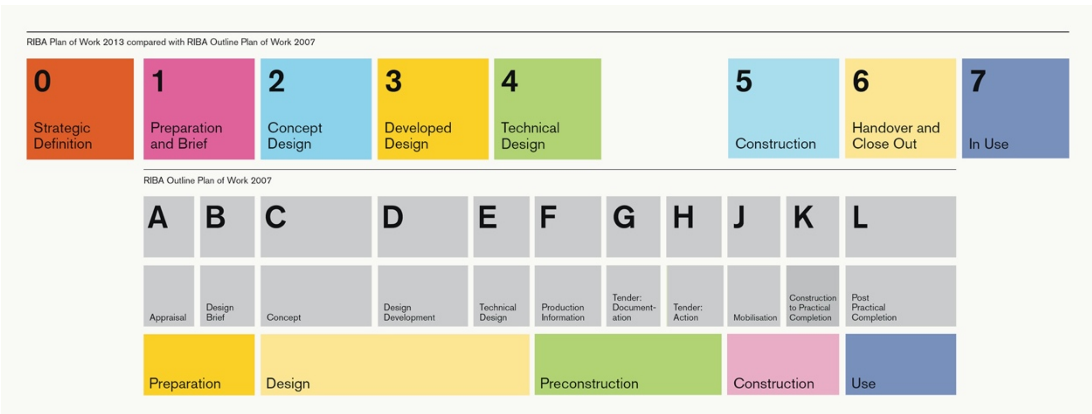


Figure 20 Comparison of RIBA Stages 2007 and 2013

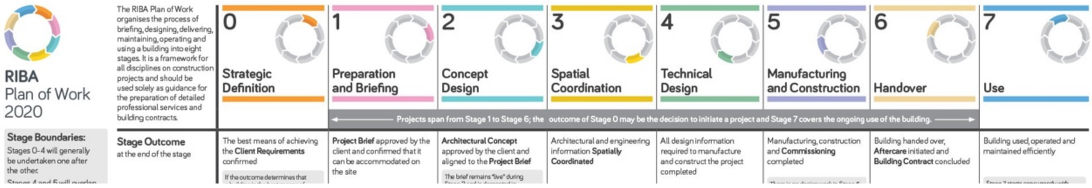


Figure 21 RIBA Plan of Work 2020

Enyon (2013) defines design management in three project stages:

- Pre-project defined as Project Definition;
- Project as Project Procurement and Project Delivery; and
- Post-project as Project Operation

and relates design management roles to these stages. Although these stages correspond roughly with the RIBA Plans of Works (1964, 1976, 2007, 2013 and 2020), the descriptions align with design and build procurement rather than the traditional route of the RIBA. In identifying the different design management roles Enyon (2013) suggests that strategic design managers could possibly be consultants to the client and that the preconstruction design manager could be either a member of the construction company or the lead designer with the delivery design manager being a member of the site team. Hughes (2003) compares the 1964 version with that of 2000 and concludes that the interaction now takes place at Stage D rather than Stage C – as shift from concept design to design development. It appears to have more coordination and less control. Another paper relating to this subject by Zambelli (2017) looks at both the 2007 and 2013 versions and the "occlusions" or blockages in the operational system through the discussion of Robert Matthew (architect) and Andre Leroi-Gourhan (anthropologist) and the French process of 'chaine operatoire'. This points to the need to address the problems of overlapping design, procurement and construction activities.

Following the methodology set out in Chapter 3 in Figure 22 the design management stages are set out to reflect the design stages rather than the project stages, eliminating contractual bias. Although design management involves a linear sequence, it can also be illustrated in circular format, demonstrating how knowledge needs to be transferred for future projects.

1. Pre-design
2. Design Concept
3. Design Development
4. Work Package Design
5. Design in Construction
6. Design Feedback

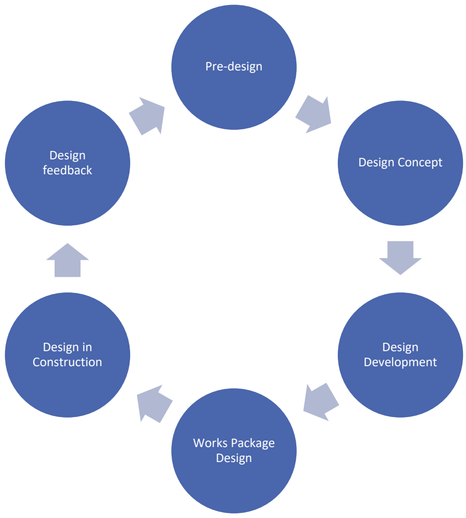


Figure 22 The Design Process

4.3.1 Pre-Design and Briefing

This stage represents the preparation for design where the primary function is briefing and depending upon the type of project and client may be static or dynamic, highly repetitious, variant type or unique. This will result in different types and levels of design management, strategic in the case of the wider system and more aligned with Enyon (2013) at project level.

Nicholas (2001) defines a project as "unique and temporary to achieve a goal involving unfamiliarity and possessing elements of uncertainty and risk." Before designers can start to prepare a concept design, they need to have a clear brief from the client and in many instances are involved in preparing the brief with the client. Being involved at the earliest stage gives designers a better understanding of what the client 'thinks they want' and 'what they actually want'. In healthcare projects the client represents multiple stakeholders. This section looks at the development and understanding of project briefing.

Blyth and Worthington (2010) with reference to Zeisal (1984) looks at the difference between the 'paying client' and the 'user client' and that it is vital to bridge the gaps between them and the designers in order to get a deep understanding of the project requirements. Designers in this model are faced with trying to satisfy two clients. Whilst trying to manage these gaps of understanding of different priorities and levels of communication, the current method of procuring hospitals involves more than one paying client and the designers are employed as sub-contractors to the design and build contractor making the designer/client relationship even more difficult. Smyth (2017) emphasises the importance of architects for helping clients and end users to articulate the brief and outcomes and translate them into the design proposals.

One of the key issues in healthcare briefing is related to whether it is static or dynamic, healthcare is a dynamic subject, the buildings are complicated with long design and construction periods and clinicians want ‘state of the art’ on completion. Chandra and Loosemore (2010) and Loosemore and Chandra (2012) look at cultural learning in the briefing process of a hospital between clients/clinical users firstly with the construction project team and then with facilities management concluding that a flexible rather than a prescriptive approach to briefing needs to take place to facilitate the uniqueness of cultural behaviour. Prins et al (2006) in contrast consider that in light of the move towards Design build for manufacturing offsite (DBFMO) static rather than dynamic briefing seems more appropriate as uncertainty and change orders are difficult to control. Traditionally, the brief has remained an unaltered statement of intent' i.e. static! And Worthington (2006) looks at briefing as an integrated part of the entire construction and project management processes and not just as part of an early stage. Oliveira and Marco (2017) studied a fourth year architectural student project to assess non-prescriptive briefs – where students have to determine their own briefs to aid design flexibility and promote creativity. They conclude that further research is required and that there were time period overlaps in the process. Further research relating to healthcare could provide an interesting study with Trusts providing output specifications rather than schedules of accommodation.

Chandra and Loosemore’s (2011) research also indicated that healthcare planners emerged as the ultimate decision makers of facility related issues during hospital briefing. This raises an issue which is of concern in practice as there are no formal qualifications to become a healthcare planner which means that there is no quality control and uniformity to the advice being given. They consider that further investigation is required as clinicians’ expectations are not being delivered. Project managers need to see the briefing process as a cognitive rather than a technical process through which project participants interact to socially construct a common understanding of project objectives and requirements.

Schein (1978) describes three types of consultant roles, in the purchase of expertise model states that a client knows exactly what the problem is; what needs to be done and from whom to get help. This would be described as an ‘expert client’ who is capable of providing a brief to designers without their input. In the second illustration the doctor-patient model the client becomes totally dependent on the consultant to diagnose the problem and therefore needs input from advisors. In the process model the consultant as either the catalyst or facilitator does not take total control, but the client is involved in the diagnosis of the problem and generating a solution. This latter describes the situation where the designers and advisors need to be involved in the briefing process.

The main briefing tool for healthcare projects is derived from the Nucleus Activity Data Base (ADB) used to produce Room Data Sheets, Room Layout Sheets and the Equipment Data Base. The latter of which is subdivided into different groups according to who supplies the individual items. It is linked to the HBNs and HTMs and despite little updating of this system, particularly regarding equipment, it is still used on the majority of healthcare projects. Alternative systems such as the Hiltron Planning System (circa 1990s-2013) developed by equipment specialist advisors have been used, but they have failed due to a lack of understanding by stakeholders and interaction with design software.

Othman et al (2004) focuses on the theory that the final product should exceed client expectations and reflect the requirement of the brief in order to achieve client satisfaction and introduces the concept of dynamic brief development (DBD) as a process that facilitates client satisfaction. They identify milestones throughout the process where evaluation can take place including feedback and lessons learnt as the final stage. Whilst providing a strong case for DBD, the process and relationships again focuses on the RIBA Plan of Work (2000) and does not relate to the current method of hospital procurement which is design and build.

A more recent paper by Yu and Shen (2015) looks at what constitutes critical success factors (CSF) for briefing construction projects and identifies seven significant factors including reference to stakeholders' roles and requirements, decision making and management skills, competencies and an understanding of the client business and organisation. It highlights where previous research Kelly and Male (1993),Shen (2004), Kamara and Anumba (2001), Kelly and Duerk (2002) and Yu (2007) who have all identified the following problems associated with the briefing process:

- Inexperienced clients who do not know how to proceed;
- Lack of identification of client needs;
- Inadequate involvement of all the relevant parties of a project (stakeholders);
- Inadequate communication between the parties;
- Insufficient time allocated for the briefing process;
- Briefing continuing during the design and construction phases; and,
- The contractor having no real understanding of client objectives.

Yu and Shen (2015) conclude the briefing process changes dependent upon the procurement or delivery method. This is also borne out by Kelly and Male (1993) who advocate the use of value management techniques in briefing, something which is difficult to adopt in competitive design and bid projects.

Smith (2005) proposes the use of Strategic Needs Analysis (SNA) to aid pre-design processes to prepare a strategic brief or business case. The concept of pre-design briefing was also the subject of Kelly and Male (1993). Although Smith (2005) addresses the need to involve stakeholders in this process, this strategic level needs to be linked to the wider delivery system rather than project delivery in terms of healthcare. Once a project has been proposed the design team should be engaged at the earliest stage and not as a follow up to pre-design in order to understand the client’s requirements. Even in the case of the wider delivery system, strategic briefing requires the engagement of designers. The separation of pre-design briefing from the rest of the project lifecycle is counter-productive in terms of project integration.

Fellows and Liu (2016) recognise that project briefing is problematic, often hurried, the relevant stakeholders are not involved, and decisions made from a power stance rather than from sensemaking. They emphasise the importance of culture in establishing project processes and the need for understanding other cultures involved in the project, something which is very important in trying to bring together the different cultures which exist not only between designers and contractors but between clinical staff and hospital estates staff.

The client roles during the briefing period can also affect the process and this is highlighted by Thomson (2011) in a pilot study of client complexity, emergent requirements and stakeholder perceptions of project success. It looks at the relationships between the Project Sponsor and the Architect/Project Manager.

4.3.2 Design Concept and Integration

This stage in the process is where the designers interpret the brief and the role of design management is to ensure that the design concept reflects the brief in terms of functionality and primary level coordination. Presentation of a ‘Wow’ factor scheme which cannot be achieved following design development does not build up good client relationships and leads to disappointment. Regardless of procurement method a fundamental principle of good design is to ensure that the architect engages early in the process with a structural engineer and mechanical and electrical services engineers before presenting schemes to a client. This is particularly important in the case of healthcare facilities where around 50% of the building cost relates to mechanical and electrical services.

It is during this stage Emmitt (2007) that looks at the role of the design manager, one that relates to design quality within the architects' office where "the design manager is employed to oversee (manage) all design activity within the office and ensure a consistent and coordinated approach to every project in the project portfolio'. p.9. The creation of this role is to allow the design architect to concentrate with the creating and developing the design with the engineers by reducing unnecessary administration and the burden of office management. The role exists in many architectural offices but is given different titles, on some large projects this role is designated as 'project manager'. In this model the Design Manager is the link between the architectural team and the contractor's 'Construction Design Manager'.

4.3.3 Design Development and the Importance of Stakeholder Engagement

The results of post occupancy evaluations often demonstrate the failure to engage effectively with stakeholders- understanding their requirements, issues of communication and visualisation and managing them to ensure that the right people are involved at the correct time in the process. Over 25 years ago Amoako-Gyampah and White (1993) explored the relationship between user involvement and user satisfaction in a systems' setting concluding user perception of involvement has a direct positive and significant impact on user satisfaction. Ackerman and Eden (2011) looked at the strategic management of stakeholders in a research paper which spans a period of 15 years and involved 16 top management teams. It examines the power-interest grid with four groups of stakeholders – subjects (low power and high interest), players (high power and high interest), crowd (low power and low interest) and context setters (high power and low interest). This grid, which was applied to a Scottish Office project, could be applied to a major hospital project. The results showed that separating power and interest, stakeholders with significant levels of interest were not necessarily powerful and vice versa. Austen (2008) produced a research report 'Multi-Outcome Construction Policies: Literature Review on Stakeholder Theory' which looks at applying stakeholder theory to construction projects and adapts Freeman's (1984/2010) original conceptualisation of stakeholders or construction. Newcombe (1999) in his stakeholder matrix of levels of interest and power identifies the low power/low interest as the general public, the low power/high interest as the local authority contractor, the high power/low interest as the developer and the high power/high interest as the designers/users. This makes an interesting comparison with Ackermann and Eden more than 10 years later where the roles of designers have changed in the public sector

Olander (2006) also applies a matrix: level of impact to probability of impact related to: keep satisfied, key player, keep informed and minimal effort. This tool can be used for both planning and evaluation for stakeholder analysis and results indicated that failure to involve affected public in the early stages resulted in reactive measures needing to be taken rather than proactively addressing their concerns at the decision-making stage.

Several papers focus on stakeholders in the construction industry Cherns and Bryant (1984) looked at the role of the client in construction management and proposes the setting up of temporary multi-organisations (TMO) as project teams due to the client being a complex system of interest groups, this is very relevant to healthcare projects where there is the need to include multiple and diverse stakeholders. Liu and Walker (1998)'s model of GBPO (goals, behaviour, performance and outcomes) identifies goal attainment as level 1 success and satisfaction as level 2 rewards, as a means of articulating stakeholder involvement. Smyth (2008) looked at the ethics and evidence relating to the gap in stakeholder management and the RIBA Journal (2015) highlighted the need for good client /architect relationships, both emphasising the importance of stakeholder involvement.

Fellows (2014) also looked at client satisfaction and distinguishes between the paying client and the users and that the involvement of the user stakeholders can be seen as an important contributor to competitive advantage. The client in a construction project is identified as the party who commissions the work. Thyssen et al (2010) assert "the client is a complex assembly of different individuals with different values and perspectives". Sensemaking is recognised as important for addressing non-routine issues and problems and Fellows (2014) states that concern should extend to recognition that designing and constructing a building is a social as well as a technical process, hence the sensitivity is required in ensuring stakeholders mutual understanding of their requirements and their priorities. Ward and Chapman (2008) sets out with the premise that stakeholders are a major source of uncertainty and looks at a framework to analyse the issues. SHAMPU (Shape, Harness and Manage Project Uncertainty) is a nine phase process for stakeholder management that differentiates between influencers and stakeholders and a distinction of internal and external stakeholders. This again relates to the power/interest matrices of Ackermann and Eden and Newcombe. They discuss management contracting, joint ventures and PFI but there is no reference to integration– talk of network, role and social dynamics. References to aspirations and contingency allowances and the need to monitor and review during the process.

Bryde et al (2013) created success criteria for construction projects using content analysis of the literature, Lech (2013) determined a project was successful if it met "business/organisational goals (product success) and functionality/schedule/budget met or functionality/schedule/budget adjusted for uncertainty (business change and project planning)". Basu (2014) conducted a mixed methods approach to examine the role of quality in the 'iron triangle'. This examined key stakeholders but only through project and programme manager and found project quality was defined by achieving customer requirements and "quality of the product (design specifications), the quality of management processes (conformance to specifications) and the quality of the organisation (leadership, skills and communication)".

Thomson (2011) suggests the current project management paradigm of framing stakeholder interactions with construction practitioners will be problematic as project sponsors will lack the ability to reconcile differing viewpoints, and the requirements that emerge from them, into a coherent stance. Leung et al's (2004) proposition is that construction team conflict and goal commitment do not predict satisfaction with project outcomes, rather the initial goal-setting process does, a finding at odds with this work. They however only refer to the construction team and not the client.

Shortcomings in current briefing practice and the project sponsor role have been identified. The consequences of a poorly implemented client interface have been reviewed and their influence on stakeholders' perceptions of project success observed. Proposition 2 was supported by stakeholders' desire to see their emergent requirements (rather than those embodied in the initial brief) reflected in the building and the disillusionment of those who received only a superficial response from their managers to their emerging needs.

Thomson's (2011) research established that, in the studied case, requirements continued to be emergent until after occupation and internal client complexity was such that conflict was inevitable and could not be resolved by the project sponsor positioned at the interface between the client stakeholders and the construction practitioners. The paper highlights the need for effective stakeholder engagement. It also emphasises the need for experience and competency in project roles although this has not been mentioned in the paper. It acknowledges the sampling is small and not typical, although the number of stakeholders is representative of many projects as are the participants of the stakeholder groups. The terminology is confusing describing the two groups of stakeholders as: 'Client Body Stakeholders' and 'Construction Practitioner Stakeholders' where the latter includes the client's estates and facilities department, a fundamental stakeholder group within the client body. Given the size of the project there would appear to be too many designers – three architects and three interior designers where the splitting of roles leads to fragmentation in a project which should easily have been handled by the project sponsor. This highlights the difference between the client and a project sponsor who sets the initial requirements.

Turner and Zolin (2012) develop a model of forecasting performance indicators for managers to examine how stakeholders perceive success after project deployment. They recognise projects have various stakeholders and perception can change over time, so the project manager needs to address this. They showed, for the first time, stakeholders can have different perceptions of success criteria. Therefore, stakeholders will also have different perceptions of the success dimensions because they will focus on factors related to the criteria they perceive as important.

Together with Turner (2014) they define the owner and sponsor as separate roles. The owner is the investor (with the main contact being at the start of the project) whereas the project sponsor is a pre, during - and post- project role -this is not the case in public PFI projects. They do not specify the stage of the project when evaluation takes place, but the implication the stakeholder view affects decision making indicates evaluation takes place at more than one time.

Davis (2014) is the first in a series of papers investigating stakeholder involvement and project success. It takes the format of a literature review and provides a background to a proposed set of papers investigating the 'what', the 'who' the 'when', 'how', the 'why', the 'where' with the final 'so what' aiming to achieve a greater understanding of how project success factors can be measured, to facilitate a shared stakeholder view of project success, as a successful project inspires motivation, improves communication, better team working and an increase in productivity. Davis (2014) observed authors were building on Pinto and Slevin's (1987) success factors, as opposed to creating original factors, which implies current literature views these factors as adequate without the need for further research. There was, however, consensus in the literature that time, cost and quality are important when defining success criteria. In Davis (2016), a method is introduced that adopts a post-positivist structured approach to recognise gaps in literature that merit future empirical work and studies projects such as the Sydney Opera House and Terminal 5 Heathrow. It cites the measuring of project success by Thomson (2011) relating to performance metrics in the construction industry based on client judgement highlighting a client becomes more aware of their requirements the further into the project they get, and states that future work is recommended to apply and compare this work to other notable models such as Morris (1997) 'management of projects' paradigms.

Davis (2017) is the third paper in the series and in conclusion suggests the need for a more participative approach using collaboration between the stakeholders involved in determining a projects outcome as a success or failure. It also highlights the need to further investigate the criteria of the 'iron triangle' and factors of 'accountability' and 'benefit to the stakeholder group'. She also states "currently there is no recorded model within the project management literature that is stakeholder centred" is presented. These papers form a kind of parallel with this thesis as the subject is progressive and develops over several years culminating in the presentation of a new 'Multi Stakeholder Model' (Davis, 2018).

Healthcare design and in particular major hospitals involve multiple groups of stakeholders which provides a large and concentrated source for research. This source is generally untapped but more recently the subject is being investigated. Pemsel et al (2009) looks at communication, behaviour and skills in managing the needs of end-users in two projects – one a university the other a hospital. The focus is an interaction among three parties: end users, end-user project manager (EPM), who is a selected end-user and a facility planner (FP), a facilities' professional. It looks at the whole construction process covering: briefing, design and delivery and concludes there is no real method for managing user input throughout the process and there are social and cultural barriers to overcome through understanding and communication.

These social and cultural barriers in relation to healthcare stakeholders are also discussed by Collinge and Harty (2014) who identify communication as fundamental issues with stakeholders and uses NHS construction projects as a study. Both the NHS and construction use acronyms and terminology which neither party intuitively understands and the language of the paper itself demonstrates the problems of communication as I found it difficult to understand. They consider hospitals a good study medium, but the paper does not demonstrate a deep understanding of hospital planning and design which is the critical issue with stakeholder communication; the ability to understand the stakeholders' needs and translate them into design layouts. Unfortunately, the interview sampling does not include designers who are acknowledged by many authors as the main participant in stakeholder engagement. The paper does highlight the issues of communication and the difficulties encountered in hospital design. The word 'communication' is broader than passing information from one party to another. In interpreting client requirements, it involves understanding what individuals are trying to explain in a situation where design and construction language is very different to medical language. It also involves different means of communication including visual forms in terms of drawings and models. The reference to "expected quality or performance" is not so simple as stated as many clients do not realise until a project has been completed that it is not what they want or expected. Mahadkar et al (2012) carried out action research studies in Primary Care Trusts (PCT) and developed a Strategic Asset Management (SAM) plan involving stakeholders. Although PCTs are very different from NHS Trusts involved with major hospital projects they still have a diverse set of stakeholders and require the same skill sets to manage them. They acknowledge that further research is required, including the adoption of visualisation and modelling tools.

Locatelli et al (2014) investigated complex projects in terms of time, cost and quality/benefits. They suggest the application of a systems engineering approach to the governance of projects and stakeholder management to enhance performance. Further work was proposed into organisation structure and culture for complexity, but they do not consider project success dimensions. This raised the question of how they aim to improve governance without the need to understand stakeholder's perceptions of governance and success. This paper and Mills and Razmdoost (2016) which looks at Key Account Management (KAM) teams in a longitudinal study involving education facilities and the relationship with stakeholders introducing the use of temporal bracketing and abductive reasoning to learn lessons. This helps to connect stakeholder engagement within individual project delivery and the wider delivery system.

4.3.4 Work Package Design – Preparation of Construction Information

The term works package design is used to describe the process which links the design development stage and operations on site. The adoption of this terminology allows for different levels of specialist and subcontractor design to be included in the tender document as it allows for additional technical design phases to be incorporated including the different design process used by mechanical and electrical services consultants:

Traditional Subcontract Package:

1. Architect's Drawings and Specifications issued
2. Tender by subcontractor
3. Accepted Tender

Specialist Subcontractor Package:

1. Architect's Drawings and Specifications issued
2. Tender by Specialist Subcontractor
3. Specialist Subcontractor selected

4. Architect's and Specialist Subcontractor's Drawings reissued following review
5. Specialist Subcontractor Tender accepted

Mechanical and Electrical Subcontractor Packages:

1. Engineers' schematic drawings and specifications issued
2. Tender by subcontractors
3. Tender accepted
4. Subcontractor prepares prefabrication and installation drawings

Ironically this stage is the one which has had different classifications through the various project plans but does not appear to have been investigated in research studies. There are many studies on supply chain management by Pryke, Dainty and Koskela relating to how these work packages are set up and the benefits in terms to clients, and the creation and transfer of knowledge. They do not however link how these supply chains relate to the design process. In the healthcare sector there are two supply chain mechanisms: the construction supply chain and the client's supply chain relating to major medical equipment and consumables. Some of the issues relating to the client supply chain are contained in Appendix C. Also in Appendix C is literature relating to Requirements Management, which has its roots in the IT industry, Young (2006) describes a process where continuity and management with subject expertise contribute to project success. This could be applied to design management particularly during the development of work packages where each package is similar to an IT project and highlights the need for an experienced design manager to bring these packages together. There are references to construction by Green et al (2004), Jallow et al (2014), Kamara et al (1999,2000 and 2002) and Fernie et al (2003) and Pegoraro and Paula (2017).

4.3.5 Design Management during Construction Activities

Design management involves communication and not just the distribution of information between parties. A design manager needs to be able to understand the translation of client's requirements, through the design drawings to ensure that a fully compliant design is constructed, working with both the design team and the construction team. Den Otter and Emmitt (2008) looking at communication within the design team and the complexity of design tasks discovered the preferred method of involved dialogue. Team communication via face-to-face communication is considered essential to facilitate and stimulate the design process. Specialist design knowledge is usually embedded in the team and needs to be communicated to become useful knowledge for the design to be produced – this is of particular relevance to major hospital buildings where individual design team members work on specific tasks which need to be integrated. This concept of dialogue is also supported in the AJ Site Architect's Guide (1983) where informal lines of dialogue existed in the form of the "Gossip Column" Figure 23 where individuals struck up relationships with their counterparts.

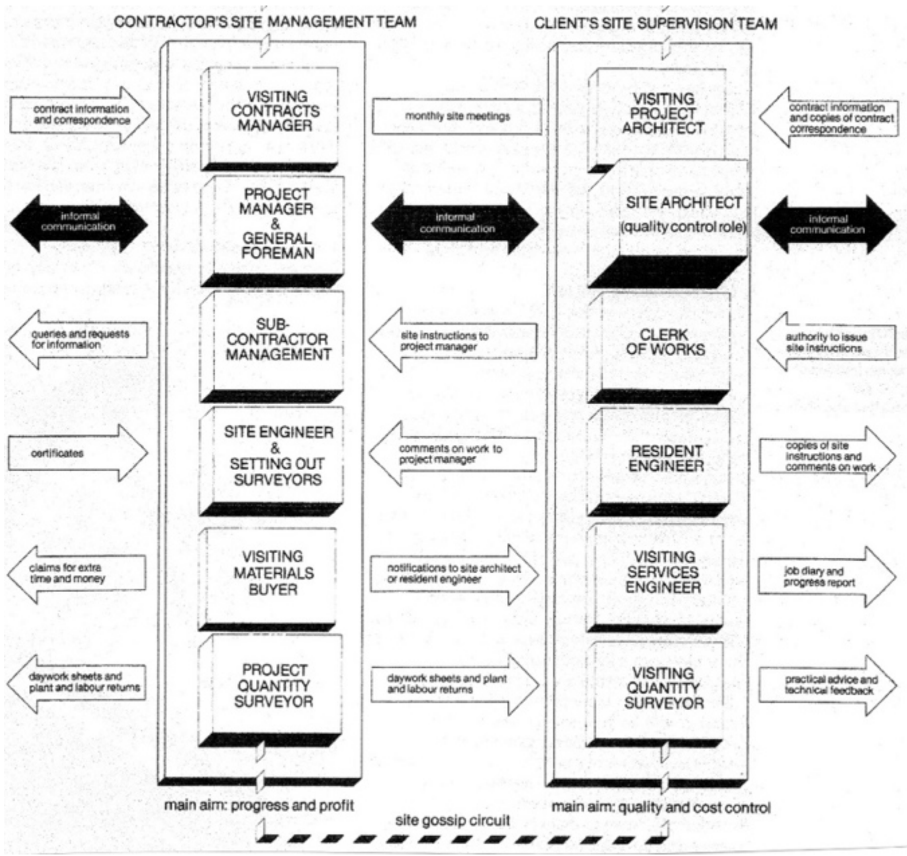


Figure 23 The Gossip Column

The benefits of this simple set up are also reflected by Daft and Lengel (1984) who introduced a theory based on a hierarchy of information richness which provided the availability of instant feedback, the capacity of the medium to transmit multiple cues such as body language, voice tone and inflection, used natural language and personal focus of the medium.

Design information management during the construction phase is vital to project delivery and is mainly the task of document controllers working as part of the construction design management team led by the construction design manager, two design management functions exist related to change management and compliance checking. Shipton et al (2014) discuss the process of making changes to a hospital project utilising an NEC form of contract and how these were used to control changes, finding that the majority of changes are client led and sometimes opportunities from potential changes are rarely considered. They also noted the absence of the designers associated with these potential changes were not part of the on-site discussions.

4.3.6 Design Feedback

The original RIBA Plan of Work 1964 included Part M: Feedback, with the intention of collecting information on design outcomes as part of knowledge transfer. This stage was covered within the architect's fee structure and as a result was rarely carried out. Post Occupancy Evaluation (POE) was first introduced in Scotland and the United States in the 1960s and one of the earliest examples comes from the Scottish Home and Health Department who carried out and published 'Building in Use' studies of their projects. The first of these relates to the Vale of Leven Hospital, published in 1963, some 10 years after the handover and involved a team comprising of the hospital staff, medical and surgical teams, the regional physicist and the regional architect. It is a very detailed study where at the end of each section it includes "points relevant to future planning". Unfortunately, this procedure was abandoned after a few studies and although published through HMSO was not widely accessed.

A summary of lectures from a Study Course for Architects in Hospital Design at the Bartlett School of Architecture, University College London (1963) includes a paper by Whitehead promoting the value of 'Building in Use' studies and provides valuable information for healthcare design. Previously, in 1960, the RIBA produced 'A Hospitals Course Handbook' following a series of lectures and presentation at the RIBA which also referred to work studies presented by the Department of Health for Scotland.

This time frame equates to the period before Temporal Period 1, but it is contemporary with the setting up of MARU (Medical Architectural Research Unit) which subsequently carried out a number of POE studies up until 2017. The research work carried out by MARU is cited by a number of authors including Carthey (2006) which considers developing a standard methodology for POE in Australian health projects with the aim of developing design standards for future projects, cementing the link between post occupancy and briefing. It draws on MARU principles and explains why a standard methodology should be adopted.

My initial observation of client dissatisfaction was as a result of taking part in a MARU post-occupancy evaluation study (Appendix A) where it was obvious that knowledge from previous projects had not been incorporated indicating an absence of post-occupancy studies being available in either the public domain or with the relevant building sector. Since

1964, when the first RIBA Plan of Work was produced as a Project Management framework covering all the work stages from briefing to feedback. The idea of feedback was to inform future projects as to how the building performed in terms of functionality, build quality and more recently sustainability (energy performance). Post Occupancy Evaluation (POE) is one method of carrying out feedback, but although part of the RIBA Plan of Work it was not included within the building cost. Hay et al (2018) cite one of the barriers to POE as being related to Insurance and liability “insurers have been worried that POEs increase professional indemnity” which could explain why there is a reluctance to share findings.

Few literature references exist in the early temporal periods with Preiser one of the few authors of the time continuing to review and update the subject. Preiser et al (1988) defined POE as "the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time".

Looking at how buildings adapt over the years, Brand (1994) is one of the earliest references to why POE should be carried out and also introduces the concept of levels with six stages in relation to buildings: site, structure, skin, services, space and stuff. This looks at post occupancy as how the buildings have performed on various levels. Preiser et al (1988) and Presier and Vischer (2005) however consider POE to be a process of systematically comparing actual building performance. Macmillan (2004) stresses the importance of feedback as a means of improving design.

Generically, POE is the review of the performance of a building in relation to its users. BarBlyth and Gilby, (2006), examined this in relation to the effectiveness for human users of occupied design environments and although written for the education sector is a good example for carrying out POE guide. Zimmerman and Martin (2001) described it as a generic term for a variety of general programme and procedures as well as specific techniques for the evaluation of existing buildings and facilities and consider it should be built into the process. Baird (2001) focuses on commercial buildings with emphasis on engineering services.

The British Council for Offices (BCO, 2007) suggests the evaluation must be an evidence-based review of how a building supports the functioning of an organisation and meets individual end-user requirements. A number of publications examining the evaluation of buildings, most recently Gorgolewski (2005), and Preiser and Nasar (2008), show how feedback could be integrated into every stage of a building’s lifecycle. However, in practice most architects and contractors have shown little interest in learning how their buildings actually perform in use; and clients seem reluctant to pay them to do so (Bordass, 2005).

According to Bordass and Leaman (2005) there are currently five different POE feedback techniques, which designers and clients may apply strictly or select a mix of methods from. These are:

- **Audit-based**, application of repeatable and scientific quantitative methods (often reviewing technical performance);
- **Discussion-based**, these are discursive and facilitated discussions between people on functional output and subjective outcome;
- **Questionnaire-based**, a general and repeatable occupant survey which may contain qualitative and quantitative items;
- **Process-based**, a live and dynamic project and design feedback that contributes to an evolving and adapting process; and,
- **Package-based**, the incorporation of a number of techniques.

Audit-based POE approaches often include those measurement methods that are energy or technical system/environment performance centred include the CIBSE TM22 (2006) energy assessment and reporting method (EARM). Discussion-based methods such as Healthcare Design Quality Assessment (Burt-O'Dea, K., 2005), and the Higher Education Design Quality Forum (HEDQF) method (Doidge, 2001), the Constructing Excellence Learning from Experience (LfE) method (Bartholomew, 2003), and the functional space fit method developed by the American Society for Testing and Materials Standards (ASTMS) (Prior and Szigeti, 2003). Questionnaire-based methods include AUDE POE guide, Building Use Studies (BUS) is a comprehensive study of user needs, the Construction Industry Council Design Quality Indicator (DQI), which also incorporates a trained facilitator and workshop function, finally an Overall Liking Score (OLS) and occupant feelings/attitude survey (Levermore, 1994).

Process-based POE includes the Building Research Establishment (BRE) Design Quality Method, this is possible the most extensive multi-parameter and bespoke review that includes architecture; environmental engineering; user comfort; whole life costing; detailed design; and user satisfaction components Cook (2007). Soft Landings; BSRIA, (2019) and Bordass (2005) look at feedback during projects. Package-based POE methods include both qualitative and quantitative methods and evidence bases that support briefing, approaches include the AMA Workware toolkit (Preiser, 2005), Value in Design (VALiD) an approach developed and applied by Loughborough University (Thomson, 2003; Mills, 2013) and PROBE (Post-Occupancy Review of Buildings and their Engineering) (Baird, 2001).

The final set of POE methods include competition-based methods such as those set up by influential people and institutions like RIBA, BCSE, The Society of Critical Care Medicine (SCCM), Design and Health, Healthcare Design, American Institute of Architects/Academy of Architecture for Health (AIA/AAH). POE may have an additional benefit of enabling benchmarking between projects, often through the application of questionnaire or competition-based approaches to POE such approaches include: BUS, DQI. Bordass and Leaman (2005) stress the importance of feedback and how it differs from 'soft landings'.

Leaman, Stevenson and Bordass (2010) look at the practice and principles of carrying out building evaluations and consider the current divisions of responsibility make it difficult to close the feedback loop from building performance in use to briefing, design and construction. It concludes the construction industry designs and alters buildings but does not know much about how they perform in use. NHS Scotland (2012) Scottish Capital Investment Manual outlines procedures for post occupancy evaluation which have to be carried out

Soft Landings (BSRIA, 2019) sets out to deliver projects which reflect the client's requirements – brief – as included in the project agreement. This however does not guarantee the completed building will live up to client's expectations. This will only happen if the briefing process has been carried out properly. Green and Moss (1998) looks at SMART value management as a means of closing the loop between post occupancy evaluation and briefing, and the facilitation skills required for VM could be applied to post occupancy evaluation to improve outcomes for future projects. Williams et al (2013) looks at POE from a different perspective – from a contractor's point of view where the corresponding author works for a major UK construction company. It highlights the fact that client commissioned POE generally involves the designers and not the contractors and contractors have internally carried out 'lessons learnt'. It cites the lack of structured POE and the many barriers to POE- some of which have been subsequently highlighted by Hay et al (2018). Carrillo et al (2013) also discuss lessons learned within construction companies and cite Secchi et al's (1999) definition

> "A lesson learned is a knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. Successes are also considered sources of lessons learned. A lesson must be significant in that it has a real or assumed impact on operations; valid in that

> it is factually and technically correct; and applicable in that it identifies a specific design, process or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result."

This definition emphasises that lessons learnt can be positive and negative. Lessons learnt focuses mainly on the construction phase and the paper identifies similar barriers to this as in in POE (Hay et al, 2018). The conclusions highlighted a disparity between the goals and outcomes, a lack of value and transparency about the collection of data and the limited use of knowledge management systems. It emphasised the need for "a champion and an adoption team to sell benefits and support users".

They conclude although a lot of practical work is being undertaken, which is currently focused on energy and sustainability, there is an appetite for more holistic evaluation measures. Whilst concluding there is no single shared definition, all the participants saw the value in undertaking POE even for their practices and making the case for investment to their clients. Interestingly one of the barriers to carrying out POE related Insurance and liability - "insurers have been worried that POEs increase professional indemnity" and "design and build contracts seen as counter-productive to POE". Another issue involved deregulation and the need for institutional support from the professions. They also identify the difference between professionals: expressing frustration with existing POE toolkit's that appear to favour quantitative measures that capture the 'headlines' but do not delve into the experience and feelings of building users or participants. Engineers and surveyors were more naturally inclined to focus on quantitative aspects, whereas architects were seen to have "very different priorities" and a capacity to take a broader view: "we are committed to creating places for people, place -making with people at heart, rather than just thinking about building". Participants reported that even a light touch POE is "better than nothing" e.g. lessons-learnt visits may not be labelled as POE but are nevertheless useful to practitioners and clients and can be used as a means of embedding POE.

Derbyshire (2001) expressed dismay at the findings of two architectural books: Muthesius and Dormer (2001) and Edwards (2000) on the design of modern universities which failed to evaluate the designs in terms of performance and focused purely on their architectural appearance. He also expressed surprise at the attitude of Basil Spence and Denis Lasdun regarding briefing where the former did not brief in development planning at Sussex University and the latter did not have a brief and did not want one at East Anglia University. These comments from Derbyshire (2001) are a prime example of how POE has failed to integrate knowledge and is disconnected from briefing with no apparent concern. A more recent architectural book by Singha (2020) on the future of healthcare design presents a similar evaluation of design as Muthesius and Edwards focusing on the aesthetics but overlooking some serious functional aspects design.

Over this 40 year period what is clear is post occupancy evaluation has been carried out sporadically and in different formats often it is too late making it difficult to transfer knowledge for future projects. The value of post occupancy evaluation is however recognised and this gap in the transfer of knowledge needs to be addressed. Sydow et al (2004) highlighted the difficulties of transferring knowledge amongst project based organisations which confirms the issues with sharing knowledge from post occupancy evaluations.

4.3.7 Design Management Roles

Emmitt and Ruikar (2013) consider the emergence of design management in the construction sector to have occurred in the early 1990s as contractors adopted new procurement routes. The terms design manager or design co-ordinator started to appear but without formal definitions. Prior to this time the management of the design was largely the domain of the architect, as set by Emmitt (2007) and Emmitt (2014) who then updated the book to reflect the changes taking place in the construction industry. Emmitt (2010) looks at managing inter-disciplinary projects and again Emmitt (2016) focuses on the construction design manager as the role becomes more prevalent. Emmitt and Ruikar (2013) suggest prior to this date "contractors had previously employed 'resident architects' and 'resident engineers' to help review and co-ordinate design information and deal with design changes". According to the AJ Site Architect's Guide' (1983) this terminology of 'resident or site architect' and 'resident engineer 'refer to individuals employed by the client; resident engineer is the client's equivalent of the contractor's site engineer. No equivalent of the architect existed on the contractor's team as at the time architects were unable to work for contractors without resigning from the professional body.

Lahdenpera and Tanhuanpaa (2000) uses the term design co-ordinator, a term frequently used by contractors on small projects as an assistant to a design manager on a large project. It must not be confused with the activity of design co-ordination which is the function of the lead designer – normally the architect on building projects. They state "the design co-ordinator cannot be an expert on all information needs of every discipline". In order to address this issue, they suggest the development of design management systematics using a design structure matrix and critical path method. The model is then split into three levels:

design disciplines, design phases and design tasks. This type of tool is similar to ADePT developed at Loughborough University in the 1990s.

Bibby et al (2003) state in order to succeed, design management requires a range of professionals to collaborate, and a significant barrier to this is a lack of understanding of the motives and actions of others. One of these barriers being the relatively low position of the design manager within the project team structure and design management and not commanding significant authority within the power structure of a construction project, a view also held by Heath et al (1994). With the construction phase of a project expending the majority of the capital cost of the project, in design and build the focus lies with construction and the procurement of work packages, resulting in non-design focused team members taking the lead. Bibby et al (2003) conclude improving design management practice within a design and construction organisation is a long-term activity and must also overcome a range of significant barriers, not least the underlying company and construction culture. The conclusions also highlight the position of the design manager within the project both in terms of comparable seniority and authority. Tzortzopolous and Cooper (2007) also conclude there is a need for clarity in the definition of design management from a contractor's perspective and also in the skills and competencies required to work as design managers.

Smith et al (2004) describe a design management case study within an Australian design and construct organisation where the role of design manager as an information manager, has expanded to focus on the customer. This case study involves the relationship between a newly created role of a design manager as a link between the project manager and the cost manager to integrated processes and teams, with a no-blame culture of mutual independence, trust and respect, an environment of sustained improvement and commitment to training. Design and build, has according to them, impacted quality (as a result of contractor's altering the design or detailing to suit their particular methods of construction or supply chain). In order to address the issues with integrating design management into construction project management, the company created a structure which has the Design Manager (who was an architect) and the Design Cost Manager (a quantity surveyor) equally accountable to the project manager.

Emmitt and Ruikar (2013) and Enyon (2013) provide definitions and guidance for design management as a formal discipline in both practice and education following its development in contractor-led design and build procurement. Enyon (2013) describes design management of all project-related design activities, people, processes and resources as:

- Enabling the effective flow and production of design information;
- Contributing to achieving the successful delivery of the completed project, on time, on budget and in fulfilment of the customer's requirements on quality and function in a sustainable manner;
- Delivering value through integration, planning, co-ordination, reduction of risk and innovation; and,
- Achieved through collaborative and integrated working and value management processes.

Emphasis is given to the design manager's role in a construction company, but less so within other organisations such as Architectural practice, and there is a lack of focus on stakeholders' requirements.

Enyon (2013) defines design management roles according to the project stages as:

- Strategic Front-End Design Manager during the pre-project phase;
- Preconstruction Design Manager during procurement;
- Delivery Design Manager (site based) during project delivery and
- Strategic Back-End Design Manager post project/ project operation

Although these stages correspond roughly with the RIBA Plans of Works (1964, 1976, 2007, 2013 and 2020), the descriptions align with design and build procurement rather than the traditional route of the RIBA. In identifying the different design management roles Enyon (2013) suggests that strategic design managers could possibly be consultants to the client and that the preconstruction design manager could be either a member of the construction company or the lead designer with the delivery design manager being a member of the site team.

Knutt (2014), in a feature article on design management, discusses architect-contractor relationships with Rab Bennett of Bennett Associates and Alan Crane, Past President of the CIOB. The article concludes there are very few good design managers employed by contractors, but also many designers who provide poor construction information. They consider the industry has been more fragmented over the years compared with the 1970s, an era described as the "High point of collaborative working" where they contribute its success to it being simpler – "a lot of it was talking, not e-mails, where a conversation can cut across dozens of e-mails". These findings support the earlier "gossip column" scenario outlined in the AJ Site Architect's Guide (1983) and communication, Den Otter and Emmitt (2008)

Zerjav et al (2013) looks at process-level design management in relation to a large-scale engineering infrastructure project and identifies a gap between process-level research and management studies of the design organisation and calls for “the development of design management techniques that acknowledge the reflective practice of design management”. The paper sets out certain skills required to carry out the role of design managers, but do not suggest how this can be achieved.

Design Management has been further defined by Knotten et al (2017) as Building Design Management (BDM) which focuses specifically on architectural projects and proposes BDM as an integration of Sinclair (2011), that design management is the discipline of planning, organising and managing the design process and Emmitt and Ruikar (2013), who simplified it further as managing people and information. What is not clear however is how this would translate to design and build as the model identified has the architect as design manager, Sinclair’s (2011) interpretation in a direct relationship with the client as in design-bid-build. They introduce the concept of integrated concurrent engineering (ICE) (not to be confused with the with the UK acronym for the Institute of Civil Engineers), developed by NASA, as an approach with synchronous communication where key stakeholders work together at the same time with the same topic where the preconditions are rapid decisions, a clear work scope and well-prepared stakeholders. It does however provide a good starting point for further research identifying the different interpretations of design management held by Sinclair (2011), whose focus is towards architects as managing design and Emmitt and Ruikar (2013), also architects focusing on design management within construction companies where the term is predominately used.

Just as with post occupancy evaluation little research has been done in the last five years to examine how design management is evolving. The different interpretations of what design managers bring to the process, how they are integrated into the teams and what skills are required presents an opportunity to research this gap.

4.4 Systems Theory and the Role of a Systems Integrator

The definition of systems integrator is from Hobday (1998) as the person who coordinates the activities of stakeholders throughout the various phases of a project such as ‘pre-production bidding, conceptual and detail design, fabrication, delivery and installation, post-production innovations, maintenance and sometimes decommissioning’. Earlier Bonaccorsi et al (1996) outlined the case for a single systems integrator working through the whole project cycle whereas Winch (1998) in contrast suggests that construction has two separate system integrators; the principal architect at the design stage and the principal contractor at the construction stage. Nam and Tatum (1997), also argue that the role of the principal architect/engineer and principal contractor is central to all innovations.

Joseph et al (2006) using a research methodology, where the researchers chose a purposive sampling method using open ended questions in digitally recorded 13 interviews lasting 40-90 minutes, identifies four major roles of the system integrator depending upon the phases of the project:

- The strategist
- Architect or designer
- The implementer or project manager
- Operator or support system integrator

As these phases often run in parallel the result is that various types of system integrators may work together to achieve project targets.

Brady et al (2005a) proposed integrated solutions which are unique combinations of products and services that address a customer's specific business problems. Identifying customer satisfaction is according to them a key constraint. They suggest that the Special Purpose Vehicle in PFI forms of procurement acts as the systems integrator and Brady et al (2005b) looks at how systems integrators and integrated solutions are perceived in construction and concludes that the growth of PFI is likely to push for integrated solutions in the public sector due to repeatable solutions. Barlow and Koberle-Gaiser (2008) also looked at the role of the SPV as a systems integrator and concludes that in the early healthcare PFIs this did not happen, and that the role was more of a hindrance. They identified the need for a systems integrator who could integrate the design and construction with the clinical operations in hospital. Studying the effect of project form and design resulting from (PFI) they concluded that the early PFIs (circa 2000) have failed to deliver the innovation that a systems integrator in the form of the SPV (Special Purpose Vehicle) could have delivered. Barlow and Koberle-Gaiser (2008) also mention adaptability as innovation and look at hospital design from the 1960s including Nucleus hospitals which they acknowledge was an example of systems integration but with no systems integrator.

Davies et al (2006) who had previously studied single systems integration in the manufacturing and service industries, extended their research into infrastructure projects and Davies et al (2009) identified six processes required to execute a mega project including systems integration in design, construction and operation into a system which is controlled by a systems integrator. At Heathrow Terminal 5 the client was the systems integrator, although one of the major contractors involved has also carried out this role on other projects. Davies et al (2009) also introduced the concept of a system of systems integration (now described as meta systems integration) related to the project at Terminal 5 Heathrow which could describe a major healthcare project where several systems exist. Davies and Mackenzie (2014) examine the construction of the London Olympics as a complex example of systems integration and relate it to a 'meta systems integration' being at a higher level. The paper looks at different levels within the systems and the clearly defined integrated and buffers between levels and individual component systems and recognises the need for further research into how systems integration is required to deal with project complexity and on the dependency of the capabilities of individuals and organisations involved.

Erbil et al (2012) also looked at the role of a systems integrator(s) in particular the role of architectural designers as systems integrators in the innovation process, making reference to scholarly addresses relating to on-site processes, project management and organisation of the construction firms whilst Prencipe (2012) states that a system integrator needs to 'develop a set of in-house technological capabilities that are broader than their particular activities (i.e. 'they know more than they do')'.

The majority of these references span a period of 10 years covering a period when construction projects were contractor led and focus on the contractor as the systems integrator. Some acknowledge that in the design bid build form of procurement, the architect is the systems integrator and in the case of Joseph et al (2006) there are up to four systems integrators.

4.5 Learning from Project Management

Egan's Rethinking Construction (1998), which followed Latham's Constructing the Team (1994), set out to challenge the construction industry's performance, which was in need of dramatic improvement particularly in relation to time and cost. Morris et al (2012) recognises the need for value to be built and benefit realisation optimised, not just delivered efficiently "on time, in budget, to specification". The Critical Path Method invented by DuPont (1957-59) was seen as a symbol of project management and was first adopted by contracting organisations as part of the project planning activities (Harris and McCaffer, 1989).

As a result of Latham and Egan public procurement moved away from the traditional form to Contractor Led Design and Build which was seen as bringing more certainty in terms of time and cost, with a single point of contact – the building contractor. Ironically, the NHS building programme, which used a well-developed 'standardised system' including cost guidance which managed cost within traditional procurement was abandoned as a result of freedom of choice. This results in a change of emphasis in terms of time, cost and quality. Various tools such as AEDET (Achieving Excellence Design Evaluation Toolkit) and DQI (Design Quality Indicators) have been introduced to bridge this gap. Following the attempts to re-engineer construction to improve performance, Winch (2003) suggests mass production is not relevant to construction and refers to hospitals as an example of major projects where they rely on concept to order strategies. He recognises the need for 'lean' but, also because of its complex nature, does not think comparisons should be made with the automobile industry. Fewings (2005 and 2013) considers project success depends upon strategic planning, integration and ensuring the right people are involved. The 2005 edition includes a chapter on the PFI model of DBFO and the book is updated in 2013. The book also acknowledges the changing roles and the development of design management, although the interpretation of design manager is seen through the eyes of a planning engineer.

Project failures were related to exceeding initial budgets, completion beyond target date and lack of expected quality or performance requirements. One example quoted is Terminal 5 Heathrow - completed on time but failed to meet user needs (Brady and Davies, 2010). Analysis of this project indicated inadequate client requirements management contributed to the problem. The paper states for a project to be deemed successful, it has to be completed within the defined constraints (budget and time) and meet the quality and performance requirements. In the RIBA Plan of Work 2007- the functions of construction project management include: defining client's requirements; establishing a good communications channels in which all parties can perform effectively; developing and managing a good change control procedure; and, monitoring all decisions and approval in respect of the programme.

Brady and Davies (2014) analyse two complex mega projects at Terminal 5 Heathrow and the London Olympics, both large infrastructure projects. The projects being selected as having been delivered on time and within budget. The disastrous public opening of Terminal 5 was not due to time or cost and BAA admitted afterwards they had perhaps not worked closely enough with airline customer post-handover of the facility, one of the issues raised previously by Brady and Davies (2010). In this follow up paper it was noted both projects displayed strong leadership and capabilities, collaborative behaviours, the ability to be adaptive and responsive, innovative approaches, the use of digital technologies and an outcome-driven approach. They acknowledge in the case of the Olympic development lessons had been learnt from the issues that took place during the handover period at Terminal 5 Heathrow. They consider some culminative learning has taken place in the UK on how to manage complex projects and the Crossrail project is being managed in the same way. They also consider that although they have concentrated on megaprojects the concepts of structured and dynamic capability may usefully be applied to other projects.

Kelly et al (2013) examines the sharing of knowledge and the role of the project manager and confirms the limited usefulness of knowledge management initiatives, but also makes reference to Ratcheva (2009) who suggested that social networks seemed to favour the transfer of learning and lessons learnt which again confirms the value of the gossip column in the Site Architect's Guide (1983) and networks such as MARU and EuHPN.

4.6 Reflections

This chapter has reflected upon design management. It has defined the various stages in the current design and construction process and the role of design management in integrating the process.

There are however conclusions which can be drawn from the literature in this chapter:

- Design management is a developing discipline (Emmitt and Ruikar, 2013) and lacks clear definition of implementation and processes particularly in healthcare projects.
- The RIBA Plans of Work (commonly adopted) have issues with critical design/ construction interface stages suggesting a new integrated approach is required.
- The levels of design management, including roles and responsibility mean different things to different people/ organisations
- There are few holistic studies of managing design requirements during design and limited post occupancy evaluation into hospital building projects
- There are issues with communications and terminology in terms of roles and function as demonstrated by the use of the terms such as design coordinator, Design Management and Design Information Management
- Lack of using critical incidents to identify issues of systems integration
- The role of a systems integrator is generally considered to be beneficial to projects but there are opinions as to who carries out or should carry out this role. In some

instances, different parties are identified at different stages but not different disciplines carrying out the role throughout the process. The role is linked to the type of contract rather than the overall system.

Chapter 5 Temporal Period 1: Prescriptive Integration

5.0 Temporal Period 1 Prescriptive Integration

5.1 Introduction

The approach taken in this thesis is auto-ethnography as I have been involved in all the case studies in a senior design position either as an architect or a design manager. I have defined the Temporal Periods in terms of my project case studies longitudinally which reflect the stages in my professional career, education and academic reflections. Against each temporal period there is a description of what happened in relation to the wider delivery model (Table 15). The descriptions of these temporal periods reflect my interpretation in relation to the level of integration which took place. It is based on the case study and a general view of what was happening in the wider delivery model. I have described this first temporal period as prescriptive integration. It is the longest of the temporal periods spanning from 1975 to 1993 and represented a stable period in terms of established processes and procedures at a time when the government invested heavily not only in hospital building but in healthcare design research and development.

Table 15 Temporal Periods and Period 1.

Project Delivery Model		Wider Delivery model
Temporal Period 1 Prescriptive Integration Case Study 1 Design Bid Build	1975-1993 Chartered Architect, RIBA 1976 Project Architect	Nucleus hospital programme; England and Wales, NHS Estates extensive guidance in the form of HBNs and HTMs Underpinning of professional services
Temporal Period 2 Dysfunctional Integration Case Study 2 First Wave PFI/ Contractor led Design and Build	1993-2001 MSc Construction Project Management (1993) Project Architect	Removal of professional fee structures Removal of Crown Immunity 2001 Change of procurement – role reversal between architects and contractors Reduction in support by Department of Health
Temporal Period 3 Adaptive Integration 1 Case Study 3 Second Wave PFI/ Contractor led Design and Build	2001-2006 MSc Planning Buildings for Health (2006) Project Architect/ Senior Design Manager	Department of Health began to reduce investment and support for research and development Architects losing skills related to stakeholder engagement, contract administration and the ability to learn from site inspections
Temporal Period 4 Adaptive Integration 2 Case Study 4 Third Wave PFI/ Contractor led Design and Build	2007-2012 Senior Design Manager	Department of Health continuing to reduce investment and support for research and development Advances in Medical Technology
Temporal Period 4 Disintegration Case Study 5 PF2/ Contractor led Design and Build	2013-2020 PhD Thesis Health Design Consultant	Department of Health ceased investment and support for research and development. Last update of HBNs 2013 Adoption of multiple design consultants

This first case study is described as prescriptive in terms of meeting standards and guidance, but as in was in Scotland was not subject to the even more prescriptive functional layout imposed by the use of the nucleus template.

As outlined in Chapter 3 the auto-ethnographic method of narratives used adopted from which identified critical incidents and the introduction of new positive integration. A hypothesis that a requirements' crunch point (RCP) had an effect on project outcomes, which initiated this thesis, although no longer the focus of study was identified in each case study to determine at what point in the project did it have an influence on the outcome. Chapter 10 analyses the longitudinal outcomes from the five temporal periods. The full narratives are contained in the appendices.

5.2 Case Study 1 Background

Case Study 1 is a district general hospital in Scotland which first started in 1980 and was procured traditionally with the architect as the 'supervising officer' and the main contractor selected through competitive tendering. The project required several approval stages:

- Pre-design Cost Limit – in theory no design required, based on departmental cost allowances;
- Preliminary Cost Limit (PCL) – based on 1:200 layouts, elevations etc.;
- Final Cost Limit (FCL) – based on 1:50 room layouts, detailed design; and,
- Pre-Tender Estimate – based on an outline Bill of Quantities.

Delays in stage approvals meant it took until December 1987 to get approval to issue the tender documentation. The tender period was three months and with a 90-day tender acceptance period the contract was not awarded until June 1988 as a result of savings having to be made to the tender.

The new building was constructed on a greenfield site adjoining the existing Edwardian hospital which contained mainly wards (Nightingale), outpatient facilities and accident and emergency. The main radiodiagnostic department, together with orthopaedic operating theatres and wards, was situated in an 'ex-wartime hospital' outside of the town. The planned redevelopment on the main site was to provide a new building with facilities for accident and emergency, radiodiagnostics, Intensive Care, outpatient department, new operating theatres, an additional 200 beds, a new boiler-house and upgraded kitchen facilities.

The initial construction programme should have taken three years, but due to several major changes, delays to the programme resulted in a 48-week extension of time being granted and the building was handed over in 1992.

The full narrative is contained in Appendix C.

5.3 Case Study 1 Critical Incidents

Critical incidents describe events which had the potential to seriously disrupt time, cost, quality or a combination of the three elements of project management. The table format sets out these critical incidents over six design stages:

1. Pre-design
2. Concept design
3. Design Development
4. Works Package Design
5. Design in Construction
6. Design feedback

Each critical incident is then described in terms of what caused it, what effect it had on the project, how it was resolved and what lessons were learnt.

Table 16 sets out the critical incidents related to the temporal bracketing periods:

Table 16 Case Study 1 Critical Incidents

Design Stage					
Ref	**Critical Incident**	**Cause**	**Effect**	**Resolution**	**Lessons Learnt**
1. Pre-design					
2.Concept Design					
3. Design Development					
4. Work Package Design					
1C1	Lowest tender was greater than the approved pre-tender estimate	Mechanical and Electrical Tenders were greater than their estimates – QS had no control over M&E costs	Delay in contract award	Savings had to be made in the builder's work to cover additional engineering costs	Greater need to integrate within the design team.
5. Design in Construction					
1C2	Contractor seriously behind programme	Lack of experience by site management team, site engineers and general foreman	Failure setting out concrete frame resulted in remedial works Low site moral	Replacement of the site management team, engineers and general foreman in agreement with the design team	Contractor's reputation at stake, being one of the largest companies does not guarantee success
1C3	Difficulties by the architect in providing information to the site timeously	1. Difference between the information required for tender and construction 2. lack of experience of site architect	Potential delay notices submitted by contractor due to lack of information Extreme pressure being continually behind	As Project Architect I relocated to site 3-4 days per week	Need to work more closely with the contractor
1C4	Subcontractors' request for setting out information for M&E services (1)	Status of Room Information Sheets 'for information' and not 'construction issue'	Major dispute between ourselves (architects) and the Common Services Agency (CSA) Engineering Division	Status of drawings confirmed as 'for information' and agreed to review 1:50 drawings jointly on site	Lack of transparency of consultants' appointments Site review meetings were more effective and less confrontational

Ref	Critical Incident	Cause	Effect	Resolution	Lessons Learnt
1C5	Subcontractors' request for setting out information for M&E services (2)	1.Subcontractors responsibility to take site sizes for manufacturing ductwork. 2. Grille positions required for rigid connections	Subcontractor unable to take measurement due to no partitions being erected	1. Partition head channels fixed to concrete soffit to allow dimensions to be taken 2. Architect to dimension grille centrelines on ceiling layouts	1.Working together we were able to come up with a solution which not only worked but reduced damage to floor channels if the traditional method of setting out partitions had been adopted. 2. As an architect if you want something to be positioned exactly as indicated on a drawing you need to dimension it.
1C6	Cost control disputes	Savings exercise at contract award	Proposed savings for reinforcement not achieved	Unresolved until the end of the contract when a 'commercial settlement' was agreed with the contractor.	Importance of the term 'Contract Administrator' and the need as an architect to carry out rather than delegate the responsibilities to the QS
1C7	Client Change 1 Proposal to redesign or remove the Hospital Sterlising and Disinfecting Unit (HSDU) from the project	Change in HBN guidance relating to Sterile Supplies Departments into HSDU and the introduction of GMP	Delay to the contract. Option appraisal: 1. complete department as per the drawings and alter once the building has been completed. 2. complete the department 'shell' to allow for redesigned unit to be built in the future.	Option 2 was adopted and during the course of the contract the area was changed in a Theatre Stores department.	Changes can be made during the course of a contract by working together. Although the area had to be put 'on hold' for a period of time, additional cost post contract was avoided and building works were completed.
1C8	Client Change 2 Proposal to delete the Incinerator Facilities	Change in legislation relating to incineration. Large new regional facility to be built elsewhere	The shell of the building had been completed and the chimney base cast. What to do with them?	The contractor proposed moth balling the chimney base by creating a chamber using concrete rings and capping it. The trust then used the building as a store for the estates department.	Another example of discussing with the contractor to come up with a solution which would suit all parties.

1C9	Installation of Radiodiagnostic Equipment	1. CSA equipment procurement. Delay in agreeing items with the radiologists. 2. No provision for builder's attendance during the installation (after handover).	Delay to the contract. Contractor awarded an extension of time (with costs)	Delay was mitigated by installing computer flooring in the X-ray rooms to allow for flexibility in choosing machines. Agreement with the contractor to help with the installation of the equipment.	Although X-ray equipment is designated as a client supply – it is fixed item requiring infrastructure to be incorporated within the building contract. the selection and process of installing such equipment needs to be considered at an early stage and involve all parties.
1C10	Installation of Theatre Tables	Trust took too long to select the theatre tables and then chose fixed base tables	Delay and disruption to the contract	The theatres were on the ground floor and the floors had to be dug up to accommodate the table bases	Need to integrate the requirements for the installation of medical equipment earlier in the project and discuss with all stakeholders

The critical incident during Stage 4 concerned affordability, where the lowest tender was greater than the pre-tender estimate and cost limit. At this point savings had to be made in order to achieve the target cost and allow the project to proceed. As leaders of the design team, we as the project architects, had to propose a list of items to the client where costs could be reduced. In some instances, this meant omitting certain items and in others reducing the specification of components. This was in effect the requirements' crunch point, a critical stage in the project where the decisions made would influence how the completed building would achieve the client's expectations. Compliance with the mandatory sections of HTM and HBN guidance was fundamental and in this case the provision of wash hand basins in single rooms was sacrificed as it was not mandatory (Infection Control was not part of guidance at this stage) in favour of aspects of engineering services where recent additional statutory requirements had been introduced. It was a lesson in understanding the 'contractual status' of complying with the hierarchy of statutory and non-statutory elements.

Nine critical incidents occurred in Stage 5: Three of these related to experience: 1C2 concerned the contractor, who was seriously behind programme, due to inexperienced staff. 1C3 concerned ourselves as architect, coping with the different requirements of tendering and construction information and the other due to the employment of an inexperienced site architect. 1C6 concerned the quantity surveyor who was not experienced in healthcare projects, was very commercially minded and not a team player.

Two of the critical incidents in table 1C4 and 1C5 related to the provision of engineering services information. This highlighted the difference between architectural design and services design where architects' drawings need to be fully dimensioned as in 'workshop' drawings for manufacture giving all the information necessary for the builder to carry out the works and the services drawings which were schematics with the subcontractors preparing installation drawings.

Two incidents 1C7 and 1C8 involved the client where two major changes were made to the requirements due to changes in service provision by a third party – the health service supplies division. Changes were also made due to statutory requirements (prevention of legionella) but the two described as critical incidents are included as they involved discussions with all parties to agree solutions to the problems created by the CSA.

The final two critical incidents 1C9 and 1C10 relate to the installation of medical equipment which was supplied by the hospital and the health service supplies division. Major items of equipment were traditionally procured centrally on behalf of the hospital and although deemed to be Group 3 (defined as being freestanding placed in position by the client) many items of equipment such as radiodiagnostic machines, dental and catering equipment are fixed and require fixed mechanical and electrical services. This classification anomaly causes installation problems and an allowance for 'pre-installation requirements' is included within the building contract. These requirements cannot be determined until the equipment has been selected. In this case the installation of the radiodiagnostic equipment caused a major delay due to the late selection of machines which we ultimately discovered had in fact been pre-ordered against the wishes of the radiologists. This was a salutary lesson for future projects – no one wants to open a hospital with out of date equipment and the selection and installation of major items of equipment requires an integrated approach.

The other item involved fixed base theatre tables, again a Group 3 item which normally would have been freestanding changed to a Group 2 item which was supplied by the client and fitted by the contractor. It had been discussed earlier in the project, but the hospital user group (with whom we were not involved after the project had started on site) did not make a decision until a year after work had commenced, which was too late to avoid disruption.

5.4 Case Study 1 Integration Resolution of Critical Incidents

Following on from the critical incidents, Table 17 below illustrates who was responsible for resolving the lack of integration of the sub-systems which led to them. The table sets out the type of issue, how type of integration involved and by whom it was resolved.

Table 17 Case Study 1 Integration Resolution

Reference	Issue	Integration Issues	Integration resolved by
1C1	Affordability	Mechanical and Electrical Services	Design Team
1C2	Programme delays	Contracting Team	Contractor
1C3	Provision of Information	Design Team	Architect
1C4	Positioning of electrical items	Mechanical and Electrical Services	Architect and Contractor
1C5	Coordinated ceiling layouts	Mechanical and Electrical Services	Architect and Contractor
1C6	Cost control	Design Team	Architect
1C7	Client Change	Stakeholders	Architect
1C8	Client Change	Stakeholders	Architect and Contractor
1C9	Radiodiagnostic Equipment	Equipment	Architect

1C10	Theatre Equipment	Equipment	Architect

5.5 Case Study 1 Introduction of Positive Integration

Integration was not only related to the critical incidents, six significant positive areas of integration also took place on this project as in Table 18:

- Provision of construction information (1)
- Design integration (1)
- Equipment related (2)
- Contract related (2)

Two of these were of particular importance: 1SD4 which was the decision to use a specialist nominated subcontractor to build the hydrotherapy pool and 1SD6 instructing the main contractor to provide attendance works for the client's radiodiagnostic equipment installer. Both of them were adopted on future projects and this is referred to in Chapter 9, the longitudinal study.

Table 18 Case Study 1 Positive Integration

Design Stage			
Ref	**Positive Integration**	**Reason**	**Outcomes**
1. Pre-design			
2. Concept Design			
3.Design development			
1SD1	Separation of Drawing layers for different construction stages	Clarify construction information	Information for site use simplified. Enabled better work package preparation on future projects
1SD2	Fitment Coding system for components	Aid clinical users, design and construction team	Improved Communication and Understanding. Similar concept to ADB but numbers in the codes related to actual sizes, closer to manufacturers' codes in Component data base (CDB)
1SD3	Integration of external structure	To reduce awkward corners in rooms	Similar concept to Nucleus design. Needs to be understood and incorporated in the early design stages. Beneficial both for aesthetic and infection control purposes
4. Work Package Design			
1SD4	Nomination of specialist subcontractors	To reduce risk	Advantages of using specialist sub-contractors. Integration of different activities to be completed by one contractor
5. Design in Construction			

1SD5	Issuing of Architect's Instructions by trade	To aid cost control procedures	Improves Contract Administration. Good practice and is an aid to cost control
1SD6	Instructing the main contractor to carry out post-installation works in the Radiology Department	Equipment specialists did not include for attendance by building trades	Protected the client's 'Making Good Defects' clause in the contract Emphasised the need to integrate the installation of major medical equipment with the building programme

5.6 Auto-ethnographic Interpretations of Project Based Design Management

In Case Study 1 the first incident that forms a Requirements Crunch Point (RCP) is where the project appeared to be in danger of not proceeding, although politically this was highly unlikely. The RCP in this case study concerned the project cost, where the lowest tender was greater than the pre-tender estimate. The pre-tender estimate was normally accurate as it was prepared by the design team quantity surveyor based on current pricing. The problem related to the prime cost sums for the engineering services where the mechanical and electrical tenders were greater than the estimate, highlighting the inherent problem of the different levels of design and procurement in relation to engineering services. What the RCP did was to bind together the major stakeholders: the Health Board, Design Team and Contractor were forced to review the whole project to make the necessary savings to deliver a successful outcome. Also included in this process were the Common Services Agency (CSA) advisors specifically as some of the additional engineering requirements had been requested by them. The final cost and time frame were greater than the agreed contract, but the client was able to include changes which if left until after the original time frame would have resulted in disruption to a working hospital.

Design management was not a term used in this case study, but The Site Architect's Guide (1983) described in Chapter 4 had included a "relationship diagram between the Site Architect and the Contractor" referred to as "the site gossip circuit". I have adapted this 'gossip circuit' to reflect to the roles and responsibilities in each of the case studies as in Table 19:

Table 19 Case Study 1 Gossip Column

Contractor's Site Management Team	**Design Team Duties**	**Design Team**
Regional Director	Quarterly meeting	Supervising Officer /Project Architect Site Architect
Project Manager	Monthly meeting Issuing site instructions	

General Foreman	Site Inspections	Clerk of Works
Site Engineers	Site Inspections, issuing site instructions	Resident Engineer
Services Subcontractors	Site Inspections, issuing site instructions	Visiting Mechanical and Electrical Services Consulting Engineers
Commercial Manager	Valuations	Site Quantity Surveyor
	Main Objectives	
Progress and Profit		**Quality and Cost Control**

The Gossip Circuit was an important feature in Case Study 1 in building good relationships and also easily highlights where poor relationships exist (Table 20). After the initial problems with the lack of experience of the senior site management team, when the new team took over, we developed this 'gossip circuit' which turned out to be highly successful and demonstrates how the design team integrates with the construction team.

Although anecdotal, the client was very pleased with their new hospital, engaging with Arts for Health, commissioning new art works to reflect the town's history, fund raising with local businesses (some of whom were very prestigious) engaging with the local press and planning the move and the Royal opening. The hospital administrator's comment regarding potential future projects was that they would be happy to work with us again, using the phrase "Better the Devil you know". The Trust were also willing to show off the facility before handover and we took representatives from another health board, who were preparing their own new build project, on a visit around the hospital. They were impressed with the new building and its facilities and thought it provided value for money.

The incidents after the RCP highlight problems in the following areas:

- Need for total integration of the team
- Difficulties with experience and capabilities
- Need to integrate mechanical and electrical services early in the design stage and have a common appointment and contract procedure
- A new approach to procuring major medical equipment
- The majority of the positive integration measures were related to lessons from previous projects, namely in connection with contract administration, particularly the issue of Architect's Instructions and dealing with Nominated Sub-contractors. A previous large hospital project which had been cancelled at tender stage provided the basis for project numbering systems and an integrated design approach for incorporating the structure and services

- Computer aided design was not widely used at this time but overlay drafting and the use of ‘copy negatives’ allowed base negatives to be used by other members of the design team and could be used for creating separate layers to provide information relating to particular work sections. This together with the use of the NBS Specification and the principles of Coordinated Project Information (CPI) improved the quality of construction information and a future understanding of BIM. The issue with design integration reflected the conflict between designers and the quantity surveyor. The concept of containing the structural columns within the external envelope for both aesthetic, future proofing and infection control reasons was deemed to be an additional cost as it was extending the footplate of the building although not the gross area of the building as defined by the SHHD. Unbeknown to us at that time it was one of the basic integration principles of nucleus.

5.7 The Wider Healthcare Delivery Model

5.7.1 Statutory Requirements

Crown Immunity was removed from the NHS on 1st April 1991 by the passing of the National Health Service Community Care Act 1990. This resulted in all hospital building projects needing to obtain building permission from the local authority. It also meant for the first time that buildings could be inspected at any time by environmental control inspectors. In 1986 Hansard reported a House of Commons Debate of June 9, 1986 stating that for all purposes: “(a) a health authority shall not be regarded as a servant or agent of the Crown or as enjoying any status, immunity or privilege of the Crown and, (b) premises used by a health authority or provided by a health authority for use by health authority staff shall not be regarded as property of or property held on behalf of the Crown”. The three main issues resulting from this affected:

- Fire Safety Regulations;
- Food Hygiene Regulations; and,
- Health & Safety Regulations.

One of the issues related to health and safety was however not included in legislation and this was control of infection, something which was highlighted in the Hansard debate of June 9, 1986.

This did not mean however that up until this legislation came into force building standard regulations could be ignored. Department of Health guidance, such as HTM 83 Firecode 1994, had existed prior to this time and Health Boards expected their designers to use this and other guidance. In Scotland Compliance consultation took place with the Scottish Home and Health Department to review compliance with the building standards regulations. Planning permission was also subject to Crown Immunity but courtesy consultations were usually held with the local planning authority, sometimes resulting in approval by the Royal Fine Arts Commission to be obtained.

5.7.2 Prescriptive Healthcare Standards and Guidance

The Estates Department of the NHS produced briefing documents in the form of Hospital Building Notes – descriptions and accommodation requirements for standard hospital departments and Health Technical Memoranda for building components and engineering services. Each building component HTM, which had developed out of a previous Component Data Base, comprised of a standard specification and details that could be procured from a list of suppliers approved by the Department of Health.

The cost control process to monitor project costs, release provisional sums, approve changes related to contingency funds with compliance controls applied to the architectural and engineering design by professional staff employed by the Scottish Health Service Healthcare planning advice and approval by medical and nursing advisors employed by the Scottish Health Services Expert advice and procurement of Radiodiagnostic Equipment, Dental Equipment, Decontamination and Catering Equipment through specialist division of the common services agency of the Scottish Health Service.

Project briefs were highly prescriptive, but Health Boards and architects in Scotland had more freedom to adjust their requirements and adapt room relationships to suit newer models of healthcare, Table 20;

Table 20 Comparison between Nucleus and Scotland

Brief	England and Wales (Nucleus)	Scotland
Departmental Schedule of Accommodation	Standard	Standard
Room Data Sheets	Standard	Standard
Room Layouts	Standard	Customised
Departmental Layouts	Standard	Customised

5.7.3 The Nucleus Building System

Appendix A contains a description of the Nucleus System, a prescriptive health building-system which was prevalent during this temporal period. The Nucleus Building Programme began in 1975 and by 1992 about 80 Nucleus Hospitals had been built with another 50 in the pipeline, at the same time all new hospitals in Scotland, although using similar guidance documents to England and Wales, were not required to be designed in accordance with the nucleus template. The building forms developed taking cognisance of the site topography and the departmental relationships, resulting in different solutions. The development of the Nucleus System in the 1970s and 1980s tried to create a template for the design of new District General Hospitals. Together with Hospital Building Notes and Technical Memoranda, Health Authorities and Designers were provided with a framework for the planning of new facilities. Project costs could also be effectively compared, and it provided a uniform standard of facilities throughout the country. Changes and development in models of care, methods of treatment started to make the nucleus template less and less attractive, together with the criticism, with the exception possibly of Maidstone Hospital, this method of development did not produce buildings of architectural quality due to the main driver being cost.

5.7.4 The Catalyst for Delivery Model Change: The Chelsea and Westminster Hospital

The early 1990s saw the demise of the NHS Nucleus building programme. The rigid template could no longer cope with the changing demands for NHS facilities and NHS Estates reduced its involvement in the management and issuing of guidance documentation. Strategic Health Authorities and Regional Health Boards were reformatted and with introduction of NHS Trusts who could offer services to patients out with catchment areas as a result of ‘patient choice’ risk and uncertainty clouded the establishment of client requirements.

This project marks a change in direction of hospital procurement in England. “Chelsea & Westminster is an international benchmark for innovative healthcare design, providing a flexible and user-friendly environment for healthcare professionals and the public, including the main teaching centre for the Imperial College Medical Faculty.

The hospital houses 70 departments including operating theatres, intensive care units, maternity facilities, day surgery, outpatients and imaging departments, a separate mental health unit, and more than 600 acute beds. These facilities are based around eight atria and a large central public atrium space.

The concept developed the traditional hospital street into a vibrant six-storey, light-filled atrium sustaining interaction and accommodating the healing arts through performance and major pieces of art-work" (Sheppard and Robson website).

Figure 24 Chelsea and Westminster Hospital

The North West Thames Regional Health Authority decided in 1987 to rationalise health services in the district by replacing five other London Hospitals with a large teaching hospital (at the time it would be the largest NHS hospital in the UK) on the St Stephen's site in Chelsea. A Project Manager was appointed in October 1987 with a design team in December 1987. The request for Approval in Principle was based on the assumption the total costs would ultimately be funded from the sale of four surplus sites, and on completion in September 1992 the rationalised service would result in projected revenue savings of £75 million over a five year period at 1987 prices. The proposal was received enthusiastically by the Treasury and the Health Authority was given authorisation to proceed. The Estates Director decided to proceed with a fast track option following a National Audit Office Report that had just heavily criticised the traditional procurement system. In April 1988, Laing Management were appointed as Management Contractors following selected competition. Approval in Principle (AIP) was granted in December 1988 – the anticipated submission of September had to be postponed in order to accommodate design changes following a successful protest by influential occupants in the Fulham Road. The Standard Form of Management JCT87 was used. It was a 37 month construction period using fast track construction methods with no client changes after commencement of construction. In order for the client to keep as much control as possible, they were prepared to share risks and hence the Management Contract.

Not only was this hospital project to use a Management Contract but it did not adopt the Nucleus Template. The main reason for this was the very tight site for a hospital of its size. Nucleus was designed to accommodate two storeys, three in some, but not six as was built! This was reduced from seven storeys through the town planning process.

It remains one of the fastest completed large hospitals, with the design starting in April 1988 and opening taking place in April 1993 a period of five years. The design appointment was made 18 months before start on site and the original 37 month contract was extended by 25 weeks thereby eating into the commissioning period. By reprogramming the commissioning programme to overlap the construction programme the original opening date was achieved. What this demonstrates is the close working relationship between the client and the contractor. The extension required was partly due to liquidity problems with some of the sub-contractors which was a sign of the economic problems resulting at that time and the other reason was the need to increase the basement excavations.

The client was very pleased with the building; it received and is still receiving very favourable public reactions. Due to the state of the property market, the sale of the properties failed to reach their target valuation and there was a shortfall in funding. This overshadowed the successful aspects of the project and resulted in no further management contracting projects. The introduction of the large atrium and public spaces is something which has become a 'requirement' in the new Private Finance Initiative (PFI) hospitals which followed this project. It has therefore, become an aspirational benchmark for all new hospitals.

5.7.5 Professional Requirements

The Health Board or Authority would either employ their own in-house professional teams or engage design consultant from approved lists of architects, services engineers, structural engineers and quantity surveyors with healthcare experience. During this period of time the professional bodies, such as the RIBA, published guidance for clients on fees and expenses which included minimum fee scales. The fee for engaging an architect on a large new build hospital projects would be 6% of the building cost. This would be the approved figure regardless whether the Trust engaged the local architect or a large firm of internationally renowned architects. Selection of the architect/designers was made on demonstrating competency in delivering the project not on cost. Professionals could charge more if they thought they were worth it and clients were willing to pay, but they could not reduce fees to win work.

This all changed in 1998 with the Competitions Act which challenged minimum fee scales for professional services and led to fee cutting. The RIBA attempted to scrap fee scales in 2004 but had to back down after pressure from its membership, however it has now sounded the final death knell for the fixed fee scales. The RIBA wanted resource-led fee bidding, based on architects' own calculations and accumulated knowledge, to replace the use of fee charts across the board, referenced by Hoxley (1998) and Nicholson (2003) in the Architect's Journal 6 November 2009.

5.7.6 Government Procurement Policy

The main method of procuring hospital projects was design-bid-build with health board's appointing a design team and then going out for competitive tender to Main Contractors using JCT 63 or JCT 80 Local Authority Edition with Quantities. Main or general contracting being the preferred method at that time unlike separate trades contracting which had been more prevalent in Scotland where the architect organises all the subcontractors. It was also the system in France known as 'lots separes'.

The major contractors in healthcare are main contractors for builder work trades, with management teams comprising a mixture of professionally qualified staff - civil and structural engineers and quantity surveyors -Institute of Quantity Surveyors (IQS) as opposed to the Royal Institute of Chartered Surveyors (RICS) quantity surveyors employed by the client often referred to as the PQS (Private Practice Quantity Surveyor) and unqualified staff who have risen up through various building trades - predominantly joiners and bricklayers. Their domestic subcontractors - include concrete workers, plumbers in terms of supply and fitting of sanitary ware, fitment suppliers and installers, floor layers and painters.

The installation of the Mechanical and Electrical Services was carried out by Nominated Subcontractors where prime cost sums were included with the tender documents for the main contractor. The documentation was prepared separately by the mechanical and electrical services engineers and the architect but did not include the quantity surveyors much to their annoyance and issued to lists of approved Subcontractors at the same time as the main tender document. Once the main contract had been awarded the management of the nominated subcontractors became the responsibility of the main contractor. The nomination did however protect these subcontractors as their payments were authorised through the consulting engineers. Due to this type of subcontract strong relationships built up between subcontractors and consulting engineers.

5.8 Design Management Organisation and Structure

In this temporal period design management was the remit of the architect as the client's representative as set out in Figure 25 to coordinate the information and its issue to the main contractor (Activity 1), to undertake the contract administration (Activity 2), ensure that the contractor has constructed the building in accordance with the contract and to the build quality expected by the client (Activity 3). On large projects main contractors designated the function of managing design information (Activity 4) to a member of their team - often a planning engineer adopted systems such as issuing requests for information (for items which they considered they needs before they had been issued by the architect) or technical queries (Activity 5) where they consider that the information issued may be not be complete or they have concerns about what has been issued.

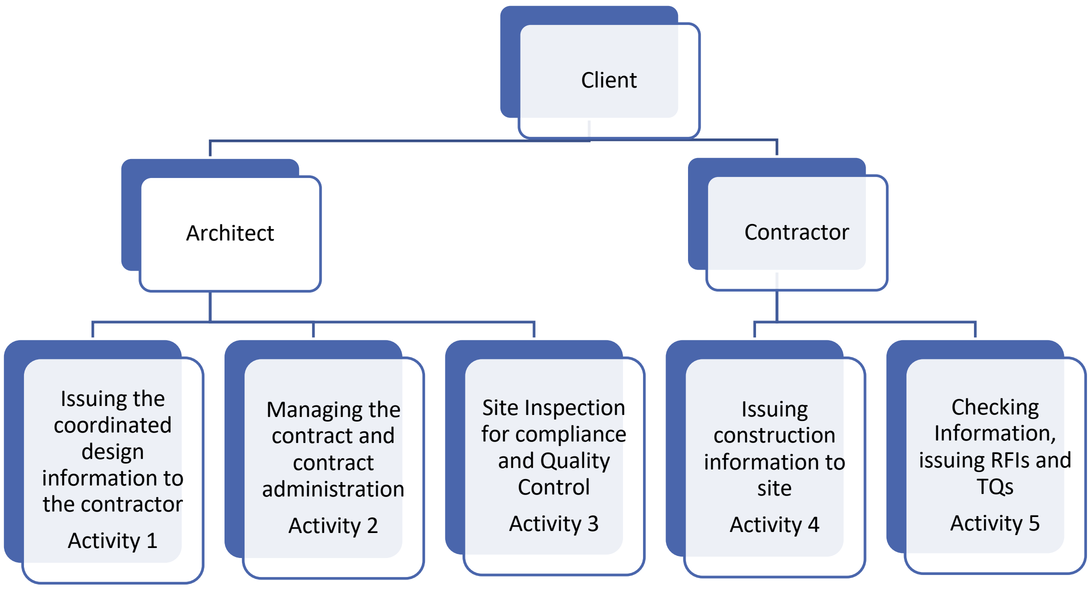


Figure 25 Design Management in Design Bid Build

The emphasis in this model was design and aiming to deliver the client's requirements with the architect having the power to control the design and its quality. On large hospital projects the architect was assisted with quality control by the appointment of full-time clerks of works. Unfortunately, many projects suffered from costly time overruns where reimbursement was through the application of liquidated and ascertained (L&A) damages. The application of L&A damages was something which was extremely difficult to apply to hospitals as they were publicly funded and unable to ascertain loss of earnings. Costs also increased due to client changes and the correction of design errors.

5.9 Auto-ethnographic Reflections on the Wider Delivery Model

During Case Study 1 I completed my first MSc in Construction Project Management with a dissertation ('Procurement Methods for Hospital Projects in Scotland'). This project had occupied several years of my life and at the end I felt I was much better prepared to take on the next major project. The project management MSc ‘plugged the gaps’ in my education and experience. My experience prior to Case Study 1 had prepared me to tackle the project both in terms of experience of designing different medical departments and administrating building contracts as a project architect.

Working on site let me see first-hand how a major contractor operated. Studying for the MSc also made me think about the construction industry as a whole, different procurement methods and how difficult situations could be improved. The study of other major hospital projects introduced me to ‘Nucleus’ and the Chelsea and Westminster Hospital. I moved onto the next challenge having ‘learnt lessons’, ideas of how things could be done differently and full of optimism.

5.10 Prescriptive Integration Relationship between Project-based Design Management and the Wider Delivery Model

The Scottish Health Services Common Services Agency fulfilled two major roles: The Building Division and the Supplies Division and was the link between the wider delivery system and the project delivery system.

The Building Division provided the following services to the Health Boards and Design Teams:

- Strategic Planning Advice
- The selection of professional teams, architects, engineers and quantity surveyors
- Liaison consultants for each discipline who attended all project team meetings
- In house health planning teams, clinicians and nursing staff
- Interpretation of all HBNs and HTMs
- Approval process through project gateways such as Preliminary and Final Cost Limits
- Monitoring project costs post contract award through monthly cost control meetings
- The provision of Clerk of Works Services for both building and engineering services

The Supplies Division provided the following services to the Health Boards and Design Teams:

- Specification and procurement of all major items of medical equipment such as radiodiagnostic, dental and operating tables
- Specification and procurement of all sterilisation equipment
- Specification and procurement of all catering equipment

Although the system had its problems, it had become bureaucratic and had also stopped publishing documents such as ‘Buildings in Use’ and it provided strong project links during the whole building process. It also provided a uniform system to execute strategic healthcare development set out by the Scottish Home and Health Department. The contractor even wished they could be present at the monthly cost control meetings, something which I think would have been beneficial. Unfortunately, the transfer to PFI completely transformed the situation.

I have described this as prescriptive integration as the pathways, roles and relationships were all predetermined and backed up by standards and guidance provided by the wider delivery system.

Chapter 6 Temporal Period 3: Dysfunctional Integration

6.0 Temporal Period 2 Dysfunctional Integration

6.1 Introduction

The second temporal bracketing period 1993-2001, Table 21 I have described as Dysfunctional Integration, a period of change not only in terms of project delivery when roles and relationships change, but also in the wider delivery model where the removal of 'restricted practices', the introduction of professional fee competition, the procurement of public works using the Private Finance Initiative (PFI) utilising design and build contracts and 'freedom of choice' in the NHS regarding healthcare treatment takes place. In was also during this period applications for building permission which would have been granted by the local authority (Crown Immunity having been removed in 1991) could be processed by independent consultants.

Table 21 Temporal Period 2

Project Delivery Model		Wider Delivery model
Temporal Period 2 Dysfunctional Integration Case Study 2 First Wave PFI/ Contractor led Design and Build	1993-2001 MSc Construction Project Management (1993) Project Architect	Removal of professional fee structures Removal of Crown Immunity 2001 Change of procurement – role reversal between architects and contractors Reduction in support by Department of Health

6.2 Case Study 2 Background

Case Study 2 is one of the first wave of hospitals procured using Private Finance Initiative (PFI). It is a major university teaching hospital which replaced two hospitals – one a major city centre hospital, the other an orthopaedic hospital in the suburbs and was built on a greenfield site on the outskirts of the city. The associated university medical school adjoins the hospital on the new site. Appendix C contains the full narrative.

The type of contract was a Design, Build and Operate between the Trust and the Service Provider – Special Purpose Vehicle (SPV). The term 'operate' is slightly confusing, as it only relates to Facilities Management (FM), in this case both hard and soft FM. The building contract used was Design and Build between the SPV and in this case a joint venture (JV): two building contractors (BC1 and BC2) and one mechanical and electrical subcontractors (MES). One of the building contractors (BC1) and the mechanical and electrical contractors belonged to the same parent company as the SPV. The designers were appointed by different members of the JV: the architects and structural engineers by the building contractor of the same parent company as the SPV and the mechanical and electrical consultants by the MES.

I worked as an architect on this project and apart from bidding on a smaller healthcare design and build project with a contractor (who allowed us to lead the design consultation process) it was a completely different experience having the contractor as the client and not the Trust. My role within the architectural team was to manage the healthcare design and liaise with the contractor to try to ensure this was carried out.

Due to creation of a joint venture, with several companies having a stake in the construction project, roles were divided up to reflect each ones' stake rather than who was the best person for the job. The project director was from BC1, the deputy project director from MES and the commercial director from BC2. This division of roles continued down through the teams and as it was such a large project when it was split into sectors each sector had a project manager from either BC1 or BC2 and one from MES, both of equal rank, which made decision making difficult.

Due to the different members of the design team having 'different clients' the role of team leader was made more difficult. Unlike some of the other early PFI projects BC1 paid consultants' fees leading up to Preferred Bidder and Financial Close, but MES had an agreement with their consultants they would not be paid until after Financial Close. In this case, because as an architectural practice and myself coming from a different practice both having worked previously with the mechanical and electrical engineers, we had a good relationship with them, but it was still difficult as the engineers were unwilling to provide the resources required to develop a fully integrated design, Figure 26.

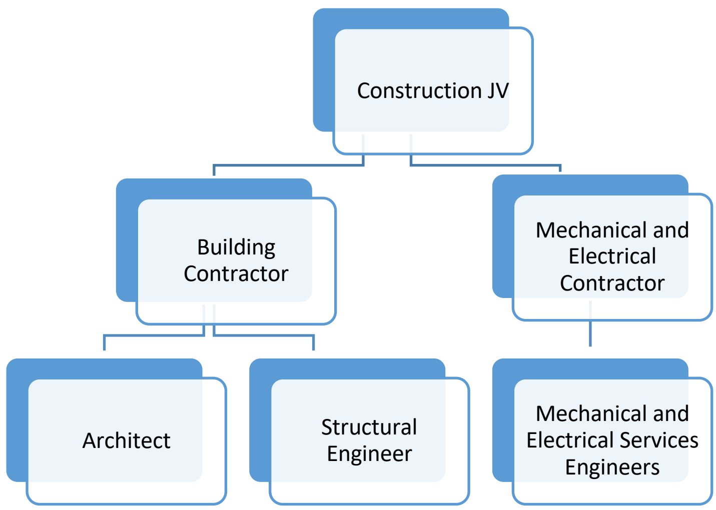


Figure 26 The Relationships between the Contracting Organisation and the Designers

6.3 Case Study 2 Critical Incidents

Table 22 below sets out the critical incidents related temporal bracketing period 2.

Table 22 Case Study 2 Critical Incidents

Design Stages					
Ref	**Cause**	**Effect**	**Resolution**	**Lessons Learnt**	**Critical Incident**
1. Pre-design					
2C1	Design of Outpatient Department	No departmental brief issued by the client only a total area for all specialties	Ground floor allocated to reflect total departmental area	When planned the proportions of some of the consulting/ examination rooms were compromised	Brief needs to be completed before design starts
2C2	Location of HSDU and Boilerhouse	Outline shapes allocated to departments	Boilerhouse requirements could not be planned within designated shell	Swap the shells of the HSDU and the boilerhouse	Inexperienced design architects
2C3	Preparation of the Room Data Sheets	Two data bases existed – one held by the Trust and the other by the Contractor	Equipment requirements were not integrated into the building	Unresolved White sheets were titled Contractor and pink sheets titled Trust	Only one data base should exist
3. Design Development					
2C4	Checking the schedule of accommodation	Missing rooms	Design did not comply with the brief	1.Plans had to be adjusted to accommodate the missing rooms 2.Departmental Review Process put in place	Schedule of accommodation needs to be checked throughout the design process
2C5	Management of User Group Process	1. Lack of knowledge by contractor 2. Decision by Trust not to allow direct contact between the contractor and the users	1. Managed by individuals with the wrong skills and competencies	Unresolved	1. The process needs to be managed by someone with the necessary skills and capabilities

		and the marking up of drawings	2. Room requirements misinterpreted		2.Designers need to work directly with users
2C9	Location of internal drainage	Change of frame from concrete to steel	Drainage pop ups further away from walls	Creation of larger 'box outs'	Frame design is integral to the building
2C10	Partition/grid relationship	1.Centring partitions on grid lines internally and externally 2. Movement joints not indicated on drawings 3. Inexperienced staff allowed to make decisions	Corners boxed out in rooms leading to difficult detailing and creating situations difficult for infection control	Unresolved – deemed too late to amend drawings	Partition design needs to be integrated Junior staff require supervision from more experienced staff
4. Work Package Design					
2C14	Architects' behind programme in the eyes of the contractor	Architects and contractor working to different programmes	Architects' suffered continual complaints from the contractor	Unresolved	Need for greater understanding by the contractor regarding the design process and to discuss with designers prior to preparing programme.
	5. Design in Construction				
2C6	Temporary redesign to accommodate early occupation of orthopaedics	1. Contractor's decision to construct the building in two phases 2. Trust sold the Orthopaedic Hospital earlier in the process	The Radiology and Orthopaedic departments were in Phase 2 Disruption and expense relating to theatre equipment	The Medical Wards and Cardiac Theatres in Phase 1 had to be built to suit orthopaedics and Phase 1 had to be extended to accommodate part of the radiology department.	1.Designers need to be made aware by the contractor if they intend to build in phases – no hospital can open without an X-ray department 2. Client and contractor need to coordinate activities
2C7	Positioning electrical items within rooms	1. Use of 'standard' room layouts. 2.Lack of dimensions on drawings or protocol	Continual requests for information from the site	Sketch drawings marked up om site	1.Standard rooms must mean 'identical' not similar 2.Dimensioning protocol needs to be established

2C8	Setting out light and grilles in ceiling tiles	Ceiling layout drawings and individual ceiling layout on room layout sheets	1.Clashes occurred 2. Lack of dimensions	Mark up drawings on site	Integrated ceiling layouts required. Proposal for future projects – drawings should be prepared by the services engineers
5. Design in Construction					
2C11	Wrong colour of doors ordered for the university building	Lack of an integrated door schedule detailing all doors. Contractor assumed door colours (by floor) were the same as in the main hospital	Delay and disruption	Replacement doors ordered	Architects need to prepare a complete door schedule Assume nothing!
2C12	Delivery of 'high-low' baths	Site management team ordered them too early in the contract	Site not ready to install them and they had been dispatched from Sweden	Contractor had to rent a storage facility until they were required	Equipment procurement needs to be integrated into the overall programme
2C13	Equipment installation	1.Secondary steelwork incorrectly dimensioned 2. Lack of information from the client regarding equipment	Theatre Pendants fitted in the wrong location	Pendants had to be taken down, steelwork moved and then repositioned correctly	Installation of equipment needs to be integrated
2C15	Trust requests for change orders	Change control procedure	1.Delay to implementing changes 2. Cost to the trust for making changes 3. Souring of relationships between the contractor and the Trust	Attempt to improve the assessment process, but the procedure had been written into the contract documents.	Changes will inevitably be requested and therefore greater understanding is required by all parties. The process does not need to be as protracted if there is a willingness from all.
2C16	Installation of Nurse Call System	Separate work steams in existence – services engineers consulted with the estates department and architects excluded	1.Nurse call system did not suit the users 2. Location of components clashed with other items	1.Decisions had to be made on site 2. Room layout sheets had to be amended to reflect agreed positions.	Systems need to be integrated and all relevant stakeholders need to be involved.

2C17	Design of 'end station's for Pneumatic Tube System	System was designed and agreed with the mechanical subcontractor without consulting the architect	No provision for the end station in the laboratories	Joiners made an end station which looked rather 'Heath Robinson'!	Pneumatic tube system can be specified as integrated system to include manufacturer's cabinetry – which would be part of the builder's work.
2C18	Window installation	Contractor did not procure the windows as part of the cladding system.	Windows didn't fit into cladding system.	Window fixings altered to allow windows to be inserted.	Ensure compatibility of components before procurement. Using an integrated system is more cost effective in the long run.
2C19	Bedhead trunking installation	The Mechanical Subcontractor had decided to use proprietary bedhead trunking	The bedhead trunking needed to be located between the patients' wardrobes – with no gaps!	To site measure all locations – hospital had more than 650 beds!	Need to integrate subcontract proposals into the design by the contractor.
2C20	Construction of the Aseptic Pharmacy	Contractor had not considered using a specialist contractor	1.Difficulties in verification and validation of Aseptic Pharmacy 2. Possible project risk	To engage a specialist subcontractor to complete the works	Highly integrated facilities need to be procured as a package from a specialist subcontractor.

The three critical incidents which occurred during Stage 2 involved issues relating to briefing and scheme design which were caused by inexperience, lack of competency and 'silo' working. The first one related to designing the hospital with an incomplete brief. The brief was prepared by a firm of American Architects based in London and they used a different approach from standard UK practice whereby departments are defined by and in relation to Hospital Building Notes (HBN): accident and emergency, radiodiagnostics, critical care, inpatient wards and outpatient clinic. The brief for this building was based on medical aggregation: reproductive medicine; general medicine; GI (Gastro-intestinal), Liver, Renal; CVTR (Cardio-vascular, thoracic and respiratory) and Orthopaedics. Each aggregation had its own wards, clinics, operating theatres and critical care units. The design concept for building was based on three linear, parallel blocks: the outer block being curved with outpatient accommodation on the ground floor and two floors of wards above. The central block containing support services on the ground and first floor (radiodiagnostics, laboratories etc.) with the critical care suites on the second floor. The third block contained the main entrance linking the blocks, and other support services at ground and first floor level with the second floor consisting of the operating theatres. This allowed patients in each aggregation to move from the operating theatres through to critical care and to the wards all at the same level and for medical staff to work within their own 'mini' specialist hospitals. The two anchor blocks at either end comprised the maternity unit and the accident and emergency – closest to the orthopaedic aggregation. The accommodation was fully scheduled apart from the outpatient department where a lump sum of 10,000 square metres was included. It was deemed this area could be planned out later. There were over 600 beds in this hospital and as such standard layouts were produced- not only for the rooms, but templates for the wards – a similar concept as in the nucleus hospitals. The ward templates were planned very efficiently around a series of courtyards, but unfortunately, unlike nucleus, where the template was designed to cater for different departmental layouts, this template did not suit the room shapes and sizes of an outpatient department. Planning of this department was extremely difficult, and the end result was that many of the consulting/examination rooms were of awkward shapes and oversized just to make them function. There was no healthcare planner involved to produce the information and whereas an architect working directly with the Trust as client would have prepared their own schedule, based on HBNs to establish room sizes and relationships to ensure that the area could be more easily planned, the JV were not prepared to instruct this work to be done as it was the 'responsibility' of the Trust to provide the brief.

The second related to the design of the boiler house and the HSDU (hospital sterilising and disinfecting unit). When I first became involved with the project, I was asked to redesign the HSDU as I had previous experience from Case Study 1. This building had been located within the Estates/FM services yard and had an outline shape created by the design architects who, although considered to be good designers, were both young and inexperienced regarding buildings such as the HSDU and boiler house as necessary evils which should be divorced from the main building. The building shapes did not suit the functions required and up to that point the services engineers had been complaining about the boiler house, which was a very peculiar shape and the difficulty of accommodating the boilers. As I had a good working relationship with them and had designed a boiler house (Case Study 1) I swapped the HSDU which was rectangular and more suited to the boiler house with the boiler house where the more awkward shape could accommodate the requirements of the HSDU. This satisfied both the engineers and the Trust.

The third incident again related to briefing and the provision of room data sheets. These are normally issued by the Trust and at the time the Department of Health, Activity Data Base (ADB) was the most commonly used system. The Trust's equipment managers had sourced an alternative system 'Hiltron' which had been developed by a company specialising in providing healthcare equipment and planning services. The JV decided to adopt this system and as it was a time when computer generated databases were being developed and it wanted to link this into a document management system. This proved to be difficult. Firstly, Hiltron had produced their own accommodation schedule from which to generate the room sheets and secondly the Trust's equipment manager refused to combine his database with the JV's database which had been set up to reflect the project accommodation schedule. This continued throughout the project with the result the equipment supplied by the Trust did not match with the requirements. The issue was compounded by the fact the management of the room data sheet process was tasked by the JV to an electrical construction manager from MES who had no briefing or design experience but was available to carry out this work.

Two of the incidents related to Stage 3: checking the schedule of accommodation and managing the user group process. Here the issues concerned design non-conformance where proposed departmental layouts had missing rooms and room functionality issues and the other lacked direct communication between the architects and the users. The users being defined as the people who work in the hospital: medical and nursing staff, administrative staff and FM staff. Again, competencies and inexperienced staff within the Trust's team, the

SPV, the JV and the designers were the cause of these incidents. It also highlighted a lack of trust. The Trust were afraid to let direct access to the users in case they wanted to make changes and the JV were afraid to let the architects have direct access to the Trust in case it allowed or encouraged changes.

The highest number of incidents – twelve, occurred in Stage 5, the majority of which related to the failure of design integration and programming. These ranged from major issues, such as the contractor intending to carry out the construction in two phases, but not considering it necessary to inform the architects who designed the building in one phase. Due to their lack of knowledge as to how hospitals operate, changes had to be made to incorporate part of the radiodiagnostic department in phase one as the hospital would have been unable to function without these facilities. One of the buildings on the existing site was a standalone facility – the department of reproductive medicine (Maternity) and this was included in phase one. This allowed for the earlier decant from the building which had developed serious structural problems. The orthopaedic hospital was designed in phase two. but an early sale of site meant the service had to be included in phase one. The temporary redesign was extremely costly as orthopaedic theatres require completely different fixed equipment and ventilation services.

Design programmes were set by the contractor without an understanding of the design process and the project architect rather than defend his position tried to please 'his client'. As a result, incomplete information was issued to the site and then the site complained! The situation was very much we as contractors are in charge and do not require consultation with the design team. The benefits of 'buildability' were not apparent when procurement resulted in them asking the designers to sort out the problems of incompatibility. The divisions between the builders and MES were less integrated than in traditional construction and there were no benefits from them all belonging to the one company.

The equipment installation was difficult, partly due to the separation of the databases and the Trust's list not reflecting the users' requirements but also due to the agreed contract. ADB clearly states who provides the equipment (even if it includes anomalies such as radiodiagnostics), but this categorisation was not used on the project resulting in equipment being procured by the Trust which should have been part of the building contract. The information necessary for the designers and contractors to incorporate these items in a timely manner and efficiently was not provided resulting in rework having to be carried out.

The final critical incident occurred during Stage 6 when during a visit to the accident and emergency department to carry out a post occupancy evaluation study I discovered several of the rooms were not used as they were designed as, although the Trust had signed off the room layouts, they had not discussed them with the users and some of layouts had been misinterpreted. This demonstrates the result of an RCP which was not addressed when it first appeared.

6.4 Case Study 2 Integration Resolution of Critical Incidents

Table 23 below illustrates who was responsible for dealing with the lack of integration of the sub-systems which led to the critical incidents or in some cases where the issue was not resolved.

Table 23 Case Study 2 Integration Resolution

Reference	Issue	Integration Issues	Integration resolved by
2C1	Incomplete design	Stakeholders	Architect
2C2	Building design	Design Team	Architect
2C3	Room Data Sheets	Client	Unresolved
2C4	Schedule of Accommodation	Design Team	Architect and Contractor
2C5	User involvement	Stakeholder	Unresolved
2C6	Phasing	Contractor	Client, Contractor Architect
2C7	Location of electrical items	Mechanical and Electrical Services	Architect
2C8	Coordinated ceiling layouts	Mechanical and Electrical Services	Architect
2C9	Location of internal drainage	Structural frame – change from concrete to steel	Architect
2C10	Partition/grid relationship	Design Team	Unresolved
2C11	Wrong doors ordered	Contractor	Unresolved
2C12	Delivery of equipment	Equipment	Architect and Contractor
2C13	Theatre pendants	Contractor	Architect
2C14	Programming	Contractor	Unresolved
2C15	Client changes	Stakeholders	Unresolved
2C16	Nurse call system	Mechanical and Electrical Services	Architect
2C17	Pneumatic Tube System	Mechanical and Electrical Services	Architect
2C18	External Envelope	Contractor	Architect
2C19	Bedhead Trunking	Mechanical and Electrical services	Architect
2C20	Aseptic Pharmacy	Contractor	Architect

6.5 Case Study 2 Introduction of Positive Integration

There were seven instances of significant positive areas of integration, Table 24 which took place on this project in the following areas:

- Prefabrication (2)
- Project requirements (2)
- Contact administration (3)

As this was a PFI contract, and contractor led, there was a shift towards construction processes, and this included a move towards the introduction of prefabrication. The other important development was the setting up of an electronic document management system – something which at that time could only be funded by large construction companies. The other issue at the time was the loss of Crown Immunity for building approval and this meant a steep learning curve for local authorities who were now responsible. Again, the contractor had the foresight to offer both an electronic approval system and accommodation on site for building control officers to manage the approval system.

Table 24 Case Study 4 Positive Integration

Design Stages

Ref	Positive Integration	Reason	Outcomes
1. Pre-design			
2. Concept Design			
2SD1	Room scheduling format	Briefing Aid	Checklist which could be used to ensure no missing rooms
2SD2	Electronic data management system	Provided an audit trail for the flow of information	Scale and size of project required a large and more sophisticated document management system than previous manual methods of issuing information. Drawings were now computer generated and project data bases were being introduced.
3. Design Development			
2SD3	Setting up of Departmental Reviews	Need to check Accommodation Schedule	This is linked to 2SD1 and the requirement to check drawings against the schedule of accommodation and user group meetings.
2SD4	Involvement of Building Control Officers on site	Loss of 'Crown Immunity'	Better understanding of each other's requirements resulting in a greater integration amongst parties
2SD5	Electronic Building Approval	Allowed for stage approvals	Reduced delays in the approval process and became a model for future projects
4. Work Package Design			

2SD6	Prefabricated steel bathroom pods	To improve quality	Need to design for standardisation required integration between designers (architects and engineers) and constructors
2SD7	Bedhead Trunking	To improve quality	Need to design for standardisation required integration between designers (architects and engineers) and constructors

6.6 Auto-ethnographic Interpretations of Project Based Design Management

In Case Study 2 the RCP does not appear until the project is handed over when the users start to discover problems due to the lack of stakeholder involvement with the designers. The consortium was the only team left at Preferred Bidder and at Financial Close the Trust had under written the cost of the steel frame which meant a quick site start could take place and so again, politically the scheme would proceed. It was one of the first projects involving 'role reversal' and as such a steep learning curve caused problems. If the RCP had appeared before this stage, the outcome for the users could have been better. The incidents however highlighted the following problems:

- Need for direct user engagement with the designers;
- Team integration and roles;
- Communication and contract administration;
- Difficulties with experience and capabilities;
- Need to integrate mechanical and electrical services early in the design stage and have a common appointment and contract procedure; and,
- An understanding of procuring contractor supplied equipment and major medical equipment.

In Case Study 2, Table 25, the 'gossip circuit' did not initially exist due to the design and build contract. The contractor had wanted the design team to be present on site, but not in a role to either inspect quality or liaise directly with the client. A small team was set up on site for the roles as listed above. There were two clerks of works, one for building and one for engineering services, but both were employed directly by the contractor and were therefore not independent. Some 'gossip circuit' relationships did start to develop, namely between the site architect and the construction team. He had carried out that role on a previous major hospital project work with the same contractor, but in the traditional site architect role, and knew many of the contractor's team. As a healthcare architect, I had previously worked with some of the Trust team on traditional procurement projects (DBB) and often acted as a 'go-between' with the contractor. Having been involved with Scottish Health Services cost control procedures I became the main contact with the Cost Manager.

Table 25 Case Study 2 Gossip Column

Contractor's Site Management Team	**Subcontracted Design Team Duties**	**Subcontracted Design Team**
Project Director	Monthly meeting to review design progress	Visiting Project Architect
Construction Manager	Answer technical queries and provide additional design information	Site Architect
General Foreman		
Clerk of Works		
Senior Design Manager	Monthly meeting to review design information	Design Team
Client Liaison	Review of Room Layouts and Room Data Sheets	Part time healthcare architect
Site Engineers	Answer technical queries and provide additional design information	Resident Engineer
Services Subcontractors	Answer technical queries and provide additional design information	Resident Mechanical and Electrical Services Engineers
Commercial Team	-	No commercial team member
	Main Objectives	
Time, Cost, Quality and Profit		**To deliver a compliant design**

6.7 The Wider Healthcare Delivery Model

The wider delivery system in this period saw the release of the prescriptive practices, and the catalyst for change. It also saw the use of value management techniques, such as charettes, to aid in the briefing process an example of which had occurred in a smaller design bid-build non-healthcare project in which I was involved with simultaneously as the second major case study which involved a first wave PFI project. A mini case study of this project is contained in Appendix E to highlight aspects of value management which were lost due to the adoption of PFI, design and build model.

The 1994 Latham Report (Constructing Excellence) 'Constructing the Team, was commissioned by the government and the construction industry with the aim of helping clients obtain the high-quality projects to which they aspired. The notable absentees from the consultees were the professional bodies, allowing the major contractors to promote themselves as being most capable of delivering client expectations. This resulted in public procurement adopting design and build contracts which were contractor led. At the same time the mandatory professional fee scales were abolished to introduce competition, something which removed the idea of a 'level playing field' where reputation, experience and capability had been the previous benchmarks for selecting designers and transferred the selection basis to cost. In some instances, architects and engineers participating in the PFI process were not paid unless they were involved in the winning bid.

6.8 Design Management Organisation and Structure

It is during this period 'Design management' began to appear as a separate discipline, Emmitt & Ruikar (2013) mainly within the construction teams with the adoption of Design and Build contracts. Figure 27 demonstrates how the traditional professional relationships and roles have changed and the introduction of design management within the construction team. The contract administration and quality control roles have been transferred from the architect as the client's representative to the commercial and construction teams respectively, with compliance checking transferring to the design management team.

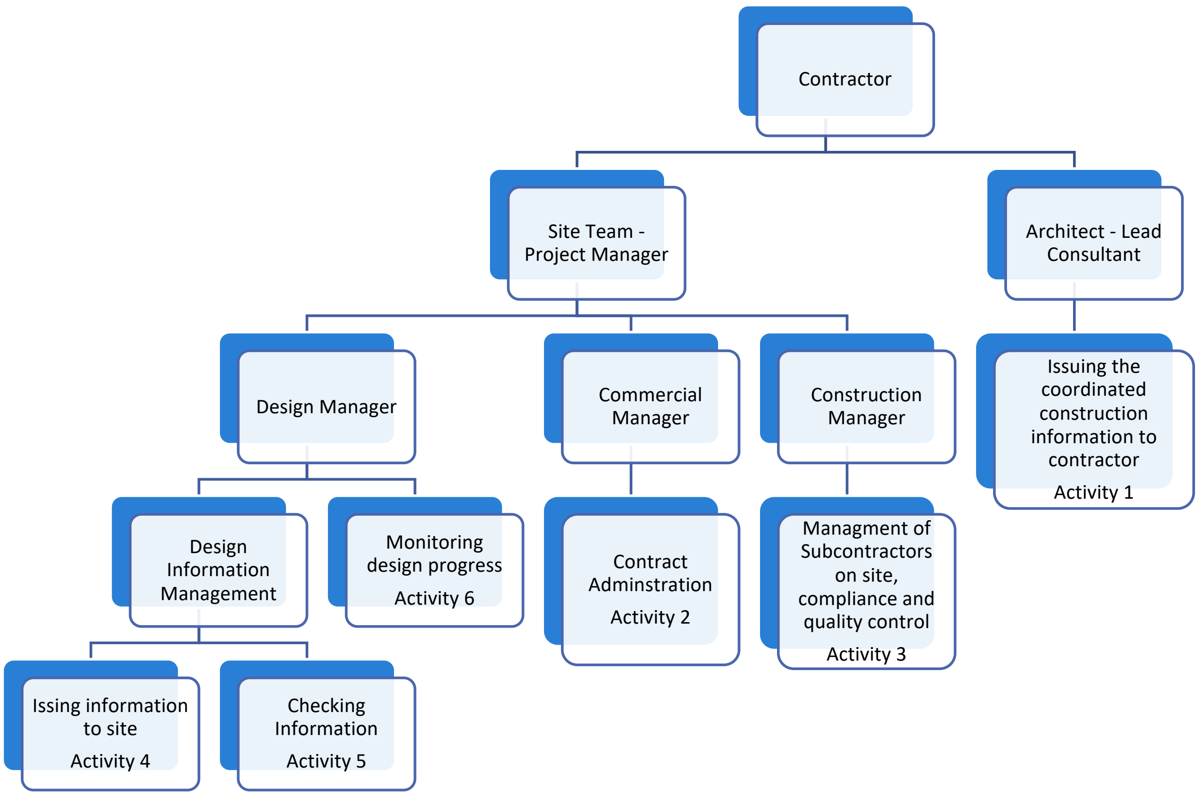


Figure 27 Design Management and Design and Build (1982)

6.9 Auto-ethnographic Reflections on the Wider Delivery Model

Professionally this was a very frustrating period, having successfully completed the design and overseen the construction of a major hospital and developing as a systems integrator I was unable to make decisions and could not implement lessons learnt from previous experience in Case Study 2. The contractor was now in charge and with the change to design and build with 'role reversal' wanted to put their stamp on the process and demonstrate their capabilities. It proved to be a difficult learning curve for the contractor, adapting to a different role where instead of challenging the design team and behaving in an adversarial manner (Dickason, (1982) JCT and the Builder) now had to administer the contract and instruct the design team as their client. On the contrary, working on the prison project (Appendix K) which was traditionally procured was very enjoyable and also educational as it had allowed me to experience the benefits of value management which I had learned about during my MSc studies. I was also able to implement lessons learnt from Case Study 1 which I was unable to introduce in Case Study 2.

6.10 Dysfunctional Integration Relationship between Project-based Design Management and the Wider Delivery Model

The change from design bid build to contractor led design and build initiated in the wider model as a response to Latham (1994) to improve project delivery in terms of time and cost (with the assumption that quality would be maintained) resulted in disruption in terms of roles and responsibilities. This can be demonstrated by comparing the roles and responsibilities in Table 15, the 'gossip column' with the one in Case Study 1. Certain roles were easy to transpose; 'resident engineer' and 'site engineer', in both cases the individuals came from the same discipline. The role of supervising officer, the architect in Case Study 1, is now taken over by the Project Director of a construction company. These two roles are not interchangeable as Project Directors do not have the understanding of the design process up to the point when construction starts because previously, they were not involved at this stage. They are also not experienced in user stakeholder engagement or contract administration, all of which were the responsibilities of the architect.

The result is a steep learning curve to reassign roles within the construction and develop new roles. Added to this challenge was the lack of support from NHS estates or in this case the CSA Building Division which had been disbanded. The freedom of choice to select teams and to encourage innovation also released the monitoring role carried out by NHS Estates. The early project gateways were still in place for Trusts to gain project approval from the

Department of Health but once financial close had been achieved the trusts were left to negotiate any changes with their contractor and the SPV. The process also brought with it teams of lawyers (who were often writing contract documents and asking questions like "What is a room data sheet?"), bankers, accountants and 'independent testers' to oversee the contract.

The Department of Health was still issuing guidance, although in a reduced capacity, with contractors often unable to access the 'Knowledge Portals' which were available to NHS staff. The healthcare planning advice and direction which had been provided by the CSA in the form of multidisciplinary teams of architects, engineers, medical and nursing staff no longer existed and contractors had to rely on independent unqualified healthcare planners, their architect and engineers for the interpretation of the HBNs and HTMs.

It is for these reasons that I have described the period as dysfunctional as many people had no clear definition of their roles and responsibilities and had no one to turn to seek advice.

Chapter 7 Temporal Periods 3 and 4: Adaptive Integration

7.0 Temporal Periods 3 and 4 Adaptive Integration

7.1 Introduction

Temporal period 3 is from 2001 to 2006 and relates to second wave PFI projects. In terms of procurement it is a period of relative stability as clients and contractors are beginning to have a better understanding of the roles and responsibilities and how to express their expectations. More contractors were competing for projects and some of the stages became more prolonged. The Capital Investment Manual stated periods of six months from Preferred Bidder to Financial Close – hardly achievable if Planning Approval had to be achieved.

Table 26 Temporal Period 3

Project Delivery Model		Wider Delivery model
Temporal Period 3 Adaptive Integration Case Study 3 Second Wave PFI/ Contractor led Design and Build	2001-2006 MSc Planning Buildings for Health (2006) Project Architect/ Design Manager	Department of Health began to reduce investment and support for research and development Architects losing skills related to stakeholder engagement, contract administration and the ability to learn from site inspections

It was also during this time Building Approval could be outsourced to private bodies and self-certification was introduced. The Department of Health continued to update the HBNs and HTMs but the information tended to be uploaded to a portal which only NHS members could access. It was during this period I undertook a second MSc – Planning Buildings for Health, a degree course designed for NHS staff wishing to become Project Directors, to help them understand the design and construction elements and the stages in project procurement. The course also attracted architects who wanted to get a better understanding of healthcare design and how the NHS worked. I was fortunate to be in a group which included a number of healthcare estates staff, the people involved with the day to day running and maintenance of the hospital buildings, people who were often forgotten about in user groups. Through them I was able to keep up to date regarding the latest information on Department of Health Guidance.

The Private Finance Initiative was used for major hospital projects but was not an attractive proposition for smaller and refurbishment projects – particularly when works in existing buildings could uncover events which would lead to additional expenditure. Consequently, two other methods of procurement were introduced: Procure 21 a framework set up for minor hospital projects and LIFT a system for smaller healthcare projects such as health centres which could involve local authorities.

This chapter includes two major PFI projects – second and third wave projects, probably with a unique connection in as much as the principal project team members in Case Study 3 moved on to Case Study 4 and both projects involved the same SPV and contractor (including the same structural, mechanical and electrical engineers). It also includes two P21 projects, one associated with the batch partner of Case Study 4 as an enabling works contract and the other as part of the overall development of the redevelopment scheme at Case Study 4.

7.2 Case Study 3 Background

Case Study 3 is a second generation PFI hospital where I was involved from the start of the bidding process until handover, starting the project as the architect, but completing it as the design manager for the contractor. It also involved the transfer of acute services from a town centre to the outskirts to form a major extension to a nucleus hospital built over four phases from the 1970s to the 1990s. I was working for the same firm of architects as in Case Study 2 and for the same contractor. This time however the JV consisted only of BC1 and MES. Some of the senior management staff from Case Study 2 were involved in the bidding process, but this time the project was in England and a different division of the contracting organisation was involved. The same consultant mechanical and electrical engineers were engaged, but a different structural engineer who had worked on another PFI hospital project with the contractor joined the team.As many of the team members had worked on Case Study 2 there was the opportunity to learn from lessons learnt. Appendix C contains the full narrative.

The site was extremely exposed to weather and had the same site conditions as Case Study 1 in that the main HV cables serving the town transversed the site giving constraints on the available footprint for the new building. This time the bidding process started with a selection of six bidders, reducing to three bidders, then two until the preferred bidder was reached. The Trust had created a 'Data room' for contractors within the existing hospital (like a library) which included all the information they had prepared including the Public Sector Comparator (PSC) which was based upon adding on nucleus templates to an existing hospital street.

7.3 Case Study 3 Critical Incidents

The Table 27 sets out the critical incidents related to temporal bracketing periods

Table 27 Case Study 3 Critical Incidents

Design Stage					
	Critical Incident	**Cause**	**Effect**	**Resolution**	**Lessons Learnt**
1. Pre-design					
2. Concept Design					
3C1	Preparing the schedule of accommodation	Conflicting information from the Trust 1.Output specification prepared by one party and 2.PSC prepared by another 3. Capabilities of Healthcare Planner	Difficulty in trying to establish the project requirements	Schedule of accommodation developed jointly between the architect and contractor based on the output specification and the HBNs using past experience	Schedule of accommodation needs to be prepared objectively and not influenced by 'desires to please' such as reducing room areas to reduce cost
3C2	Preparing a concept design	Lack of an agreed schedule of accommodation	Scheme had to be redesigned	Adopt schedule prepared by the architect and the contractor	Brief needs to be completed before design starts
3C3	Agreeing the Room Data Sheets. Architect and contractor proposed using a different format	Trust proposed using ADB	ADB not user friendly for construction – four A4 sheets for each space and codes which were not intuitive	Single A3 data sheet, simple codes for contractor supplied equipment and ADB codes for trust supplied equipment	The Room Data Sheet needs to reflect the requirements of all parties
3. Design Development					
3C4	Achieving Preferred Bidder Status	Nurse managers approved layouts which they did not understand	Ward layout in operable	Revised ward layout submitted and approved	Need to ensure that all stakeholders understand the information being presented to them for approval

3C5	Departmental Review Meetings	Resolution of missing rooms	Design did not comply with the brief	Plans had to be adjusted	Designers need to take responsibility for checking requirements
3C6	User Group Meetings	Programme	Meetings had to be cancelled due to the production of late information	Agree a timetable which allowed a 6 week 'meeting organisation slot' to ensure the relevant stakeholders could attend	Need to integrate programme requirements with all parties
3C7	Quality Checks	Room Layout Sheets not reflecting the contents of the Room Data Sheets	Trust not prepared to issue drawings to user groups	1.Codebook programme checks scrutinised 2.Contractor employed another firm of architects to check the outputs	Robust QA checking process needs to be in place
3C8	Financial Close	Building area had increased and with it the cost	Affordability delaying Treasury approval	Non-clinical areas had to be reduced to ensure that all clinical facilities could be accommodated	Cost is directly linked to area
3C9	Connection to existing building	New building had a steel frame whereas the existing building had a concrete frame	The floors did not line through as the steel frame required an extra 300mm per storey to allow for services distribution	Other than the entrance level all other floors required a ramp to connect the buildings	Need to take cognisance of adjoining buildings when designing extensions.
3C10	Demand by contractor for a separate room layout sheet for every room	Problems on site with previous projects with 'standard' room layouts	Additional work for the architect	As the room layouts were computer generated room sheets were issued for every room	Easier to issue all room layouts than spend time arguing. Made potential changes and compliance checking easier
4. Works Package Design					
3C11	Wind bracing	Contractor discussed the frame properties directly with the subcontractor and structural engineer without involving the architect	External wind bracing affected window design and internal wind bracing affected room layouts	Change type of wind bracing to portal bracing – more expensive	Design and construction needs to be integrated and changes in construction can affect clinical functionality

3C12	Laboratory Design	Automated analysers were being introduced	Service and drainage requirements unknown at design stage	Lower the slab over part of the laboratory and allow for drainage connection and then use computer flooring	There will be new technological developments which will occur and there is a need to have flexibility
5. Design in Construction					
3C13	Electrical (Reviewable Design Data) RDD relating to Video Entry Systems	RDD meeting set up between the electrical subcontractor, engineer and the Trust Estates Department	Proposed locations of VE did not suit departmental functionality	Myself and the Trust's Project Manager attended the RDD in order to review all the locations and integrate them with the User Group comments	It was a chance discussion with the electrical subcontractor and myself which raised the issue. Emphasized the need to have cross work stream integration.
3C14	Programme	Phased handover included in the contract different from the design proposal	The contractor had difficulties accessing parts of Phases 1-4 as they were still be used by the trust.	In agreement with the Trust to adopt the phasing proposal used to work out the design philosophy and project viability	Construction phasing needs to be discussed with the designers in order to understand how the building functions
3C15	Doors and ironmongery	Although part of the same group Swedor and ASSA worked separately and what was thought to have been an integrated package was not!	Wrong ironmongery was fitted to the wrong doors	Remove ironmongery – replace doors if necessary and correct all the mistakes	Doors and ironmongery need to be integrated and managed together. In this case the schedules were integrated but the failure was with the subcontractor
3C16	Selection of theatre pendants	Procurement by JV partner not used to buying medical equipment and incomplete specification by client	Users did not get the pendant models they expected	As the architect I had to review pendants	Specialist equipment requires an integrated approach
3C17	Coordinated Ceiling Layouts	Architects prepared ceiling layouts but M&E subcontractors worked to their approved installation drawings	Problems with location of fire barriers, many ceilings reconfigured	Ceilings had to be reconfigured on site. I had to produce site sketches	Requires an integrated approach with M& services

The three incidents in Stage 2 were related to the Trust and the preparation of the brief. Different sections of the brief were prepared by two different parties; the clinical output specifications set out the requirements with reference to HBNs but did not include a schedule of accommodation as the Trust did not want to be tied too prescriptively and was keen on innovation. The PSC however, on which the costs were calculated, was based on a nucleus design using room areas which were no longer current in ADB and the area of the building was considerably smaller. This discrepancy in area had a knock-on effect in the preparation of a concept design. The Trust were very keen on engaging their user stakeholders in the design process and this time we were able to meet with them – although at this stage BC1's design manager was also present at all the meetings. Just before the Preferred Bidder was announced we discovered a major problem with the ward layouts and the Trust realised that some of their users had misunderstood the drawings and drew it to our attention. This allowed us to make alterations which resulted in us achieving Preferred Bidder status.

Seven incidents occurred in Stage 3, the stage leading to Financial Close. It was a very difficult time as the JV changed their team and the emphasis focused on programme compliance; again, the JV failed to realise the difference between design and construction programming. The JV also started to monitor our quality procedures at a time when we were introducing new technology, using new software and again involving inexperienced staff. The JV did not understand the timescales involved in organising user group meetings to ensure the correct stakeholders were available. They also failed to realise the implications of imposing their construction requirements on the design by insisting the new building should have a steel frame resulting in higher floor to floor heights (4200mm) than in the existing concrete framed building (3900mm) meaning only one floor lined up with the existing structure and it was necessary to construct ramps to accommodate the change in levels for the other floors.

The main critical incident occurred at Financial Close when affordability became a major issue. This happened due to the differences in requirements resulting from the clinical output specifications and the PSC. This was the requirements crunch point. It was successfully dealt with by sitting down with the Trust to agree certain changes and by the Trust going to the Strategic Health Authority to approve additional funding.

Two critical incidents occurred during Stage 4 one with the structural design, a reoccurrence of an incident in Case Study 2. The JV had a very close relationship with their preferred steel subcontractor and held meetings with them without involving the architects as designers (they also did involve the structural engineers). This resulted in the selection of a type of wind bracing that was the cheapest solution and included internal as well as external bracing. As a result, I had to fight hard to get some of it changed as it would have been installed in areas affecting windows and internal rooms. The other involved Trust supplied equipment again it became an issue; this time it involved the laboratories. The Trust informed us before financial close that by the time the building would be occupied automated analysers were likely to be installed rather than the equipment on the room data sheets. This posed a problem for drainage as the laboratories were on the ground floor. Having encountered a similar issue in Case Study 1, with radiodiagnostic rooms, the solution was to drop the slab and use heavy duty computer flooring. Before FC the commercial manager considered this too expensive and said this could not be included. The problem remained unresolved until work started on site. By this time the commercial manager had left and when the Senior Project Manager, who was effectively the Design Manager, asked me how to deal with the problem I again suggested the computer floor. This time he agreed, and the Trust were able to install the automated analysers successfully.

Five incidents occurred during Stage 5 three of which involved design integration. Another reoccurrence from Case Study 2 concerning programming. Again, it involved phasing, but this time the refurbishment of some of the existing nucleus template had been designed in a specific sequence to allow the Trust to decant from one ward to another to allow alterations to be made. As it was a different team which took over, they looked at it from a construction programming point of view. They did not discuss it with us and proceeded to put this programme into the contract. During the course of the contract the JV discovered they could not get access to certain work areas and had to renegotiate the programme with the Trust following the sequence as designed.

The second item related to Reviewable Design Data (RDD) where the client reviews the contractors' proposals as the project progresses. There were four strands to RDD: clinical, architectural, mechanical and electrical services. The Trust's project manager only had authority over the clinical and architectural RDD and as such the mechanical and electrical designs were overseen by the Trust's Estates Director. The services RDD meetings were held separately and involved the Trust, MES and the consulting engineers. On one occasion, I was asked by MES to look at some drawings proposing the layout of the security and video entry system. I discovered they had not understood how the building functioned as units were in the wrong place. I told the Trust's Project Manager and as a result we both attended the RDD meeting. I made the point these meetings needed to involve all stakeholders as previously in Case Study 2 the same thing had happened, and in that case, systems had to be altered after they had been installed.

Lack of integration was again demonstrated with the door and ironmongery subcontractor. The doors were all doorsets and the ironmongery supplied by a company who were part of the same group. This was presented to the JV as a completed package. Unfortunately, the reality was different, and the wrong ironmongery was fitted to the wrong doors despite having been given a comprehensive door and ironmongery schedule.

The final critical incidents related to the integration of mechanical and electrical services. The first being the provision of room layout sheets or 'C' sheets as they were known in nucleus. These sheets gave the layout of each room and the wall elevations. In Case Study 2 we had produced standard room layouts which, other than the ward areas, had high repetition and tended to be generic. This resulted in MES demanding dimensioned sketches on site in order to position electrical sockets. In this case study MES who were different individuals, some of whom had been involved in many nucleus hospitals, demanded a room layout sheet for every room. At first, we resisted this, a room data sheet existed for every room but not layout sheets. The argument was difficult to defend as, by this time the computer programmes were more sophisticated and, it was easier to produce all the layouts which we ended up doing. This proved to be extremely successful and was something we were able to take to the next project.

Two critical incidents on previous projects reoccurred: the procurement and installation of pendants and the coordinated ceiling layouts.

7.4 Case Study 3 Integration Resolution of Critical Incidents

Table 28 below illustrates who was responsible for dealing with the lack of integration of the sub-systems which led to the critical incidents and in some cases where the issue was not resolved:

Table 28 Case Study 3 Integration Resolution

Reference	Issue	Integration Issues	Integration resolved by
3C1	Schedule of Accommodation	Stakeholders	Contractor and Architect
3C2	Building design	Design Team	Architect
3C3	Room Data Sheets	Client	Client, Contractor Architect
3C4	Building layouts	Stakeholders	Architect

3C5	Departmental Reviews	Design Team	Contractor and Architect
3C6	User Group Meetings	Stakeholders	Client, Contractor Architect
3C7	Quality Control	Design Team	Architect and Contractor
3C8	Financial Close	Client	Client, Contractor Architect
3C9	Link to existing building	Structural frame – change from concrete to steel	Architect
3C10	Room elevations	Mechanical and Electrical Services	Architect
3C11	Wind bracing	Structural frame	Architect
3C12	Laboratory equipment	Equipment	Architect and Contractor
SC13	Video entry systems	Mechanical and Electrical Services	Architect
3C14	Phasing	Contractor	Client, contractor and Architect
3C15	Ironmongery	Contractor	Architect
3C16	Theatre pendants	Mechanical and Electrical Services	Architect
3C17	Coordinated ceiling layouts	Mechanical and Electrical Services	Architect

7.5 Case Study 3 Introduction of Positive Integration

There were 10 instances of significant positive areas of integration which took place on this project in the following areas, Table 29:

- Prefabrication (2)
- Project requirements (3)
- Contact administration (4)
- Transfer of knowledge (1)

Advances in computer technology and software were responsible for some of these significant developments along with increased prefabrication, but the most important development was the improvement in integrated working within the design and construction teams and the relationship with the Trust client.

Table 29 Case Study 3 Positive Integration

Design Stages

Ref	Positive Integration	Reason	Outcomes
1. Pre-design			
2. Concept Design			

3SD1	Single A3 Room Data Sheet	To simplify information from ADB 4 sheet format	Easier to use – one single sheet could be viewed alongside a room layout sheet. Easier to check. Approved by both the Trust staff and site staff
3SD2	Use of Codebook software programme	To improve quality of drawn information	Ensured that the drawings included all the information recorded on the room data sheets
3SD3	User group meeting scheduling to suit Trust	Involving right stakeholders	Introducing this additional programming element ensured that the right people attended meetings and aided Contract drawing approval
3. Design Development			
3SD4	Room Mock-ups	Stakeholder Understanding	Full size mock-ups of 4 bed bay (standard repeatable room) ensured staff understood what the final layout would be like. Process was repeated successfully on future projects.
3SD5	Drawing Status 'B'	To aid the approvals process	Enabled dialogue to continue with the client users for minor changes and for the incorporation of issues related to construction
4. Work Package Design			
3SD6	Prefabricated GRP bathroom pods	Quality and Buildability	Development of the of the bathroom pods in 2SD6
3SD7	Modular Wiring	Services Installation	More detailing required earlier in the process, but installation time reduced considerably.
3SD8	Integrated Equipment Meetings	Split procurement within BHJV	Enabled the correct equipment to be procured and installed.
5. Design in Construction			
3SD9	Compliance Checking Procedure	Quality	Ensured a smooth handover by the contractor to the Trust
6. Design feedback			
3SD10	Patient Transfer	Transfer from existing to new hospital	Introducing the Trust to members of the Trust in Case Study 2 who had been involved in a similar exercise to transfer patients from a city centre site to a new site on the outskirts proved very beneficial to the Trust and helped to build good relationships

7.6 Auto-ethnographic Interpretations of Project Based Design Management

In Case Study 3 the RCP occurs at the end of Stage 3 after ten critical incidents. The RCP resolved these issues which resulted from the lack of integration within the Trust and the failure to provide a clear brief. The user engagement process, which the Trust were very proactive with was improved after preferred bidder stage as by this time only one set of meetings had to be arranged and a target schedule of accommodation was being developed following agreement to follow the clinical output specifications. Before preferred bidder stage, separate meetings had to be arranged with the different bidders. After the RCP there were nine further critical incidents involving:

- Need to integrate mechanical and electrical services early in the design stage and have a common appointment and contract procedure;
- Team integration and roles which resulted in silo working;
- Communication and contract administration; and,
- Installation of major medical equipment.

As also stated in Case Study 2 and continued through into Case Studies 3 and 4 a close working relationship existed between the consulting mechanical and electrical engineers and the subcontractor. Having worked with both parties over several projects I tried to integrate the building services team more closely with the construction team, firstly as part of the architect's role and then as a design manager. The shift from DBB to D&B altered the architect's role. What did develop informally was members of the construction team would consult the site architect and myself, as healthcare architect, for information and advice in Case Studies 2 and 3 if they knew that person could give them quick answers rather than going through official channels. The 'gossip column' arrangement is outlined in Table 30 below.

Table 30 Case Study 3 Gossip Column

Client Team	**Contractor's Site Management Team**	**Subcontracted Design Team Duties**	**Subcontracted Design Team**
Project Director	Project Director	Monthly meeting	Visiting Project Architect
Estates Team	Construction Manager	Answer technical queries and provide additional design information	Design Team
	Design Manager	Monthly meeting	Design Team
Project Manager	-	Review of Room Layouts and Room Data Sheets	Part time healthcare architect
	Site Engineers	Answer technical queries and provide additional design information	Visiting Structural Consulting Engineers
	Services Subcontractors	Answer technical queries and provide additional design information	Visiting Mechanical and Electrical Services Consulting Engineers
	Commercial Team	-	No commercial team member
		Main Objectives	
	Time, Cost, Quality and Profit		**To deliver a compliant design**

7.7 Case Study 4 Background

Temporal period 4 is from 2007 to 2013 and relates to third wave PFI Projects and represents a time which heralds the end of the Department of Health's support for guidance and standards.

Table 31 Temporal Period 4

Project Delivery Model		Wider Delivery model
Temporal Period 4 Adaptive Integration 2 Case Study 4 Third Wave PFI/ Contractor led Design and Build	2007-2012 Senior Design Manager	Department of Health continuing to reduce investment and support for research and development Advances in Medical Technology

This PFI project was part of a 'batch', a concept where SPVs bid for three hospitals based on the costs of one of the hospitals, thus helping to reduce bidding costs. Case Study 4 was the hospital chosen as the cost model. Before Preferred Bidder Status one of the hospitals dropped out and so the batch proceeded with two. This scheme had been developed in the Technical Services department of BC1 led by an outside consultant as Bid Manager and an in-house architect design manager. By this time, I had joined BC1 as a Senior Design Manager as part of the core team for the batch. The core team comprising the project director (BC1), deputy project director (MES), commercial director (BC1) and myself. We became involved in the project following the award of preferred bidder.

Case Study 4 was the larger and more complex of the two hospital projects involving three new buildings, two of which needed to be connected to some of the newer existing buildings on the site. The third building was a standalone multi-storey carpark. The major redevelopment of the site also included a satellite cancer radiotherapy unit and was part of another Trust. This building was also built during the later stages of the programme by BC1 as a P21 project.

The study focuses on the major building which contains acute services: accident and emergency, a major critical care unit, a large renal unit and surgical wards. The project was also quite unique for a hospital project as not only had the members of the core team led the project in Case Study 3, the Project Director and Project Manager from Case Study 3 were now part of the Trust and leading their team in Case Study 4. A member of the estates department in Case Study 3 was now the Director of Estates at Case Study 4. It was a JV with the same members as Case Study 3; BC1 and MES and many of the subcontractors were common to both projects. In the design team a different firm of architects was involved (in the other batch project, the architects had designed Case Studies 2 and 3). The structural and mechanical and electrical services engineers had also worked on previous schemes. Appendix C contains the full narrative.

7.8 Case Study 4 Critical Incidents

Table 32 sets out the critical incidents related to temporal bracketing period 4

Table 32 Case Study 4 Critical Incidents

Design Stage					
Ref	**Critical Incident**	**Cause**	**Effect**	**Resolution**	**Lessons Learnt**
1. Pre-design					
2. Concept Design					
4C1	Building form rationalisation	1. Building form taking precedence over functionality 2.Lack of structural and services integration 3. Gross area over and net areas under target 4. Errors in the schedule of accommodation	Although the scheme had been awarded Preferred Bidder status it was unaffordable, functionally uncompliant and unbuildable!	As design manager I took control of managing the schedule of accommodation and then spent a considerable length of time with the architects revising the layouts and ensuring that they consulted with the structural and services engineers	The project architect needs to have the ability and experience to lead the team both in integrated design and healthcare requirements
4C2	Buildability 1	Proposed location involved building over the telephone operators and switchboard rooms	Impossible to construct and would have resulted in a Main Entrance unacceptable to the client aesthetically.	The building was moved further towards the main road in order to clear the switch building. Accommodation was created within the new building for operators and the whole of the existing building demolished after the new building was completed	1.Do not deliberately ignore buildability in order to win a contract 2. The planning engineer needs to work directly with the design team

4C3	Buildability 2	Gap between proposed link to the existing building	Not enough working space to build the link to the existing building	To build the link corridor directly onto the façade of the existing building. Result greatly improved the elevation and tied the new building into the existing	The planning engineer needs to work directly with the design team. This was again resolved between myself and the planning engineer
4C4	Wayfinding	Lack of understanding of interdepartmental relationships	Missing links and difficult circulation routes	Adjusting circulation routes following a meeting with all stakeholders	Departmental design needs to be integrated into the whole development
. Design Development					
4C5	Project Management by SPV	Experience and competencies	Process was more difficult than it should have been	Encouragement of interdisciplinary working by arranging visits to consultants' offices	Unless you have experienced staff with correct capabilities you need to be prepared address a steep learning curve
4C6	Position of clinical wash hand basin in single room	Comment by an Infection Control Nurse who had not attended user group meeting but who visited the mock-up	The layout of the room had to be revisited just before financial close following approval of the drawings	Type of drainage pipework had to be changed to allow the wash hand basin to be positioned	1.Although information relating to infection control is for guidance only, these stakeholders are very powerful. 2. Physical mock-ups are easier for users to comment upon rather than drawings and 3D models
4C7	Equipment	ADB failing to reflect up to date requirements	Conflicting requirements	Issues resolved at User Group Meetings	Users- stakeholders are aware of the latest technological developments
4C8	Departmental Change	Wrong project stakeholders involved	Accident and Emergency Resus room had to be relocated	New layout agreed with A&E consultant Steelwork needed to be redesigned	Need to engage the correct stakeholders and ensure users understand the importance of attending user group meetings
4.Works Package Design					
4C11	Architects' behind programme in the eyes of the contractor	Architects and contractor working to different programmes	Architects' suffered continual complaints from the contractor	As design manager responsible for implementing the company design procedures I reviewed the works package scope sheets and set out a revised process	Need for updating company procedures to reflect the design process and to discuss with designers prior to preparing programme

4C13	Wind bracing	Contractor discussed the frame properties directly with the subcontractor and structural engineer without involving the architect – commercial issues	External wind bracing affected window design and internal wind bracing affected room layouts	I organised a meeting with the architect, structural engineer and the subcontractor to resolve the issues which resulted in changing the type of wind bracing to portal bracing – more expensive	Design and construction needs to be integrated and changes in construction can affect clinical functionality – third time this had happened – even worse on the other batch project
4C14	Design of the Main Stair	Subcontractor's proposed steel drawings	Did not look like the architects' impression drawings approved by the client. Client strongly objected	Stair had to be redesigned to reflect the client's requirements but at a cost which could be contained within the budget	Design and Build does not mean that the contractor can change the design to suit cost and his interpretation!
4C15	Render joints on building elevations	Specialist Advice and architectural design	Joints unable to line through	To line the joints to the tops of the steel beams and not the bottoms as in the case of Tameside	Specialist subcontractors should be consulted for advice but not left to detail without the designers input
4C16	Renal Dialysis Stations	Commercial procurement and a lack of understanding of Trust requirements	End result likely to fall short of Trust's expectations	As Design Manager I intervened and had a mock up built to create a solution acceptable to all parties	Design and Build does not mean that the contractor can change the design to his interpretation!
4C17	Roof Design	Decision by the site team not to fit all the roof struts once they discovered that they were not structural	Trust's Project Director was furious. The elevations did not look like the planning drawings – 1. potential problem with planning 2. more importantly he wanted the additional struts aesthetically!	Additional struts had to be procured and fitted	Design and Build does not mean that the contractor can change the design to his interpretation!
4C18	Main Signage	Decision by the site to appoint an 'unapproved' subcontractor	Potential signage would not comply with approved RDD	Commercial team on learning that the sign was not approved rescinded the subcontract order and placed it with approved 'supply chain' contractor	Site approval process needs to be fully integrated to avoid one party making decisions

4C19	Procurement of Medical Gas Pendants	1.Pendants included items which required to be supplied by the Trust - ADB 2. This item was part of the Mechanical and Electrical Package	Dispute with the Trust and the overall cost of the pendants was greater than the amount included in the contract and the M&E only wanted to pay for 'their items'!	As design manager I took up the role-which would have traditionally fallen to the architect of bringing the parties together and suggested that by deleting some of the medirail which was not required to pay for the additional costs. I ended up taking responsibility for preparing and agreeing the pendant schedule	Equipment such as medical gas pendants cannot be specified by one person. It needs to be integrated by one person but involving a variety of stakeholders
5. Design in Construction					
4C9	Project Management by the contractor	Experience and competencies	Process was more difficult than it should have been. Difficult working relationships	To limit the activities of incompetent staff and try to build up experience in other who had the capabilities. Senior management team covered roles to progress the project	Resist pressure to engage staff who do not have necessary capabilities. Better to train more junior staff who show more aptitude
4C10	Design information	Lack of requirements specification by contractor	Architect's proposed formats did not aid construction needs	The contractor had to engage a specialist to create the RDS and the architect had to prepare drawings to suit contractor's requirements. Eg details to be produced on A3 sheets and not A0	Contractors' requirements need to be built into the design team appointments
4C12	Project Management by the architects	1. Experience 2. Method of working 3. Company management and procedures	Process was more difficult than it should have been. Lack of staff involvement in the later stages	Company method of working could not be changed – healthcare planning team separate from technical design team	Need to promote the role of healthcare architect who takes overall project lead and is involved until project handover

The first critical incident was in fact the requirements crunch point, the design had affordability, functionality and buildability issues. In a desire to proceed with the scheme certain issues had been ‘glossed over’ in the knowledge these could be resolved later. Later in this case, meant immediately after appointment of the preferred bidder. The affordability issues related to actual gross area being greater than the target and the actual net areas being less than target resulting in missing and misshaped rooms. A crazy decision to incorporate part of the telephone switch room into the building rather than divert services had been made to save money. Apart from affecting the appearance of the Main Entrance, it was not possible to partially demolish the building due to telephone operators working in it and it would have made construction of the new building extremely difficult if not impossible. The proposed link from one of the existing buildings to the acute building had not been fully considered and the location of the medical gas pipelines ignored. The resolution of these items together with a focus on achieving a balance of net and gross areas resulted in affordability being achieved together with a firm idea of requirements going forward.

Four incidents occurred during Stage 3 leading up to financial close, the first being the project management by the SPV where the individual, in charge was a process engineer from industry who, did not have knowledge of either healthcare or construction. The other three events related to stakeholder involvement. The user group process was well organised by the Trust, but in one group a critical stakeholder involved with infection control failed to see a potential problem on the drawings and it was not until all the users were invited to look at the mock-up of the single room that one of her colleagues pointed out in her opinion the wash hand basin was in the wrong place. The critical stakeholder agreed with her and the layout had to be amended. Technically, the wash hand basin was not in the wrong position and complied with the HBNs, also compliance with infection control’s requirements is not mandatory, but the issue is so sensitive the Trust tend to agree with their recommendations. It was close to Financial Close and quite difficult to achieve, but between the designers, ourselves and the subcontractors we were able to come up with a solution. It did however highlight the power of some stakeholders and the need to ensure they understood fully what was being proposed. Another example of misunderstanding by users occurred in the accident and emergency department where a late intervention from one of the consultants led to the redesign of the area and the structure. The reliance on ADB for equipment was again highlighted and emphasised why user stakeholders need to be involved as, in all departments, they are aware of the latest items available. Also, in terms of Trust procured equipment they will buy the latest products which may not reflect the shapes and sizes referred to in ADB.

There were eight incidents in Stage 4 of which six were related to the contractor attempting to rather largely influence design. Again, one related to steelwork, a repetition of what happened in Case Studies 2 and 3. This time I insisted on involving the architect and myself in meetings with the subcontractor and the result was that apart from one episode we managed to integrate the design. (Unfortunately, this did not happen on the other batch project and the result badly affected the elevations). A similar incident nearly occurred with the render, the contractor allowing the subcontractor to make decisions as 'he was the expert'. Again, this went badly on the other project and I stepped in before the same mistake was made. Most of the incidents involved one individual who, was new to the team but, had been appointed as a Project Director. He believed that as it was a 'design and build' he had the right to make design decisions. This also raised an issue of 'role suitability' as unlike all the other senior members of the team he had no formal qualifications and although he had previously had the title with another contractor it was in a different role. He did not command respect from the site team and was overruled on several occasions for 'design non-conformance' which was necessary to maintain Trust expectations. Only the detailed incorporation of all the requirements into the contract following the initial critical incident made it possible to achieve this. There were still difficulties with design programmes and the lack of integration within the architect's practice which caused problems.

7.9 Case Study 4 Integration Resolution of Critical Incidents

Table 33 illustrates who was responsible for dealing with the lack of integration of the sub-systems which led to the critical incidents or in some cases where the issue was not resolved:

Table 33 Case Study 4 Integration Resolution

Reference	**Issue**	**Integration Issues**	**Integration resolved by**
4C1	Building design	Design Team	Design Manager
4C2	Buildability	Contractor Pre-construction Team	Design Manager and contractor
4C3	Buildability	Contractor Pre-construction Team	Design Manager and contractor
4C4	Wayfinding	Stakeholders	Design Manager
4C5	SPV Project Management	SPV Project Management	Contractor and Architect
4C6	Location of wash hand basins	Stakeholders	Client, Contractor Architect
4C7	Client use of ADB	Equipment	Design Manager and contractor

4C8	Departmental Change	Stakeholders	Design Manager
4C9	Contractor Project Management Team Structure	Contractor	Partially resolved
4C10	Design Information	Design Team	Partially resolved by design manager
4C11	Architect's Programme	Contractor	Design Manager
4C12	Architect's Project Manager	Design Team	Partially resolved by design manager
4C13	Wind bracing	Structural frame	Design Manager
4C14	Design of Main Stair	Contractor	Design Manager
4C15	Render Joints	Structural frame	Design Manager
4C16	Renal Dialysis Stations	Contractor	Design Manager
4C17	Roof Design	Structural frame	Design Manager
4C18	Main Signage	Contractor	Design Manager
4C19	Medical Gas Pendants	Equipment	Design Manager

7.10 Case Study 4 Introduction of Positive Integration

There were 12 instances of significant positive areas of integration which took place on this project in the following areas, Table 34:

- Project requirements (3)
- Integrated working (3)
- Contact administration (5)
- Equipment (1)

The most important development on this project was the opportunity to introduce several ideas resulting from previous lessons learnt which I had been unable to do since Case Study 1 as a result of the changing role of the architect. These included the integrated ceiling drawings being prepared by the Mechanical and Electrical Engineers, introducing the concept of Category D+ (Group 3+ in ADB terms), working directly with the planning engineer as a member of the team and helping to rewrite the company design management procedures with the Quality Manager to improve the Works Package Process, Change Management and Consultant Appointments.

Table 34 Case Study 4 Positive Integration

Design Stage

Ref	Positive Integration	Reason	Outcomes
1. Pre-design			
2. Concept Design			
3. Design Development			
4SD1	Interactive video meetings	Marking up of architect's drawings	Easier to explain changes and quicker due to the designers being located 200 miles from the site where the construction team was based

4SD2	Guide to User Group Meetings	To prepare the users in advance of the meeting	Stakeholders came to meetings fully prepared and had a good idea of what would be taking place. Meetings were more productive
4SD3	Use of 'photo album'	To help users	The trust's project manager prepared a 'photo album' of examples from Case Study 3 and was able to describe and demonstrate to users, equipment and room layouts with which she had been involved
4SD4	Creation of D+ Equipment Category	Problems with fixed client's equipment	The identification of client supplied equipment which required contractor's input such as radiodiagnostic equipment in the contract enabled the designers and contractor to help the client bring the building into use in shorter period of time
4SD5	Consultant Appointments' Matrix	Gaps in service	The preparation of a matrix of consultants' services improved the 'grey areas' where no one wanted to take design responsibility
4SD6	Working with a planning engineer	Design integration and buildability	As design manager working with a planning engineer we were able to resolve the problems described in critical incidents 4C2 and 4C3
4. Work Package Design			
4SD7	Revision to Work Package Scope Sheet	Need to reflect subcontract order	Lessons learnt from previous Case Study 3 demonstrated flaws in the company management system regarding design management and procurement. This change in scoping document reduced the term 'scope creep' by ensuring that the subcontract order reflected the drawings and specifications and not what the commercial department had agreed with the subcontractor.
4SD8	Integrated Work Package Programme	Split procurement within BHJV	Previously there were separate works package programmes for M&E and with the high level of integration problems occurred. Sequencing and information flow improved
4SD9	Ceiling drawings prepared and issued by M&E drawings	Lack of coordination between the architects and the M&E drawings	At the second attempt, (attempted but failed on case study 3, following problems with ceiling installation at case study 2) the drawings were prepared by the consulting M&E engineers and proved to be successful.
5. Design in Construction			
4SD10	Project Management Tracker	Tool to monitor programme and progress over all works packages	A single spreadsheet with all the works packages was produced which could be used to monitor design, procurement progress related to commencement on site. By monthly monitoring and reporting this helped to reduce the 'blame' culture which existed due to silo working.
4SD11	Revised Site Instructions	Approval process controlled by commercial team	Part of the change to the company management system to ensure that design issues were not ignored
4SD12	Design Manager's Evaluation	Change control process onerous	Part of the change to the company management system to ensure that design issues were not ignored

7.11 Auto-ethnographic Interpretation of Project Based Design Management

Case Study 4 starts with the RCP in Stage 2 when revised preferred bidder status is awarded (the scope of the scheme had been reduced). Working through this phase as in Case Study 1 integrated the major stakeholders, this was also easier as many of the individuals had been involved in Case Study 3 where 'lessons had been learnt'. The critical incidents in Stage 3 were mainly associated with lack of experience but were overcome by the overall integration and strength of the team. Again, there were eight critical incidents in Stage 4 relating to:

- Competencies, roles and responsibilities;
- Need to integrate mechanical and electrical services early in the design stage and have a common appointment and contract procedure;
- Team integration and silo working;
- Communication and contract administration; and,
- Installation of major medical equipment.

Again, all the significant developments were carried forward, as was the construction team with the same Project Director and the architect from Case Study 3 who was now a Senior Design Manager for the construction company. This time some of the critical incident issues resolved from Case Study 1 were also introduced and significant developments in Case Study 4 reflect this. Examples such as:

- Issuing of integrated ceiling layouts produced by the mechanical and electrical engineers; and,
- Changes to the company management procedures to improve integrated working within the construction team and with the design team.

After I joined the contractor's team during Case Study 3 and during Case Study 4 as a design manager I was also seen by the mechanical and electrical JV partners as their 'in-house' architect who would carry out all the duties the project architects did not consider to be part of their role. This highlighted not only issues with the consultants' appointment documents and some very complex matrices. Table 35 shows how the gossip column has developed in this case study.

Table 35 Case Study 4 Gossip Column

Client Team	**Contractor's Site Management Team**	**Subcontracted Design Team Duties**	**Subcontracted Design Team**
Project Director	Project Director	Monthly meeting	Visiting Project Architect
Estates Team	Construction Manager	Answer technical queries and provide additional design information	Design Team
	Design Manager	Monthly meeting	Design Team
Project Manager	Senior Design Manager	Review of Room Layouts and Room Data Sheets	Part time healthcare architect
	Design Manager	Monthly meeting	Design Team

	Site Engineers	Answer technical queries and provide additional design information	Visiting Structural Consulting Engineers
	Services Subcontractors	Answer technical queries and provide additional design information	Visiting Mechanical and Electrical Services Consulting Engineers
	Commercial Team	-	No commercial team member
	Main Objectives		
	Time, Cost, Quality and Profit		**To deliver a compliant design**

7.12 The Wider Healthcare Delivery Model

During this period the Department of Health introduced a new procurement method for smaller scale projects based upon a framework system. The initial framework described as ProCure 21. Two of these schemes were associated with Case Studies 3 and 4 and are contained in Appendix E. P21 and P22 frameworks using NEC forms of contract were centrally funded with a more alliancing approach but with the architect in the same subcontractor or tier 2 relationship with the contractor. This framework which developed the use of supply chains started to promote repeatable rooms and standard components but had little influence over the major hospital developments. In terms of standard products this was a move back towards temporal period 1 where the NHS Component Data Base existed. Each of the building HTMs was related to a list of NHS approved suppliers. This time however the suppliers were chosen by the contracting framework reflecting their bargaining power not that of the NHS and the existing hospital estates.

NHS standards and guidance in the form of HBNs and HTMs was gradually being neglected by the Department of Health. The documentation generally ceased to be updated and revised after 2013. Some of the formats changed and the HBNs started to focus on Care Groups such as ‘Cardiac Care’ with generic elements such as ward accommodation cross referred to in separate documents. All of the care groups, generic groups, documents relating to infection control former Health Facilities Notes (HFN) and Specifications for doorsets, fitments, floor finishes etc. the former HTM Building Components now being contained in the series known as Health Building Notes. The HTM series being purely related to engineering services.

7.13 Design Management Organisation and Structure

In terms of design management the design and build structure established in Case Study 2 still applies in terms of roles and responsibilities but Case Study 3 still adopts the title of Senior Project Manager to carry out the role of design manager and adds the role of design co-ordinator, a junior role for monitoring the design progress and managing the design information. By the time of Case Study 4 design management as a separate discipline has grown within the company and two other major hospital PFIs have set up design management teams both led by civil engineers. The design management structure within the company was developing with architects as design managers in Technical Services and engineers becoming design managers in the construction teams. I was in the unique position of being an architect within the construction team.

7.14 Auto-ethnographic Reflections on the Wider Delivery Model

Procure 21 and 22 use NEC 2 and 3 contracts respectively in contrast to the JCT contracts used traditionally and in the PFI design and build projects. Procure 21 uses the concept of the contractor partnering with the client and developed a framework of a selected list of contractor-led PSCPs with whom the NHS trusts could engage. Depending upon the stage of PSCP engagement the architect may be part of the contractor's supply chain or could be transferred (nominated) from the Trust to the contractor's supply chain. In the case of both P21s the architects were part of the PFI contractor's team on Case Studies 3 and 4. Although the architects were 'supply chain partners' contractually the relationship was as subcontractors to the Principal Supply Chain Partner and effectively no different to that of, for example, a steel subcontractor. The mechanical and electrical consulting engineers had the same relationships with the mechanical and electrical subcontractors as in the joint ventures of Case Studies 2 and 3 and as such silo working continued.

The reason for describing this temporal period as adaptive integration was following the periods of prescriptive integration and dysfunctional integration, roles and relationships had started to settle and a better understanding of each other's strengths and weaknesses was beginning to take place. Individuals were beginning to adapt to their new roles and with it their responsibilities. Clients began to realise in order to achieve their expectations they had to be more prescriptive in outlining their requirements. Case Studies 3 and 4 are quite unique in terms of major hospital projects, as each project normally starts with bringing different people together with a different client and different contractor. Even if the contractor's team remains the same and is able to bring lessons learnt to the next project it is usually with a new client. In this case the key members of both the Trust team and the contractor's team in Case Study 3 moved onto Case Study 4. Even if this was a 'traditional type of PFI set up' the successful outcomes from Case Study 4 demonstrate the potential advantages to be gained from alliancing. It is also demonstrated by the interaction on the two P21 projects.

On a personal level it was also a major shift from professional architectural practice to working for a contractor. It was an opportunity to be able to maintain continuity on Case Study 3 and again experience project participation from concept stage to completion, another strong factor in achieving project success. Completing the MSc in Planning Buildings for Health also widened my experiences of working with different disciplines within the NHS and the opportunity to visit many hospital facilities both in the UK and in Europe. In terms of design management, which was developing from its early stages in Temporal Period 2, it was still apparent that the role was not fully understood, design information management was successful but depending upon the individual's capabilities and background design management was not straight forward. It was also obvious many aspects of a site architect's role which often involved 'plugging the gaps' were not being carried out because either the designers' declared that was not their responsibility, or the design managers did not have the necessary skills. I found myself carrying out many of these tasks whilst ensuring I did not cross the line and carry out 'design activities' which would have been the responsibility of the architect.

Many lessons learnt from Case Study 3 were adopted on Case Study 4 but there were still problems with capabilities and competencies, something which is difficult to solve purely by changing the method of project delivery.

7.15 Adaptive Integration Relationship between Project-based Design Management and the Wider Delivery Model

The use of adaptive integration to describe this period related to my experiences on Case Studies 3 and 4 and how following the period of dysfunctional integration the new model was beginning to take shape and develop. Strangely however the area where the wider system was beginning to be understood related to the application of standards and guidance.

The period does show a move towards integration but as the construction companies in the case studies are moving towards integration issues although there are pockets of integration appearing in the wider system, the wider system itself is beginning to show signs of disintegration.

Chapter 8 Temporal Period 5: Disintegration

8.0 Temporal Period 5- Disintegration

8.1 Introduction

Temporal Period 5 spans from 2013 to the present day, Table 36, it covers a period when the PFI or the newer version PF2 and the non-profit distributing version (NPD) in Scotland are evolving. Fewer of the large UK main contractors are willing to bid for these projects, some of which are more difficult with high bid costs.

Table 36 Temporal Period 5

Project Delivery Model		Wider Delivery model
Temporal Period 5 Disintegration Case Study 5 PF2/ Contractor led Design and Build	2013-2020 PhD Thesis Health Design Consultant	Department of Health ceased investment and support for research and development. Last update of HBNs 2013 Adoption of multiple design consultants

I have described this period as disintegration in relation to major hospitals, standards and guidance. Two major PF2 hospitals under construction have been abruptly stopped due to the collapse of the PF2 provider, one NPD hospital has failed to open following handover due to non-compliance with HTMs, another recently completed operational hospital has major litigation issues involving the contractor on NPD project and another new NPD project has still to appoint a contractor with the project escalating in cost and already two years late.

In this period the regulation of design, construction within the healthcare sector is fragmented. Government legislation for outsourcing from local authority building control is increasing, the Department of Health is not updating HBN and HTM Guidance, the last update of HBNs took place in 2013, more recent updates to engineering series HTMs has taken place in 2017. The Activity Data Base (ADB) which was the backbone of NHS Project Briefing was taken over by Talon Solutions in 2017. Talon continue to update and support ADB but as the HBNs, HTMs and ADB are intrinsically linked, best practice and new models of care are not being reflected in the ADB Room Data Sheets.

In the wider delivery field, the collapse of a wall in a newbuild PFI school, the fire at Grenfell Tower and delay with Crossrail are all indicators that things are not well in the construction industry. PFI has finally collapsed and we need to investigate what went wrong in order to address future projects.

Within this period, Table 37 a series of events unravelled:

Table 37 Critical Events in Period 5

Year	Event
2016	Wall Collapse at an Edinburgh School- Schools PPI (1998-2005)
2017	Fire at Grenfell Tower as a result of recladding
2018	Collapse of Carillion affecting completion of Liverpool Royal Hospital PF2 and Midland Metropolitan Hospital PP2
2019	Delays and cost overrun at Crossrail – NEC 3 Design and Build
2019	Failure to open the new Royal Hospital for Sick Children in Edinburgh – non- compliance of ventilation requirements
2020	Aberdeen Royal Infirmary – contractor appointment still awaited

8.2 Case Study 5 Background

Case Study 5 considers a major PFI hospital project which was halted during construction as a result of financial collapse. Eventually in August 2018 the UK government decided to fund the completion of the project using a design and build NEC4 contract appointing a new contractor directly employed by the Trust. An enabling works contract was placed to stabilise the building, to make it wind and water-tight and prevent deterioration until a new contractor could be appointed to complete the building. In January 2019, an Invitation to tender was issued to select a preferred bidder who would then proceed to Financial Close for an anticipated site start in October 2019. Appendix C contains a full narrative.

It was at this stage that I became involved in the project and it gave me the opportunity to investigate what had caused the project to collapse and assess the proposed new delivery model. My role was as a design adviser to the replacement contractor checking the design for clinical functionality to ensure that the contractor did not take on board unnecessary risk. The Trust wanted to use a design and build contract, although the building was already under construction and wind and water-tight following completion of the enabling works as the design of the mechanical and electrical services had not been completed in order to mitigate risk and were only prepared to take risk for clinical functionality. The exact definition of 'clinical functionality' proved very difficult and became one of last items was able to agree before the contract was signed. In order to verify clinical functionality, it was necessary to check the design in terms of the HBNs and HTMs. The format of this case study is different from the previous studies as it is a current study. Appendix H contains a narrative history of the project to date including the identification of critical incidents, there were no apparent significant developments.

There are three phases to the project:

1. Past: The design and construction during the PF2;
2. Present: A period of 'satisficing' where the new team have to demonstrate ability to complete the project within the Trust's cost budget, time frame and project vision; and,
3. Future: Recommencement and completion of the project using a different 'untried' type of contract and method of procurement.

This study looks at Phases 1 and 2. In Phase 1 it looks at critical incidents, evidence of a requirements crunch point and how the team structure had influenced the project. In Phase 2 it considers clinical functionality and the application of standards and guidance.

8.3 Case Study 5 Critical Incidents

As I had not been involved in the project in the design and its partial construction, I could not identify critical incidents in the same manner as in the previous case studies nor in fact as in the case study in Appendix A. I was able to identify some major critical incidents through a desk top study and conversations with members of staff who had worked for the previous contractor and who were now working for the new contractor tendering the works.

The most important critical incidents are associated with:

- the integration of the structure and services outlined in the next section;
- the absence of an integrated BIM model;
- the commencement of Stage 5 construction without completing the Stage 4 design;
- the uncoordinated presentation of construction information, and
- the existence of two equipment data bases.

A more recent critical incident which influenced the Phase 2 negotiations was the appointment by the trust of several members of the previous construction team in an advisory capacity. The reason given was they had a thorough knowledge of the project and they understood that financial issues were to blame for the collapse of the previous contractor not anything to do with the project. Given the issues with integration it is highly likely the project did contribute to the firms' collapse. The individuals concerned attended all the meetings and were keen to proceed as if nothing had happened despite the unravelling of the design of the services installation and the level of additional derogations.

8.4 Case Study 5 Integration

As the design and clinical review process unfolded it became apparent this was not a fully integrated design in terms of space planning, building services and structure. There was no evidence of design integration raising questions regarding design team integration and the design management process There are three over-arching issues:

1. The overall concept design: podium design containing two levels of car parking with three levels of treatment and diagnostic departments supporting 'the Winter Garden' public access and a further four levels of ward accommodation. The plantroom floor above the diagnostic floors allows the ward structure to change and form 'fingers' of shallow planning to provide increased natural light to all patient bed areas.
2. The adoption of a regular 7.8 metre square grid without the use of double columns at movement joints.
3. The location of the main services risers at one end of the building and adoption of mechanical ventilation throughout the building.

Traditionally the architect would be the 'design systems integrator' with a strong vision and understanding of how the building functions using specific published design guidance, engaging with the users and ensuring compliance with statutory regulations. Design requires taking advice from building services engineers and structural engineers as well as cost consultants as the design develops to create a fully integrated design. It involves concurrency rather than consequence. Hospital Planning involves the bringing together of various sized rooms within departments of different sizes and complexities and as demonstrated with the demise of the Nucleus Hospital Building programme, the use of standard templates was unable to accommodate all types of department. Although a regular grid may have suited the overall concept design, the adoption of a standard grid is likely to result in compromise in relation to room sizes and room relationships. Similarly, with the design of the engineering services, the engineering design normally involves a mixture of natural, mechanical ventilation and air-conditioning in relation to individual departments. The podium concept with finger wards is often used in France, but for the purpose of creating configurations tailored to suit individual departments in terms of clinical functionality.

The Trust's 2020 vision requires the design to provide: a modern, iconic building that creates a sense of pride and looks to the future as a leader in healthcare design. Form and function are complementary, and design adds value throughout the building. Normally, only one architectural firm is engaged who would prepare a concept using their skills and expertise in healthcare design and planning with a project architect integrating both the internal teams and the engineering design. Due to the size, complexity and specialisation this type of design work can only be carried out by a large architectural practice which can provide the skills and number of people required. Managing a team of this size is not easy, even within one practice but the involvement of three architectural practices focusing on different elements makes the task more difficult. There is a tendency to focus on the specialist design aspects individually rather than holistically and inevitably compromises have to be made.

In this case form has emerged as 'the winner' and function sacrificed in certain areas which suggests design integration has not taken place and there has been a lack of design management. This is further emphasised by the difficulties encountered integrating the engineering services. Instead of developing an integrated solution as the design evolves it would appear the services design has 'followed' the architectural design and in so doing has resulted in difficult service routes which in turn will create construction difficulties and potential derogations from the HTMs and HBNs.

The decision not to design a twin column arrangement at the movement joints and conceal them with twin walls, only requiring joints across corridors has created problems in some clinical areas where it will be difficult to cover the joint in a manner acceptable to Infection Control. One of the Trust's other requirements is the building should be 'clean not clinical': Trust quote "The building will facilitate cleaning in a way that is obvious to patients and staff, so that it looks clean and tidy. This will be achieved without presenting a harsh clinical feel. Pleasant colours, finishes, shapes and designs will make users feel comfortable in the environment and will support wellbeing." The way the partitions to column junctions have been designed will result in projections which will make cleaning more difficult and are not in the spirit of the Trust's vision. A more integrated approach between the designers could have resulted in clean corridor lines, something which Nucleus did provide.

One particular example of 'disintegration" I uncovered was when I wanted to check the electrical small power drawings to ensure some items had been picked up (the architectural drawings have incorporated some electrical elements into 'unions' which do not display the items on the architectural layouts - only one icon for the union). These are items which should not have been created as unions in the first place. There were 18 A0 architectural sized drawings for each level of the podium titled Sheet 1 of 18 etc. there were also 18 sheets for each level of the services dealings - the only difference was that the two sets did not match, and it took an unnecessarily long time to find the information. At first I thought the services drawings had been incorrectly titled, but when I spoke to the planning engineer who had also worked for the previous contractor, he told me the two sets of drawings were set up differently, nobody had set out a drawing system and all the consultants and subcontractors did what they liked. Some subcontractors only had four sheets covering the podium levels. He had produced a 'conversion chart' to make life easier for himself and said he would look for a copy for me. I was horrified as never in my 40 year career had I come across such poor design information. This is symptomatic of a project where neither the design nor the construction is integrated.

8.5 Auto-Ethnographic Interpretations of Project Based Design Management

We should learn from previous projects, but unfortunately it does not often happen, however in this case there was an opportunity as a bidder to review issues and help the trust avoid potential problems encountered on previous projects. One particular issue was of equipment, the room loaded drawings indicated the equipment listed on the ADB sheets, adjusted to reflect user requirements agreed in user group meetings. During the Trust Dialogue meetings, the Trust Equipment Manager stated he had compiled a separate equipment list of the actual equipment being supplied explaining in some instances not all the rooms contained all the equipment shown on the drawings and sometimes different models. This rang alarm bells, maintaining a separate equipment list can be dangerous, it resulted in a disaster in Case Study 2 and caused problems in the Post Occupancy Study in Appendix A. In order to ensure the correct spaces and services are provided it is essential the actual equipment being used is identified. Hospitals are very large and complex and specialist expertise is essential, but it is important all the different specialties and systems are fully integrated.

The derogation study has revealed there were issues with the original design and unfortunately rather than address some of them the Trust had decided to accept these additional derogations. One of these area derogations had impacted on the engineering services; the area of the operating rooms was not originally derogated by the Trust as on average the size is greater than the HBN requirement. The layout however includes a circulation corridor and the useable area is substantially reduced from the HBN requirement of 55sq.m to 46sq.m. The Trust stated they had mocked up this room and were happy with its functionality but what they had failed to address was the reduction in useable floor area also affected the ceiling and posed difficulty with the installation of engineering services. The same agreement to the reduction in corridor widths also affected the services installation.

In terms of a requirements crunch point the decision to commence construction works without a fully coordinated design and the existence of two equipment schedules demonstrates this gateway did not happen.

8.6 The Wider Healthcare Delivery Model - Clinical Functionality and Derogations

The trust set out their design and clinical planning vision in a 'Hospital Planning Document' December 2018. The architects have also issued an updated version of the original July 2015 Planning and Design Standard Review (March 2019). This Planning and Design Standard describes the Trust agreed derogations from HBNs. The list of derogations is relatively short and many of them relate to the Trust's aims to achieve a highly efficient and innovative design by demonstrating that many of the HBN room area requirements can be reduced by using innovative layouts. The review carried out was to check whether or not as bidders we could satisfy ourselves the design is compliant with the HBNs and the derogations agreed to date. The Trust declared it is 'happy with the design' and does not foresee any changes, and in theory we should have been able to accept the situation as the clinical layout was deemed to be approved.

The developed solution used a high proportion of repeatable rooms (90%), standardised 32 bed wards with 50% single rooms and arranged in clusters of three; support hubs to service ward clusters and clinical areas; separation of patient, visitor and goods flows. According to the healthcare planners the emphasis is clear: a design that includes as much flexibility and adaptability as possible by adapting generic design and standard rooms.

The derogation study I carried out looked at the HBNs and in order to do this I had to first completely restructure what the Trust (and previous PFI Team) called the Schedule of Accommodation. This was not strictly a schedule of accommodation but a list of rooms with as drawn areas by department downloaded from the computer programme. The definition of department did not correlate with HBN definitions as it included single rooms as departments, created new 'hub' departments, designated the same functions under different headings and muddled up circulation and communication. On this list there were 75 departments or headings.

Using the format I developed from Case Study 2, and subsequently used in studies 3 and 4, I reconfigured the data into a Schedule of Accommodation which could be used to check compliance with the HBNs. The Departmental Schedule, together with sample departments, is included in Appendix H. This information was used to ratify additional derogations with the Trust at the design meetings and was ultimately included in the NEC 4 Scope of Works.

I have subsequently analysed the data for this thesis as a quantitative study into the level and nature of the derogations. The full analysis is also contained in Appendix H. The derogations are in two parts: departmental and individual rooms, Tables 38 and 39

Table 38 Case Study 5 HBN Derogations

Schedule of Accommodation	**No. Departments**	**No. Departments subject to HBN**	**No Departments with Derogations**
1. Inpatient Accommodation	21	21	21
2. Outpatient Accommodation	4	4	4
3. Diagnostic and Treatment	9	9	9
4. Clinical Support	6	4	3
5. Non-Clinical Support	7	0	0
6. Engineering Services and Communication	3	0	0
Totals	**50**	**38**	**37**

Part 1: Departmental: this includes reference to missing rooms, rooms which are under area by 10% and rooms which have potential issues regarding clinical functionality. This indicates a high level of derogation, although it could be explained by the same type of room being derogated within each department. The one department with no derogations is Radiopharmacy – a department which is governed by strict external regulation and which usually has design input from and is constructed by a specialist subcontractor.

Table 39 Case Study 5 Department and Room Derogations

Schedule of Accommodation	**No Rooms**	**Room Area Derogations**	**Percentage**	**Total No. Derogations**	**Percentage**
1. Inpatient Accommodation	1599	415	26%	517	32%
2. Outpatient Accommodation	80	8	10%	12	15%
3. Diagnostic and Treatment	809	38	5%	66	8%
4. Clinical Support	71	3	4%	15	21%

Part 2: Room derogations within the departments, the majority of the rooms are in the category relating to area and predominately in the inpatient accommodation, having been previously identified by the trust where the single rooms were 'innovatory designed' and reduced from 19.0sq.m to 15.5sq.m. In the Inpatient Accommodation this accounts for 26% of the derogations. This figure jumps to 32% when the overall derogations are added. In this

category the main missing elements related to the provision of staff facilities, sharing toilets between public and staff and in some departments the absence of cleaners and disposal rooms. Part of the design philosophy was certain facilities should be contained in 'hubs' for staff, visitors and facilities management. However, the HBNs do include dedicated facilities for certain departments. Staff changing can be centralised for some departments, but there would normally be dedicated staff toilets and rest rooms, unless they were very small sub-departments. Good practice in accordance with HBN00-09 Control of Infection would make provision for dedicated cleaners and disposal rooms.

Table 39 indicates a trend that the more technologically sophisticated the departments are that room areas are not reduced in size. The increase in the overall percentages is reflected by specific digressions from HBNs. In the Emergency Department there is no dedicated staff changing, in the Operating Department there are no exit bays and the shared dirty utilities form a linked disposal corridor connecting all 12 theatres. The clinical support areas had a low area derogation, but due to the small numbers of rooms within the departments such as pharmacy and pathology, the absence of staff facilities, dedicated cleaners and disposal rooms this results in a higher percentage.

In addition, there are also derogations related to core facilities where corridor widths have been reduced and to engineering services where the sizes and shapes of the electrical switchgear cupboards are not compliant. This is indicative of a client who has either no regard for complying with healthcare HBNs and HTMs albeit some of them are out of date and yet wants them all without clarifications to be included in the Trust Core Requirements (TCRs).

8.7 Design Management Organisation and Structure

Why does this matter? A recent article by Andy Law, FRIAS - RIAS Quarterly Spring 2018, 'The State of Construction' looks at the three major incidents which happened in the construction industry in 2016, 2017 and 2018 (The Wall Collapse at Edinburgh Schools, the Fire at Grenfell Tower and the Collapse of Carillion). He looks at the change from buildings designed by teams, led traditionally, by an architect - a professional trained to discover and understand the needs of the client, and to design a building which satisfies these needs and those of the community and environment. The change to contractor-led design and build projects in the public sector resulted in changes to the architect's role, with the architect becoming a 'subcontractor' to the construction company; this tended to cause conflict as the architect no longer had any direct communication with the healthcare client. When the architect is employed by (and therefore responsible) to the client, there is both an appropriate chain of authority and responsibility. Each professional has a code of conduct, establishing ethical standards with which members must comply and exercises sanctions if they do not.

Where the architect is employed by the contractor, who is in turn employed by the client, the link between professional and contractual responsibility is broken. Legally, the architect is now responsible to the contractor, but still owes a professional responsibility towards the client. The contractor however is a commercial entity, bound only to fulfil the terms of the contract and with no professional code of conduct. By separating the architect from the client, the system reduces the architect’s ability to understand requirements.

The roles and responsibilities of P22, and the use of NEC contracts, introduce the role of pre-construction manager, something by implication suggests this should be design led. During temporal period 5 I was involved in a project to rationalise services for an NHS Trust over three sites. Our Technical Services Department normally prepared the submission for tendering, but I ended up preparing it as the library information they were using was out of date! We were selected to bid for the project, and I was included as the pre-construction manager, but after the initial stages the Trust decided they needed to review their requirements and stopped the process. A few months later the project was re-advertised, and we were selected as one of four to participate. There were some very difficult existing departmental relationships to resolve and a large part of the project involved reconfiguration, demolishing older parts of the estate, renovating some buildings and creating new buildings. Programming and sequencing were critical in order to maintain the acute hospital facilities throughout the construction project. BIM was starting to be introduced, but senior members of the company did not fully understand its capabilities or how to promote it to their best advantage.

On the second attempt the P22 manager from technical services (who was also an architect/design manager) decided the commercial manager should take on the role of pre-construction manager and my involvement reduced. I had spent a considerable amount of time working with the healthcare planner to come up with a healthcare strategy and with the planning engineers to work out construction phasing and sequencing. The planning engineers had created a sketch BIM model to demonstrate site construction and traffic movement around the site. However, when it came to presenting the proposal to the Trust, the P22 manager decided this should not be included and he should lead the presentation as he considered the Trust was very traditional and would prefer an ‘all male’ team, something which I had not previously encountered. To the Case Study 4 Team's dismay we did not win the project, and in fact were third out of four, the team with the winning bid's female architect had demonstrated how they could help the user groups by 'loading 3D room models' on an iPad. The P22 manager had misjudged the Trust and the role of technology. Had we focused on our health strategy and presented the 'construction' video the outcome could possibly have been different.

I have included another P22 project in Appendix E which was started during this period as t contains some of the same issues. I consider it to be my 'time warp' project as rather than continuing to progress and develop skills and processes it went backwards.

During the same period the Project Director from Case Study 4 and I became involved on another project with the same SPV team that had worked on Case Study 4. It was just before the final submission for preferred bidder. At this stage there were two bidders and the company was very confident the bid would be successful. The idea was the Case Study 4 construction team would run the project on site and the Project Director and myself were asked to get involved to try to ensure a smooth transition and to review the scheme for buildability. Up until that point the team representing construction consisted of a design manager from Technical Services, an experienced architect, although one who had no healthcare experience, the bid director from Case Study 4 and a commercial manager from another hospital PFI project. The architects were an American company based in London who we had not worked with before, the structural and services engineers had worked on Case Studies 3 and 4. Unfortunately, it was too late! The healthcare planner for the SPV was the same one who had been involved in Case Study 4. She worked very closely with the healthcare planning architect and had a good relationship with the Trust. The architects however operated the split system, the project architect was responsible for the overall design and external elevations and the healthcare planning architects looked at the internal layouts. I noticed the mortuary layout would not work and in this project this department was very sensitive due to adverse publicity several years previously. The design manager said at this stage it was too late to change it. The Project Director and I went with the SPV to visit a hospital in Leipzig to look at 'automated guided vehicles' (AGVs). I had seen this type of system on a MARU visit and it highlights the value of looking at new developments during the design stages. I was also given the task of constructing a sample room and a section of the external envelope to show to the Trust. Organising the sample room was very enjoyable, my remit was to ensure it looked like the design 3Ds as much as possible - not easy as the there was too much 'artistic licence'! The project architect influenced the design and was specifying components which were not healthcare compliant. Although the aim was to recreate the design, I also ensured it could be built and insisted allowances had to be made for structure and services. The end result was very successful, but unfortunately as our competitors had not built a sample room the Trust would not let staff see it. The external sample was built in the carpark at Case Study 4 and the brickwork looked terrible! The architect wanted a random effect, but people thought that it was just badly built brickwork! The commercial manager was costing the building based on previous projects and not the sample room - the basins in the single room were bespoke and cost £500.00 without fittings! He also wanted to employ a subcontractor to provide equipment, but the quantity surveyor who had worked on Case Studies 3 and 4, and I told him this was a complete waste of money. Much to the team's horror the project was awarded to our competitors with design being one of the failures. I was disappointed, especially for our Case Study 4 construction team, but not surprised. Whether, if our team had been involved earlier would have made a difference, I don't know but we could have ensured a more integrated and realistic approach was taken. Splitting the design between design concept and detailing healthcare planning caused problems as did trying to bring in 'specialist equipment suppliers'; more integration is required not less.

It is also important to listen to the client - if they do not request a sample room then don't build one at this stage. All this did was to demonstrate the differences between the designers' thoughts from those of procurement. What was built was not affordable and had we been successful there would have been a serious problem trying to deliver what we had promised. It is again an example of involving staff with the right level of experience at the right time. Building sample rooms again demonstrated the value it brings to understanding but unfortunately the users did not get to see it!

8.8 Auto-Ethnographic Reflection on the Wider Delivery Model

In January 2018, Carillion collapsed under a £1.5bn pile of debt, included within its portfolio of projects was the new £335m Royal Liverpool Hospital which had originally been scheduled to open in March 2017. At the time of Carillion's collapse, it was 80-90% complete and it was not until September 2018 that the government announced it would publicly fund the completion of the building at a cost of £100-120m. It became one of the factors in signaling the end of PFI and PF2 procurement. In October 2018, Laing O'Rourke were appointed as management contractor to complete the works and in June 2019 set out their programme for carrying out remedial structural works. Several floors of the nearly completed building needed to be stripped out in order to carry out the structural repairs and currently there is no cost or timescale to completion. One major issue for the Trust relates to warranties for equipment which has already been installed and the additional costs of maintaining the existing estate and the potential replacement of new equipment before the new building is in operation.

Carillion were also in the midst of constructing another hospital, the Midland Metropolitan Hospital which was only about 50% complete with the frame and envelope almost wind and watertight. As with the Royal Liverpool, the government decided to publicly fund its completion when no other PF2 consortium was prepared to. This time a different delivery model was proposed adopting an NEC4 contract similar to that of the P22 framework.

8.9 Disintegration Relationship Between Project-based Design Management and Wider Delivery Model

I have described this period as disintegration as it not only marked the end of PFI procurement for major hospitals but reflected a further decline in support from the Department of Health for standards and guidance with no revisions to HTMs and HBNs despite major technical developments and new innovations and changes in models of care. Disintegration also expresses the increase in the number of subcontractors in supply chains and the introduction of multiple specialists with the object of transferring risk. This level of fragmentation is difficult to project manage which is demonstrated by the issues in carrying out the refurbishment of Grenfell Tower.

Attitudes to derogation appeared to be taken lightly with some designers and clients not realising this cannot be applied to the building standards regulations, only relaxations can be granted, and these are for predetermined situations in existing buildings. Like the healthcare standards and guidance, a review of building regulations was long overdue.

This period includes four bids/projects in which I was involved none of them had the same level of integration which had been achieved in Case Study 4. The first was a bid for a major PFI project, reaching the final stage against one competitor. The second was a P22 bid and the third a P22 project. I left the company in 2013 and whilst doing consultancy work decided to study for a PhD. During this period a number of major projects began to fail, including five major hospital projects. One of these projects was in a ‘half-finished state’ and I was asked by one of the bidding contractors to review the building design and compliance with clinical functionality. I accepted this opportunity to be involved as it meant that I could add a further case study to this thesis as this signalled the end of PFI/PF2 as a means of procuring major hospital projects.

There are some common threads amongst these failures relating to problems with regulation and its administration – differences in opinion regarding interpretation and more fundamental the increased use of 'self-certification" creating an absence of impartiality. Case Study 5 has provided the opportunity to carry out quantitative analysis in standards and guidance which is part of the wider delivery system and to relate this back to literature. Contracts have become more complicated with increased numbers of specialists this has led to all parties trying to pass risk to each other.

The issues in Temporal Period 5 Disintegration indicate the creation of a 'Perfect Storm', three major PFI hospital projects unable to open or be completed, all of them displaying issues with compliance. In all cases it is a failure to produce the correct project requirements and the focus has been of passing risk from one party to another. The lack of up to date healthcare guidance and attempts to include old guidance and then ignore it as it is not mandatory has been demonstrated in Case Study 5. The issues with the Edinburgh Schools PFI , Cole (2017) are a failure to independently supervise the contractor's work, allowing self-supervision is a dangerous practice. What was considered to be a 'flag ship' example of project delivery, Crossrail will no longer be completed on time and within budget and can be summed up by the Channel 4 quote that it had been designed as "a tunnel with a railway running through it rather than a railway going through a tunnel' – it had not been designed as an integrated solution.

The most horrific failure in this period was the fire at Grenfell Tower which claimed the lives of 72 people. The issues here relate to compliance with building regulations, the introduction of new and untested materials, not engaging the correct professionals to oversee the work, having no building operational policy Hackitt (2018). It is an example where, by carrying out the refurbishment of the tower and only looking at one aspect – improving insulation the knock-on effects regarding fire strategy have been overlooked. It also demonstrates the need to look at buildings holistically and not keep bringing in 'specialists' for one element and assuming they understand the consequences of what they are doing affects other aspects of the building. In a minor comparison on Case Study 4 the cladding contractor was deemed to be the expert on movement joints, but if I had intervened the joints would not have lined through because they would have set them to line with the bottom of the beams not the top. A simple change of lining the tops through achieved the correct elevational treatment.

After Case Study 1, when I felt I had gained knowledge which I could transfer to future projects, working on Case Study 2 felt like a step backwards and then through Case Studies 3 and 4 lessons learnt began to influence outcomes and by the completion of Case Study 4 I again felt the same sense of achievement from Case Study 1. This period of disintegration I found very hard and the current Case Study 5 was a challenge as it is apparent there are still problems with competencies and capabilities within the construction industry and major issues with standards and guidance.

Chapter 9 Longitudinal Outcomes from the Temporal Periods

9.0 Longitudinal Outcomes from the Temporal Periods

9.1 Introduction

The four previous chapters have described and analysed the data from the individual temporal periods, each one summarising the outcomes. Now these are combined to form a longitudinal auto-ethnographic study, Figure 28.

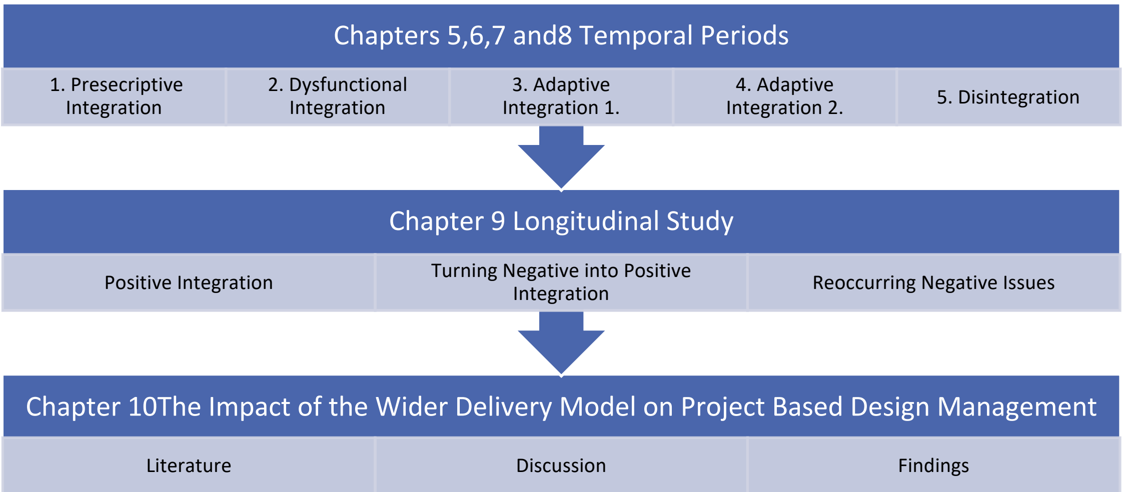


Figure 28 The Longitudinal Study

The method of analysing the retrospective case studies in Temporal Periods 1, 2, 3 and 4 involved the identification of the critical incidents (the results of negative integration) and occurrences of positive integration. The individual results for each case study have been collated and a column added to indicate the progression of the events through the temporal periods to ascertain whether lessons have been learnt from one project to the next or the same errors continue to occur. Common themes are identified which then be discussed in relation to literature relating to individual project delivery and the wider delivery system.

The table 40 sets out the scope of each of the temporal periods in terms of individual case studies, my role in each project and my educational status linking to the wider delivery system. Temporal Period 1 was for me a time when I gained healthcare design experience from working on projects and became aware of changes happening in the wider delivery model and resulted in undertaking a master's degree in construction project management.

Temporal Period 2 was a transitional period where although still working as a project architect, the scope of the role was now considerably reduced, and it was a period of adjusting to a different learning curve. In Temporal Period 3 in this adaptive period with the architect's role changing it was a time to revaluate and within this period I embarked on a second master's degree into healthcare planning. This opened up a second area of the wider delivery model and an introduction to various healthcare networks and comparative study courses of European Hospitals in addition to those in the UK.

Temporal Period 4 concentrated on building from Temporal Period 3 and in Temporal Period 5 I decided to review my 40 years in healthcare architecture in the form of this longitudinal auto-ethnographic thesis.

Table 40 Definitions of Five Temporal Periods, Researcher's Retrospective Role and Awareness of the Wider Delivery Model

Project Delivery Model	My Education and Role	Wider Delivery model
Temporal Period 1 Prescriptive Integration Case Study 1 Design Bid Build	1975-1993 Chartered Architect, RIBA 1976 Project Architect/ Supervising Officer MSc Construction Project Management (1993)	Nucleus hospital programme; England and Wales, NHS Estates extensive guidance in the form of HBNs and HTMs Underpinning of professional services
Temporal Period 2 Dysfunctional Integration Case Study 2 First Wave PFI/ Contractor led Design and Build	1993-2001 Project Architect	Removal of professional fee structures Removal of Crown Immunity 2001 Change of procurement – role reversal between architects and contractors Reduction in support by Department of Health
Temporal Period 3 Adaptive Integration 1. Case Study 3 Second Wave PFI/ Contractor led Design and Build	2001-2006 Project Architect/ Senior Design Manager MSc Planning Buildings for Health (2006)	Department of Health began to reduce investment and support for research and development Architects losing skills related to stakeholder engagement, contract administration and the ability to learn from site inspections
Temporal Period 4 Adaptive Integration 2. Case Study 4 Third Wave PFI/ Contractor led Design and Build	2007-2012 Senior Design Manager	Department of Health continuing to reduce investment and support for research and development Healthcare Architects exploring new strategies New models of Health Care Advances in Medical Technology
Temporal Period 5 Disintegration Case Study 5 PF2/ Contractor led Design and Build	2013-2020 Health Design Consultant PhD Thesis	Department of Health ceased investment and support for research and development. Last update of HBNs 2013 Adoption of multiple design consultants Serious failures in the construction industry

9.2 Resolution of Critical Incidents

The majority of the negative integration issues related to the critical incidents – specifically the lack of design integration where the initial coordination of space planning, structure and engineering services became focused on the contractor’s work package programme, setting up different working relationships making it difficult for the architect as lead designer to fully coordinate. At the same time the contractors 'design managers' were unfamiliar with the iterative nature of the design process causing confrontation. The outcomes of many of these situations did however result in positive integration and were adopted on future projects. Table 41 sets out the critical incidents giving a short description of the event, the category of the event, the person responsible for integration and whether this item has been adopted in subsequent case studies. This table demonstrates how analysis over a long period of time helps to identify the time frames of relating to the transfer of the integrator role took place and the increasing number of critical incidents requiring resolution.

A indicates adopted to identify when they occurred, and R repeated indicating that it had been carried on to the next project as 'lessons learnt'. In Case Study 5 where a new contractor has taken over P indicates where it is proposed to adopt these items of positive integration and U indicates unknown. The reference code contains a suffix indicating which design stage integration took place.

/1: Pre-design
/2: Concept Design
/3: Design Development
/4: Work Package Design
/5: Design in Construction
/6: Design Feedback

Case Study 1 is separated from the other four studies as it represents a different delivery model and enables a comparison to be made regarding how the change from one model to another has affected different types of integration and who was the integrator.

Table 41 Critical Incidents Across Temporal Periods which if Unresolved Would Create Disintegration

Ref	**Description**	**Category**	**Resolution/ Integrator**	**Lessons Learnt over Temporal Periods**				
Design Bid Build				**1**	**2**	**3**	**4**	**5**
1C1/4	Affordability	Mechanical and Electrical Services	Architect	Y	N/A	N/A	N/A	N/A-
1C2/5	Programme Delays on Site	Construction	Architect	Y	N/A	N/A	N/A	N/A-
1C3/5	Provision of Information	Design	Architect	Y	N	N	N	N
1C4/5	Positioning of Electrical Items	Mechanical and Electrical Services	Architect	Y	N	N	Y	N

1C5/5	Coordinated Ceiling Layouts	Mechanical and Electrical Services	Architect	Y	N	N	Y	N
1C6/5	Cost Control Disputes	Cost Management	Architect	Y	N/A	N/A	N/A	N/A
1C7/5	HSDU Redesign	Client Changes	Architect /Contractor	Y	N/A	N/A	N/A	N/A
1C8/5	Change to Incinerator	Client Changes	Architect/Contractor	Y	N/A	N/A	N/A	N/A
1C9/5	Radiodiagnostic Equipment	Major Medical Equipment	Architect/Contractor	Y	N	Y	Y	N
1C10/5	Installation of Theatre Tables	Major Medical Equipment	Architect/ Contractor	Y	N/A	N/A	N/A	N/A
Contractor Led Design and Build								
2C1/2	Design of Out-patient Department	No Schedule of Accommodation	Architect	-	Y	N/A	N/A	N/A
2C2/2	Design of Boilerhouse	Layout issues	Architect	-	Y	N/A	N/A	N/A
2C3/2	Room Data Sheets	Two different Data Bases	Unresolved, resulted in equipping issues	-	N	N/A	N/A	N/A
2C4/3	Missing Rooms	Agreeing the Schedule of Accommodation	Architect/Contractor	-	Y	N	Y	Y
2C5/3	Absence of User Group Meetings	Stakeholder Engagement	Limited engagement with specialist departments during equipment installation	-	Y	Y	Y	Y
2C6/5	Construction Phasing	Design v Construction Phasing	Architect/Contractor	-	N	N	Y	N
2C7/5	Positioning of Electrical Items	Mechanical and Electrical Services	Architect	-	N	Y	Y	N
2C8/5	Coordinated Ceiling Layouts	Mechanical and Electrical Services	Architect	-	N	N	Y	N
2C9/3	Location of internal drainage	Change of frame design by contractor	Architect	-	Y	Y	Y	N/A
2C10/3	Partition grid relationships	Lack of integration	Too late to change the layout drawings	-	Y	Y	Y	N
2C11/5	Wrong colour of doors ordered	Contractor error	New doors ordered	-	Y	Y	Y	N/A
2C12/5	Delivery of equipment	Contractor failed to understand sequencing	Architect and Contractor	-	Y	Y	Y	U
2C13/5	Installation of Theatre Pendants	Issues with Secondary Steelwork	Architect	--	N	Y	N/A	N/A
2C14/5	Architect's Programme	Failure to meet Contractor's Programme	Disputed by both parties	-	N	N	N	U

2C15/4	Trust request for Change Orders	Change Control Procedures	Fixed in contract	-	Y	Y	Y	N/A
2C16/5	Nurse Call Installation	Mechanical and Electrical Services	Architect	-	N	Y	Y	U
2C17/4	Pneumatic Tube System	Mechanical and Electrical Services	Architect		Y	Y	Y	U
2C18/5	External Envelope	Contractor procured incompatible Components	Architect		Y	Y	Y	N/A
2C19/5	Bedhead Trunking	Integration with partitions	Architect		Y	Y	Y	U
2SC20/5	Aseptic Pharmacy	Turnkey Package	Architect	-	Y	Y	Y	Y
3C1/2	Preparing Schedule of Accommodation	Client briefing discrepancies	Architect/ Contractor	-	-	Y	Y	Y-
3C2/2	Initial Concept Design	Client briefing discrepancies	Architects	-	-	Y	N/A	N/A
3C3/2	Agree Room Data Sheets	Use of ADB	Architect/ Contractor/ Client	-	-	Y	Y	N/A
3C4/3	Achieving Preferred Bidder	Design change due to Users' misunderstanding	Architect	-	-	Y	Y	N/A
3C5/3	Departmental Review Meetings	Missing Rooms by architect	Architect	-	-	Y	N	N/A
3C6/3	User Group Meetings	Programming	Architect/Contractor/ Client	-	-	Y	Y	U
3C7/3	Design Information	Poor quality checking by architects	Architect	-	-	Y	Y	Y
3C8/3	Financial Close	Building over area	Architect	-	-	Y	N	N/A
3C9/3	Link to Existing Building	Interface Issues	Architect	-	-	Y	Y	N/A
3C10/3	Full set of Room Elevations	Mechanical and Electrical Services	Architect	-	-	Y	Y	N
3C11/4	Structural Wind Bracing	Integration with Elevations	Architect	-	-	N	N	N/A
3C12/4	Laboratory Design	Equipment Installation	Architect	-	-	Y	Y	U
3C13/5	Video Entry Systems	Mechanical and Electrical Services	Architect	-	-	Y	Y	U
3C14/5	Construction Phasing	Design v Construction Phasing	Architect/Contractor	-	-	Y	Y	N/A
3C15/5	Doors and Ironmongery	Joinery Sub-contractor	Architect	-	-	Y	Y	U

3C16/5	Theatre pendants	Mechanical and Electrical Services	Architect	-	-	Y	Y	U
3C17/5	Coordinated Ceiling Layouts	Mechanical and Electrical Services	Architect	-	-	Y	Y	N
4C1/2	Design not integrated	Functional design	Senior Design Manager	-	-	-	Y	N-
4C2/2	Building relationships	Major buildability Issues	Senior Design Manager and Planning Engineer	-	-	-	Y	N/A
4C3/2	Link to existing building	Major buildability Issues	Senior Design Manager and Planning Engineer	-	-	-	Y	N/A
4C4/2	Wayfinding strategy	Functional Design	Senior Design Manager	-	-	-	Y	U
4C5/3	Relationship with SPV	Project experience	Senior Design Manager	-	-	-	Y	N/A
4C6/3	Position of WHBs	Stakeholder Engagement	Architect/Client/Senior Design Manager	-	-	-	Y	N/A
4C7/3	Client use of ADB	Out of date information	Senior Design Manager	-	-	-	Y	N
4C8/3	Departmental Change	Stakeholder Engagement	Architect and Senior Design Manager	-	-	-	Y	N/A
4C9/5	Construction Team Set up	Project Management	Senior Management – damage limitation	-	-	-	Y	N
4C10/5	Design Information	Integration issues	Architect and Senior Design Manager	-	-	-	Y	N
4C11/5	Architect's Programme	Failure to meet Contractor's Programme	Senior Design Manager- damage limitation	-	-	-	Y	U
4C12/5	Architectural Design Management	Design Management	Senior Design Manager- damage limitation	-	-	-	Y	N
4C13/4	Structural Wind Bracing	Integration with Elevations	Senior Design Manager	-	-	-	Y	N/A
4C14/4	Design of Main Stair	Contractor Design Interference	Senior Design Manager	-	-	-	Y	N/A
4C15/4	Render Joints	Contractor Design Interference	Senior Design Manager	-	-	-	Y	N/A
4C16/4	Renal Dialysis Stations	Contractor Design Interference	Senior Design Manager	-	-	-	Y	N/A
4C17/4	Roof Design	Contractor Design Interference	Senior Design Manager	-	-	-	Y	N/A

4C18/4	Main Signage	Contractor Design Interference	Senior Design Manager	-	-	-	Y	N/A
4C19/4	Medical Gas Pendants	Equipment Procurement	Senior Design Manager	-	-	-	Y	U

Again, the architect in Case Study I is responsible for resolving the majority of the issues, many of which did not reoccur. As the relationship grew between the architect and the contractor, when the client caused critical incidents the parties combined to resolve them.

Case Study 2 had a large number of critical incidents and although many of them resulted from the contractor's actions it was left to the architect to resolve them. In many of the situations the architect pointed out potential problems, but these were dismissed by the contractor but when they occurred the contractor then asked the architect to resolve them as if it was a traditional contract. A different set of critical incidents took place in Case Study 3 and again it was the architect who had to resolve them.

However, in Case Study 4 the situation changes and this time it is mainly the Senior Design Manager who resolves the situation. Considering that the team from Case Study 3 apart from the architect all transferred to Case Study 4 there seemed to be a large number of critical incidents. Some are reoccurring issues, but mainly they involve the transfer of the project from the contractor's technical services team to the site team, the lack of integration by the architects and the appointment of a site project director, new to the company, with no formal qualifications and an attitude that 'design and build' meant that he could make design changes without consulting the architect or client or even the design manager.

A few of the critical incidents were unable to be resolved, all of them occurring in Case Study 2. The most significant issue relating to the existence of two data bases, one held by the contractor and the other by the client. The two were uncoordinated and this made life difficult for the architect and mechanical and electrical engineers to provide the correct room requirements. It was also further compounded by the fact that the Trust's equipment database did not reflect the user requirements. It highlighted a dangerous situation founded on mistrust which Case Studies 3 and 4 sought to remove by the use of Codebook software which the architects used to translate the room data sheet requirements into room layout sheets. This worked successfully and is recognised as being an 'industry standard'. Strangely however in Case Study 5, although Codebook was used to prepare the room layouts and the Trust signed off the drawings following user consultation, we discovered at the first 'Dialogue' meeting that the Trust's Equipment Advisor kept a separate equipment list of the actual equipment being proposed. We pointed out to the Trust the dangers this presented and that we should be present at meetings being held with the advisor. The Trust ignored this advice and no meetings were arranged and we were not issued with the updated list prior to the contract being signed. The previous contractor had obviously not seen this as a problem, but the due diligence exercise exposed a high level of disintegration in the design with multiple designers, healthcare planners and equipment specialists thus creating a situation where the lack of a coordinated design would not be displayed until critical incidents took place. It was a disaster waiting to happen as there was no evidence of integrated design management or a systems integrator. From the earlier case studies, particularly case studies 1 and 4 where there is evidence of a systems integrator project outcomes have been more successful, suggesting the need for a systems integrator who is present throughout the design process. It highlights the need of a role within the design management field as someone who can integrate client stakeholders, with the designers and constructors in a form of IPD contract where risk is shared, avoiding a blame culture. Table 41 also gives details of who the systems integrator is in relation to research question 4.

9.3 Positive Integration Across Temporal Periods

Positive integration describes events which took place in each of the retrospective case studies and follows its adoption through subsequent projects. Case Study 5 was partially completed when I became involved and as a result it is difficult to establish if these actions had been adopted. Similarly, as the project is only now recommencing it is unknown if some will be included. However, following the due diligence exercise which I carried out I was able comment on some of them. Table 42 sets out the examples of positive integration in a similar format to Table 41. The table sets out the effects of long term learning over the temporal periods, which elements have been adopted and developed further and who was responsible for integrating them.

Table 42 Examples of Positive Integration Across Temporal Periods

Ref	Description	Category	Integrator	Case Studies				
Design Bid Build				**1**	**2**	**3**	**4**	**5**
1SD1/3	Separate drawing layers	Design and Construction Information	Architect	A	-	-	-	-
1SD2/3	Fitment Coding System	Design and Construction Information	Architect	A	R	R	R	-

1SD3/3	Integration of External Envelope	Structural Integration	Architect	A	-	R	R	-
1SD4/4	Specialist Subcontractors	Turnkey Packages	Architect	A	R	R	R	R
1SD5/5	Work Package notifications	Contract Administration	Architect	A	-	-	-	-
1SD6/5	Preinstallation works	Integrated Equipment Strategy	Architect/ Contractor	A	-	R	R	P
Contractor Led Design and Build								
2SD1/2	Room Scheduling	Schedule of Accommodation	Cost Manager/ Architect	-	A	R	R	P
2SD2/2	Electronic Data Management	Information	Senior Design Manager	-	A	R	R	R
2SD3/3	Departmental Reviews	Financial Close	Cost Manager/ Architect	-	A	R	R	P
2SD4/3	LA Building Control based on site	Compliance	Senior Design Manager	-	A	R	R	-
2SD5/3	Electronic Building Warrant	Contract Administration	Senior Design Manager	-	A	R	R	P
2SD6/4	Prefabricated Bathroom Pods	Modular off-site construction	Project Director	-	A	R	R	-
2SD7/4	Bedhead Trunking	Modular off-site Construction	Electrical Services Manager	-	A	R	R	R
3SD01/2	Single Page Data Sheet	Design and Construction Information	Architect/ Senior Design Manager	-	-	A	R	-
3SD02/2	Adoption of Codebook Software	Design and Construction Information	Architects	-	-	A	R	R
3SD03/2	User Group Scheduling	Stakeholder Integration	Architect/ Cost Manager/ Client	-	-	A	R	U
3SD04/3	Room Mock-ups	Stakeholder Integration	Project Director	-	-	A	R	R
3SD05/3	Drawing Status 'B"	Contract Administration	Architect/Project Director/ Client	-	-	A	R	-
3SD06/4	GRP Bathroom Pods	Modular off-site Construction	Project Director	-	-	A	R	-
3SD07/4	Modular Wiring	Modular off-site Construction	Electrical Services Manager	-	-	A	R	P
3SD08/4	Integrated Equipment Meetings	Joint JV Procurement	Senior Design Manager (previously the architect)	-	-	A	R	U
3SD09/5	Compliance Checking Procedure	Contract Administration	Senior Design Manager (previously the architect)	-	-	A	R	U

3SD10/6	Patient Transfer	Logistics	Senior Design Manager (previously the architect)	-	-	A	R	U
4SD01/3	Interactive Video Meetings	Design Meetings	SPV Project Director/ Senior Design Manager	-	-	-	A	-
4SD02/3	Guide to User Group Meeting	Stakeholder Integration	SPV Project Director/ Senior Design Manager	-	-	-	A	-
4SD03/3	Use of 'photo album'	Stakeholder Integration	Client/ Senior Design Manager	-	-	-	A	-
4SD04/3	Creation of D+ Equipment	Equipment Integration	Senior Design Manager	-	-	-	A	U
4SD05/3	Consultant's Appointment Matrix	Contract Administration	Senior Design Manager/ Commercial Manager	-	-	-	A	P
4SD06/3	Working with the Planning Engineer	Design Integration and Buildability	Senior Design Manager/ Planning Engineer	-	-	-	A	-
4SD07/4	Revision to Works Packages/	Contract Administration	Senior Design Manager	-	-	-	A	-
4SD08/4	Adding M&E Packages to the Works Package List	Integrated Work Package Programme	Senior Design Manager	-	-	-	A	-
4SD09/4	Ceiling Layouts prepared by the M&E Consultants/4	Fully integrated ceiling layouts	Senior Design Manager / M& E Subcontractors M&E Engineers	-	-	-	A	-
4SD10/5	Project Management Tracker/4	Reduced blame culture	Senior Design Manager	-	-	-	A	-
4SD11/5	Revised Site Instruction/4	Contract Administration	Senior Design Manager	-	-	-	A	-
4SD12/5	Design Manger's Evaluation/4	Contract Administration	Senior Design Manager	-	-	-	A	-

Four out of the six positive integration items in Temporal Period 1 were adopted in subsequent projects, the use of a layered drawing approach was overtaken by introduction of CAD and BIM. The sixth item was no longer required due to the change in procurement method. All of the issues were proposed by the architect, which considering the relationship between architect and contractor at the time was understandable, the contractor in this type of relationship had little opportunity to propose changes.

In temporal periods 2, 3 and 4 the position changes, in period 2 the contractor introduces a number of new systems, some of them related to their aspirations and some as a result of what was happening in the wider system. In Temporal Period 2 not only does the architect/

contractor relationship change but hospitals lose their crown immunity and plans have to be submitted to the local building control authority. This is also a major issue for the local authorities trying to process and manage such large applications in a building with which they are unfamiliar and to deal with contractors rather than architects. The contractor in this period made a very wise and astute move by engaging with the local authority and including them within the site team. It was also a period of time when computer software was developing rapidly where document management systems were being introduced. The advantages of being a large contracting organisation enabled the purchase of such systems – something which architects and engineers could not have afforded. In the early stages of period 2 the contractor was reluctant to listen to the architect unless they could see a benefit to themselves and this happened with the introduction of a turnkey subcontract for the installation of the Aseptic Pharmacy. Having learnt this lesson in Case Study 1, when problems arose on site trying to build this facility, I proposed the engagement of a specialist subcontractor and the Senior Design Manager realising the benefits proceeded with the specialist. The Senior Design Manager on this project was actually a Senior Project Manager, a civil engineer used to being in charge of a project and a decision maker.

The initial bid for Case Study 3 involved several members of both the design and construction teams and as a result many of the lessons learnt on Case Study 2 were taken on board. It had also developed a level of trust amongst the team and as an architect I was able to introduce more integration in the earlier phases and having transferred to the contractors' team continue this process in the latter phase of the project when I replaced the Senior Project Manager. The Project Director (another civil engineer and an extremely good leader) was very motivated in "achieving or exceeding client expectations" but initially did not consider the need for a design manager, this he considered to be the architect's role and employed a young engineer as a design co-ordinator with the Senior Project Manager effectively carrying out the role of design manager. Towards the end of the project I was 'head hunted' by this Project Director to ensure that Case Study 3 was delivered to his satisfaction and to lead the design on Case Study 4.

Working as part of the contractor's team in Case Study 4 enabled me to increase project integration by engaging with the planning engineer, commercial engineer, construction manager, mechanical and electrical JV partners all under the leadership of the Project Director.

Case Study 5 is a different situation, my involvement was as a health design consultant carrying out a due diligence compliance exercise and as unable to influence project integration. It did however allow me to review what had happened to the point when the project stopped and what was likely to happen moving forward. The level of positive integration was very low and the only examples which confirmed a continuation from the previous temporal periods related to the use of specialist subcontract packages and integrated components for the provision of bedhead services.

This demonstrates how knowledge transfer depends upon individuals rather than organisational interchange including feedback into the wider delivery systems.

9.4 Relationship Between Critical Incidents and Positive Integration

The previous sections analysed the critical incidents and positive integration through the temporal periods and the following sub sections combine the summarised data to extract common themes and relate them to each of the design stages. The original analysis indicated at which stage in the project the incident occurred whereas this analysis highlights in which design stages they actually relate to and where there is potential to avoid future instances. There are few examples within Design Stages 1 and 6 due to little or no input from design management within the wider delivery system and the absence of post occupancy evaluation demonstrating the lack of integration between the wider delivery system and project design management

9.4.1 Concept Design Stage

This stage contains two elements; the provision of design information by the client and how it is managed and design integration. It does not feature in Case Study 1 as the issuing of information to the design team was monitored by the CSA (the wider delivery system). The issue emerges in Case Study 2 where the client now has freedom of choice and it is also the time when electronic data bases were introduced. Instead of being an opportunity to have a common data base, the client's mistrust of the contractor resulted in two versions which caused major problems and was never resolved because the client failed to issue updates of their equipment information to the contractor. The other issue related to the use of ADB which due to its lack of development to cope with new technology, reflect new models of care, use of a non-intrinsic coding system and the printing of room data sheets on 4-5 A4 sheets of paper. This was resolved in Case Study 3 by the use of a single A3 sheet, the adoption of a simpler coding system (related to the original coding in the CDB elements of the HTMs) which could layout to individual room layout sheets.

The other issue concerned design integration and primarily the failure of the architect. In Case Study 3 the architects in their eagerness to make a start on the project produced a concept design based on an unchecked schedule of accommodation. As the site area was restricted the concept design had to be revised to suit the actual schedule of accommodation which was produced within the architect's office. It reflects the importance of setting out the sequence of design activities. In Case Study 4 the four issues are related and again concern a failure on behalf of the architect in respect of integration. The new building was being designed to be the new acute hub of the hospital and therefore the effective circulation links to the retained buildings were crucial. The architects however designed the building without detailed consideration of this issue which had to be resolved during design development.

Findings:

- Single data base required
- Importance of design activity sequence
- Focus on integrated design

9.4.2 Design Development

This stage involves four elements: design integration, design information, stakeholder engagement and contract administration. Case Study 1 introduced the integration of the structure with the external envelope to avoid the boxing out of columns in patient areas. It also utilised eccentrically loaded external column arrangements to allow the same column depth to be utilised on all floors. This principle was fundamental to nucleus hospital design in relation to control of infection, but as this system was not used in Scotland its introduction in Case Study 1 was challenged by the quantity surveyor on cost grounds. As the supervising officer and design team leader I was able to overrule the quantity surveyor. Another aspect of structural integration related to the column/ partition relationship where partitions were integrated to column faces rather than grid centre lines. As it was a 'hidden' feature of nucleus when the system was abandoned, designers who were unaware of its benefits failed to adopt it and the problems started to appear. This is demonstrated in Case Study 2 where it caused issues with external walls, partition and grid relationships and internal drainage. It was also exacerbated by the contractor deciding to construct a steel rather than concrete frame. The issue of missing rooms on drawings relates to poor quality control and design management within the architects' offices as does the issue of the increased building area.

The other issues relate to the contractor's role in the design development stage following the change to design and build. The lack of understanding of the design process leading to disputes over design programming, the lack of involvement of the architect in discussions regarding phased handovers – an issue which was finally resolved in Case Study 4 by the earlier involvement with the planning engineer, albeit with the design manager (a healthcare architect) and the direct design development of the frame with the structural engineer and the steelwork subcontractor without the involvement of the lead designer – architect.

In terms of design information, this mainly concerns the placement of electrical components and occurs within both types of procurement. It relates to what 'is expected' historically by the electrical subcontractors and what is contractually required. The issue was resolved in Case Study 1 by adopting a set of 'rules' as due to unknown positioning of studs exact dimensions cannot be provided and on-site workshops with architect, the main contractor and sub-contractors. Although an issue of services design coordination it was deemed to be part of the consulting engineers' remit. In Case Study 3 the issue of a full set of room elevations together with a set of rules. A fully functional BIM model should address this problem together with a fully transparent responsibility matrix as produced in Case Study 4.

The lack of stakeholder engagement on Case Study 2 resulted in several design errors which did not become apparent until after the building was occupied. It was a joint decision by the client and contractor to save time. The trust had commissioned many hospital projects and decided that within their project team they could consult the users without involving the design team. Their healthcare planner was a former nursing officer but not trained in the discipline (no formal training required to describe someone as healthcare planner) and certain design aspects were lost in translation to the users, resulting in incorrect layouts being approved. The lack of stakeholder engagement was common in nucleus but as a result of fixed briefing and standardised layouts. The importance of stakeholder engagement is seen by the number and scope of the items in this category.

The final issue in this stage relates to contract administration relating to the transfer from architect to contractor. The most significant issue was the contractor's decision to appoint the Local Authority to carry out Building Control in Case Study 2 and was something they continued on Case Studies 3 and 4.

Findings:

- The importance of design management within designers' offices
- Need for contractors to understand the design process
- The benefits of early engagement of construction planners
- Building relationships with stakeholders and common language
- Transparency between parties regarding responsibilities

9.4.3 *Work Package Design*

This stage has three sections relating to the type of work package. The term is used generically to describe subcontract scopes of work. In Case Study 1 this describes nominated subcontracts for mechanical and electrical installations and also specialist turnkey packages for specialist elements such as Aseptic Pharmacy Suites which benefit from all the activities being arranged by one contractor due to certification requirements. It is also the term used by contractors for procurement of domestic subcontractors. In traditional design, bid build a fully specified Bills of Quantities would separate sections by trade eg. steelwork, joinerwork, cladding, roofing etc. Defining the scope of a proposed subcontract as a works package enables two or more trades to be combined to ensure interfaces are included as in the case of the external envelope where the roof, external walls, window and doors are all carried out by the same subcontractor. Similarly, it allows trades such as electrical to be split up into specialist work packages to provide bedhead trunking and security systems. The third type of works package relates to modular off-site construction, the development of which can be seen through Case Studies 2,3 and 4. The critical incident with bedhead trunking related to the integration of this element within the architectural design but due to system being developed within the 'Mechanical and Electrical Subcontract' in this case the JV partner and the consulting engineers the interface problems did not manifest itself until the installation on site and the architect was left to solve the problem.

Many of the critical issues which occurred in the construction phase resulted from a failure to develop the work packages during this design stage. At the end of Stage 3 the design should be fully integrated in terms of systems including how to deliver the building infrastructure – establishment of the major circulation and distribution routes and the design coordination tightly controlled by the lead designer before taking the design detailing to the next level and involving specialists and subcontractors. According to designingbuildings.co.uk (September 2020) a £200million project is likely to have a 100 work packages and with reference to Case Study 4 this was certainly true – see Appendix G. Two of the works packages which resulted in reoccurring critical incidents had historical roots regardless of procurement. These relate to the integration of mechanical and electrical services and the installation of radiodiagnostic equipment. In Case Study 1 the issue concerns the difference between architects' and engineers' drawings at tender stage, whilst the architect is required to provide full working drawings, the engineers produce schematics from which the nominated subcontractor develops fabrication and installation drawings. This means that the drawings at tender stage cannot be fully coordinated. The change to design and build missed the opportunity to improve this situation by developing the services design with the consulting engineers as a separate workstream, making it difficult for the architect as lead designer to coordinate the overall design. As the architect was now a subcontractor of the main contractor and the services engineers were subcontractors to mechanical and electrical contractors the role was effectively weakened. It was not until Case Study 4 that this issue was resolved as a result of three actions; the contractor created a core team to oversee the batch project consisting of:

- Project Director from the construction division;
- Deputy Director from the Mechanical and Electrical JV partner;
- Commercial Director from the construction division and
- Senior Design Manager from the construction division

This was the first time that design management was represented at senior management level and also able to take part in project review meetings with other members of the site construction team. This was my role and it gave me the opportunity to review the works package process and create an integrated list to include all the mechanical and electrical packages.

The commercial team appointed all the members of the design team (the recommendations for the mechanical and electrical consultants being made by the JV partner). This allowed a transparent matrix of roles and responsibilities to be issued to all parties and also enabled me to ensure that design coordination was carried out by the architect as lead designer.

The second issue relates to the installation of fixed major medical equipment where the client is responsible for the purchase and installation of items such as radiodiagnostic equipment which is reliant on pre-installation facilities to be provided by the contractor. Originally classified as Group 3 Equipment in ADB which means that is a large item purchased by the client and placed in position not fixed, this definition has resulted in issues where, pre-installation works are required to be carried out by the contractor but details are not provided until it client has been purchased by the client. This causes problems for both the design in relation to room requirements and sequencing of the works. The issue was alleviated in Case Study 1 by scoping a nominated subcontract with a pre-installation contractor and ultimately in Case Study 4 by changing the equipment classification in agreement with the client. The integration of equipment has become more complex as the case studies have progressed and one of the project cost anomalies concerns the budget for major medical equipment. In neither design, bid, build or design and build is the architect or contractor aware what is in the client's budget making it difficult to incorporate late inclusion of fixed equipment without design changes during construction.

Very few work packages are stand alone, most involve interface detailing but in Case Studies 2 and 3 due to the parallel working between JV partners, work packages were developed independently within the 'sister' companies, until I intervened in Case Study 3 and set up 'equipment packages' where input was required from both parties. For example, in the case of the Aseptic Pharmacy, the complete package was procured by the main contractor with input from the mechanical and electrical contractor rather than as three separate packages. Other packages where the mechanical and electrical components were the major elements were procured by the services contractor with input from the main contractor. This combined approached also led to the resolution of the problems related to coordinated ceiling plans. Unlike the mechanical and electrical services contractors who would only install to their consultants' drawings and not architect's drawings, the ceiling contractor was more than willing to install to fully coordinated drawings from the services consultants. This was finally achieved in Case Study 4 and proved to be highly successful and avoided the previous issues including extensive reworking. By Case Study 4 the works package list was fully incorporated.

Findings:

- Work Package design strategy needs to be established early in the design process
- Design Management is intrinsic
- Opportunity for linking lean design and construction

9.4.4 Design in Construction

This should only relate to two aspects; contract administration and client changes, I should not reflect design changes made to reflect contractors' errors. In Case Study 1 the critical incidents reflected typical issues associated with traditional contracting. They did not however result in acrimony and the fact that both parties had difficulties led to the development of good relationships to the extent that when the client needed to make changes the contractor offered suggestions as to have this could best be achieved.

The change to design and build constituted a major change in contract administration as this was transferred from the architect to the contractor. Whilst architects had been trained in this role and had strong professional support from the RIBA, including reference manuals such as 'The Architect's Job Book' where roles and responsibilities were clearly stated, this did not exist in contracting. A site instruction issued by an architect was a precursor to the issue of an Architect's Instruction, usually issued to change or amend details as part of on-site inspection or to instruct the contractor to rectify work. A site instruction issued in contracting was written by the site quantity surveyor to the subcontractor, neither the site managers nor design managers were able to authorise work. This frequently led to delays and non-compliances. These non-compliances were evident in Case Study 4 where the project director ignored the Reviewable Design Data (RDD) and tried to influence the design by reducing specifications. In conjunction with the Quality Manager I revised the design management process to include compliance checking as an integral stage to ensure a smooth handover to the client and produced a Project Management Tracker which related as activities relating to the work packages which could be reported as part of the monthly progress meetings.

In Case Study 2 client changes proved to be a difficult issue due to the formal change control procedures set out in the contract which the client considered to be penal. It was a lengthy process which by the time it took place resulted in inflated costs to the client. It created an acrimonious atmosphere which was avoided in Case Studies 3 and 4 by adopting an informal process between the client and the design manager to assess the outcome before submitting the formal request.

Findings:

- Importance of design management in compliance checking
- Requirement for authority in design management
- Integration of design management with site construction management

9.4.5 Reoccurring Critical Incidents

Despite the continuity of many of the team members through case studies 2, 3 and 4 a number of critical incidents were repeated and have been tabulated below, Table 43 in two categories: design integration and design management:

Table 43 Critical Design and Design Management Integration

Subjects	Issues
Design Integration	
Integration of Structure	• Wind Bracing in Steel Frames • Provision of Secondary Steelwork
Integration of Mechanical and Electrical Services	• Positioning of sockets and outlets • Issues with Ceiling Installations • Height of ceiling voids • Location of Risers

	• Size of Switchboard
Integrating Medical Equipment	• Defining responsibilities • Understanding infrastructure requirements
Design Phasing	• Differences between design for phasing and proposed construction phasing
Buildability	• Failure by contractors to demonstrate their expertise
Design Management	
Information	• Management of Information • Quality of information
Design Concept	• The importance of design management within designers' offices
Design Development	• Need for contractors to understand the design process • Building relationships with stakeholders and common language
Work Package Design	• Design Management is intrinsic
Design in Construction	• Integration of design management with site construction management

A workshop described in Appendix F was held partly to test my definitions of the temporal period but one of the slides presented, Table 44 summarised the broad headings related to the critical incidents. The response from the participants was they 'recognised' them from their projects.

Table 44 Summary of Critical Incidents

Activities	**Issues**	**Case Studies**			
		1	**2**	**3**	**4**
Client Engagement	Briefing	0	3	1	1
	Stakeholders	2	2	3	3
Design Integration	Layouts	0	1	2	1
	Structure	0	2	2	4
	M&E Services	2	3	2	0
	Ceilings	1	1	1	0
Design Information	Issue to contractor	1	0	0	2
	Quality	0	0	0	1
Programming	Activities	1	1	0	0

	Phasing	0	1	1	0
Equipment	Imaging	1	1	0	0
	Theatre Tables	1	0	0	0
	Medical Gas Pendants	0	1	1	1
Cost	Cost Control	1	0	1	0
Commercial	Procurement	0	2	0	2
Construction Works	Buildability	0	0	0	2
	Installation	0	2	3	0
Management	SPV/Contractor	0	0	0	2
	Totals	**10**	**20**	**17**	**19**

These issues have described earlier and further comments relating to the workshop are contained in Appendix F but what this demonstrates is that the issues are not unique and are continuing to exist.

9.5 Comparison with Case Study 5

The previous section has summarised the critical incidents which occurred in Case Studies 1-4. Although I only became involved in Case Study 5 during the cessation of construction in order to assess design validation there was evidence to support the reoccurring issues from Table 44. Case Studies 2,3 and 4 all involve the same JV contractor who is also the contractor selected to complete Case Study 5. The original Case Study 5 contractor is also the same contractor responsible for Case Study 1 and the prison study in Appendix K. Although over 20 years between the projects it highlights the difference between design, bid build and design and build and it also enables a comparison to be made between two major contractors.

The major problem in Case Study 5 relates to the integration of the mechanical and electrical services. This exists in all aspects of the design stages. The concept design failed to how the main services infrastructure is distributed resulting in long convoluted sections of ductwork and the insertion of an interstitial plantroom which caused headroom problems. At the design development stage there are numerous services clashes and congested corridor ceilings packed with cable trays and ductwork making it virtually impossible to instal suspended ceilings. The services installation commenced before the RIBA Stage 4 Design had been signed off by the consulting engineers with the result that when the main contractor went liquidation the services consulting would not certify the design and withdrew from the project. Not only did the client need to appoint a new contractor but also required design certification for the services design. it was for this reason that the client wished for the contract to be completed as a design and build contract. Nearly all of the issues outlined in Table 44 were evident and as the building has still to be completed it is likely that more critical incidents will occur.

9.6 Roles in Design Management

The following Table 45 sets out the qualifications of the persons undertaking the design management roles related to the design management stages of the case studies. The titles in brackets describe the individual's job titles. Within the contractor's organisation three titles existed:

- Senior Design Manager
- Design Manager
- Design Coordinator

Table 45 Design Management Roles in Case Studies

Case Study and Stages		Design Integrator	Design Coordinator	Design Manager	Assistant Design Manager	Design Cost Manager	Design Information
	Stages						
1	All stages	Nominal - CSA	**_Architect_*** Lead designer	-	-	Quantity Surveyor	-
2	All stages	-	Architect Lead designer	Senior Project Manager – Civil Engineer (Senior Design Manager)	Construction Project Manager Electrical Contractor	Contractor's Quantity Surveyor	Document Controller
3	Stages 2-3	-	**_Architect_*** Lead designer	Senior Project Manager – Civil Engineer (Senior Design Manager)	-	Contractor's Quantity Surveyor	Document Controller
	Stages 4-5	-	**_Architect_*** Lead designer	Senior Project Manager – Civil Engineer	Civil Engineer (design coordinator)	-	Document Controller

	Stage 5 (partial)	-	Architect Lead designer	***Architect**** (Senior Design Manager)	Civil Engineer (design coordinator)	-	Document Controller
4	Stages 2-3	-	Architect Lead designer	Architect	-	-	-
	Stages 4-5	-	Architect Lead designer	***Architect**** Senior Design Manager)	Construction Graduate (design coordinator) Steel designer (Design Manager)	-	Document Controller
5	Stages 2-4	-	Architect (1) **Lead Designer	Unknown	Unknown	-	Document Controller
	Due diligence		Architect (3) ** Lead Designer	***Architect****	Architect Civil Engineer (Design Manager)		Document Controller
	Stage 5	-	Architect (3) ** Lead Designer	Civil Engineer (Senior Design Manager)	Civil Engineer (Design Manager)	-	Document Controller

Architect* My role in Case Studies

**Lead Designer Case Study 5 had 3 Architects: Concept (1), Healthcare Design (2) Internal layouts (3)

What this table demonstrates is that no individual was trained as a design manager and only one professional comes from a design background – the architect. It could be argued that civil engineers are also designers, but in relation to building projects their involvement ceases once the structural frame is completed. They are not involved with stakeholder engagement at the beginning of the project with clinical user groups, limited experience of 'finishing trades' and equipment installation and do not take part in compliance checking prior to handover – the majority of their work having been concealed at this stage. Historically the architect is involved throughout the whole design and construction process.

The route to becoming a design manager in the construction company after the transfer to design and build was either:

- Initially at senior level- Case Studies 2 and 3 – Senior Project Manager, usually a Civil Engineer – graduate qualifications and project management experience

- More recently – Case Studies 3,4, and 5 – graduate qualification in engineering, construction or architectural technology, starting as a design coordinator (a term seen as misleading as the person responsible for 'coordinating the design' is the lead designer, usually the architect).

The titles used in the field of design management are applied differently depending upon which organisation they are being used. This includes the two most common designations: design manager and design coordinator. In construction companies it is often used to identify seniority rather than function. Similarly, in engineering services design, the design manager is employed by the subcontractor to check the consultants design and in the case of joint ventures between main contractors and services contractors each one has their own design managers and the result is the overall design is uncoordinated.

My role in Case Studies 3 and 4 was unique within the construction company at the time, architects were employed within Technical Services where projects were being bid – up to Stage 3 but not as Senior Design Managers on site. I was 'head hunted' by the contractor for my knowledge of the project, as one of the principal architects and my previous experience in the traditional role of supervising officer on a major healthcare project -Case Study 1 together with a degree in Construction Management.

Case study 4 provided the opportunity to review design management procedures and introduce some of the tools and procedures which I had previously developed including items which I had developed with the contractor's cost manager. It enabled me to integrate architectural design management with construction design management. The frustration of watching how design management had been carried out in Case Study 2 by individuals who from no fault of their own had been placed in roles which they were unable to carry out effectively was removed. I was also able to build better relationships between the design team and the contractor and mentor new members to the design management team. Design management issues still existed in Case Study 4 as the result of interference by a project director who thought that a design and build contract gave him the right to change design elements without client approval.

The question of educating design managers has still be resolved, it needs to be recognised as a separate discipline, which may have different entry routes, it is not project management. Construction management on site involves people with professional construction skills, commercial management has professional quantity surveyors and design management requires professionals with design training.

The reference to a Design Integrator, is a role which currently does not exist. In Case Study 1 it is noted as being carried out nominally by the CSA (Common Services Agency, Scottish Health Service, Building Division). It is the link between the wider delivery system and funder with the delivery of individual projects to ensure that the design is delivered on time, on cost and quality, including compliance with standards and guidance. It also has the responsibility of feeding back project design in use studies to the wider delivery system and enabling the transfer of knowledge.

As part of the findings from the case studies it would appear that the following roles are only required but also need to have the correct training and experience, Table 46;

Table 46 Design Management Roles

Designation	**Function**
Design Integrator	Person responsible to the client for the design delivery through all the project stages
Design Coordinator	Lead designer responsible for the design and coordination of structure, mechanical and electrical services and equipment. Design interpretation of the client's brief and engagement with stakeholders. Responsible for design verification and onsite compliance checking with the design manager.
Design Cost Manager	Cost consultant (QS) employed by either the client or in the case of IPD more likely the contracting organisation who can prepare the initial cost based on departmental cost allowances and update figures to reflect current market costs. The role would also include management of cost and change control procedures.
Design Manager	Construction role involving the preparation of design programmes in conjunction with the lead designer and the planning engineer. Management of works packages, scopes in association with designers, liaison with subcontractors and members of the commercial team. Onsite compliance checking with the design coordinator.
Design Information Manager	Document controller working with the BIM Manager to ensure correct distribution of information amongst all parties.

9.7 Design Management and the Wider Delivery System

The preceding sections have concentrated on the 'project' design management activities, primarily relating to concept design, design development, works package design and design in construction. The two other stages of pre-design and design feedback have not contributed to critical incidents or positive integration but are influential in relation to the wider system.

9.8 Summary

This chapter has outlined the longitudinal findings relating to the temporal periods and indicates potential contributions to knowledge related to the analysis of critical incidents and the benefits of carrying out auto-ethnographic longitudinal studies to determine the impact that a project delivery system has on project outcomes in relation to client satisfaction. The next chapter triangulates and discusses these findings with that of the literature leading towards a contribution to knowledge focusing on the requirements for design management in a healthcare setting and a specialist design integrator to link the project system with the wider system.

Summary findings:

- Healthcare design is unique in its complexity, it takes time to understand and assimilate all its requirements and communicate effectively with healthcare professionals which is why there is a need for systems integration to link the wider delivery system with the project delivery system;
- The wider system needs to support a framework of standards and guidance keeping pace with innovation, new technology and models of care;
- Design integration at design concept starts with integration of the structure and engineering services which has the potential to develop into a layering system to deliver healthcare design;
- Design management is integral to all stages of the design process and involves several skill sets;
- When critical incidents arose someone with a design background was required solve them regardless of role or responsibility suggesting that the systems integrator should be part of the design management team;
- The importance of team working and continuity of major players across the stages;
- Ensuring that the right people are involved at the right time and recognising individuals’ skills and experiences;
- There are issues with the transfer of knowledge and the lack of post occupancy evaluation affecting the wider system which could be addressed through long term learning.

Chapter 10 Discussing the Integration of Healthcare Design, Design Management and Delivery

10.0 Integrating Healthcare Design, Design Management and Delivery

10.1 Introduction

Dr John Lowe, who taught construction economics said that "the construction industry was cyclical" describing how in the 1960s design and build was fashionable in the housing and commercial sectors and now in 1993 was re-emerging in the healthcare and education sectors as part of the PFI programmes. This represents roughly a 30-year period which follows through Case Studies, 2,3,4 and 5 to the demise of PFI in 2018. Chapters 6, 7,8, 9 and 10 have described the progression through five temporal periods, each one focusing on a case study of a major hospital within its' wider delivery model setting. With the exception of Temporal Period 1, which spanned nearly 20 years, the other temporal periods each lasted six to seven years which relates roughly to each project's design and construction phases. This chapter triangulates the findings from Chapter 9 with Chapters 2 and 4. What is interesting is that academic writing often follows specific trends in a period. For example, the literature in period 3 concentrated on the delivery model of the previous period (PFI and design and build procurement in period 2). It then drops in period 4 and levels out through period 5. The wider delivery model literature shows a steady increase through the periods indicating advances in technology and the impact of new models of care. The discussion is structured to reflect how the change of delivery model and the role of the wider delivery system has influenced the need for an integrated approach to design, design management and project delivery.

10.2 The Need for Integrated Design Management to Deliver Complex Major Hospital Projects

The literature reviews in Chapters 2 and 4 looked at healthcare design, construction and design management, the individual cases studies in Chapters 5-8 analysed the critical incidents and positive integration in terms of when they took place, what caused them and who resolved them. Chapter 9 combined all the individual findings to assess the effects of changing the delivery model, ascertaining whether lessons have been learnt or there are recurrent critical incidents.

From the literature review it was apparent that despite numerous studies relating to aspects of design, project and construction management the focus was on individual topics rather than examining the subject as a whole. The other issue concerns healthcare projects (which may not be in the same cost bracket as mega projects such as those described by Davies et al, 2009) is that the complexity of issues is relatively under explored. Compared with mega projects, of which the number is relatively low, there are a great many major hospital projects each one having unique requirements – even a standard system such as Nucleus involved different site conditions and different configurations of the standard templates. The percentage building cost related to specialist mechanical and electrical services is much greater in healthcare now approximately 50% and over the years the development of new medical specialisms has increased the number of stakeholders directly involved in the design. There is greater involvement from the wider system as the ultimate client body, the Department of Health and Social Care has a vast estate to manage and the repetition of costly errors relating to healthcare design needs to be avoided.

The critical incident analysis was set out in design stages in relation to a construction project and it was apparent from the case studies that not only is design integral to all stages but it's management differs through these stages requiring an integrated design management team comprising of individuals with different skill able to fulfil these roles and responsibilities. The case study analysis also highlighted issues with competencies. capabilities, roles and responsibilities, many resulting from the change in delivery model. Some of these issues relating to the construction industry are also outlined in Chapter 3 where ethnography has been used as a research method to understand the diversity of the industry and the various importance placed interacting actors.

10.3 The Gap between Design and Project Management Disciplines

Project management has now been recognised as a discipline in its own right and within this, construction project management. The Design Institute provides a vehicle for managing product design and branding but differs from construction design management in that it involves a single designer, producing a prototype for mass production compared with an industry where several designers combine to create a single product. Zerjav et al (2013) identifies a gap between process-level research and design management techniques and identifies certain skills required by design managers but does not suggest how this can be achieved. This highlights the difficulties encountered in the case studies where the design management activities can be identified but the lack of integrated design management is apparent. The closest form of integrated design management occurred in design, bid build where the architect was responsible for managing the design through all the project stages. The contractor's role was to manage the works packages the creation of which he was responsible in order to construct the design. The change to design and build may have transferred overall design responsibility to the contractor who has in turn ‘repackaged’ design responsibility to design consultants and subcontractors. These actions have resulted in breaking up design management continuity and creating design management roles within different organisations. Developing ‘selective’ design management in relation to stages to reflect construction activities results in fragmentation and situations where handover between stages can become weak links. This is demonstrated in Case Study 4 when the project was transferred from the contractor’s bidding team to the delivery team. Although two parts of the same company they had different agendas; one to secure the project through the design, the other to construct. Enyon (2013) describes a four-stage design management sequence with the second and third stages having a pre-construction design manager and a delivery/site design manager. This roughly reflects the role in Case Study 4 but with a major difference, the point of project procurement was prior to design development and necessitated a greater level of design input than purely managing the design through the work packages. Stakeholder engagement in the form of clinical user groups is a major part of this stage, the management of which requires different skills from those involved in construction work packages. Whilst the roles of design managers can be isolated to individual stages the design process is continuous and requires an integrated design management plan. In Case Study 4 both stages involved architects as design managers with the more experienced healthcare architect/design manager as the delivery design manager on site.

10.4 The Fragmentation of Healthcare Planning and Design Management Disciplines

Architects were trained to prepare project briefs and to prepare sketches and illustrations to explain schemes to clients and to ask questions which lead to a better understanding of what the client wants and therefore it is important that they are involved in the early stages of design management. This is highlighted by Svetoft (2005) who describes architectural education in Sweden and the need for architects to understand client requirements. Samuel (2018) highlights the need for recognition of different architectural roles within the profession unlike the medical profession where clinicians can demonstrate proficiency of speciality by gaining further professional qualifications there is no such route for design professionals despite the need for expert knowledge within design fields such as healthcare.

Equally, medical professionals all have similar educational backgrounds and sometimes do not realise for example that they need to explain principles fundamental to their method of working of which non-medical staff are unaware. This can affect the way in which certain rooms are designed. This was evidenced in Case Study 2 where the bays in the resuscitation room were handed making 50% of them unusable, for as all clinicians know “air ways are inserted into a patient from the right hand-side” something which is not included in guidance and which they failed to bring to the designer’s attention. It is therefore important that the facilitators of user group meetings possess these capabilities. I have experienced and facilitated many user group meetings and the outcomes were often dependent upon the individual stakeholder’s professional backgrounds and standardisation of their qualifications. This separation between qualified and non-qualified applies equally to the medical, the design and construction sectors.

This was demonstrated through the case studies, where in Case Study 1 the architect was involved in all the user groups unlike in Case Study 2 where there was no involvement and misunderstandings occurred. In Case Study 3 the architect took over the role from the healthcare planner who was unable to produce a viable schedule of accommodation and again in Case Study 4 where the user groups involved the architects, a healthcare planner and the senior design manager. This last example was more unusual but was necessitated as a result of poor internal clinical layouts by the architect. It also highlighted the involvement and lack of qualifications of healthcare planners.

The role of a healthcare planner varies depending upon the design stage. It is critical in the wider healthcare delivery where there are two distinct roles. One relates to strategic healthcare planning; deciding how, when, where and who should deliver healthcare and the second involving guidance, standards and expert advice into the design of the facilities. The prescriptive model in temporal period 1 ensured all hospital facilities were designed to the same standards through strategic healthcare planning at national level and project advisory teams as in Case Study 1 allocated by the Scottish Health Service Building Division.

In terms of healthcare planners there is no institute for health care planning as outlined in Dickson (2015) and no separation of the different healthcare planning functions. Following the change to contractor-led design and build this led to trusts and potential bid teams all seeking to engage healthcare planning consultants as advisors. As well as healthcare planners, another group of ‘equipment specialists’ also appeared, and the varying success levels can be seen over the case studies. Fragmentation and conflict have resulted in many instances. In Case Study 5 which had three architects (two of them healthcare designers), two healthcare planners and two equipment specialists 74% of the departments required HBN derogations involving either reduced room areas or non-provision of facilities. The most likely explanation for why this happened relates to the lead designer not having healthcare experience and 'selling' a concept design to the client which could only be achieved by reducing building area. The creation of 'neighbourhood hubs' for communal facilities such as staff changing, staff rest, FM and office accommodation were considered to be more efficient and innovative as were the layouts of the single rooms and ensuite WCs which reduced the area of the single room by 18% and created trapezoidal ensuites which could not be prefabricated. In light of the current Covid 19 pandemic it is difficult to see how this design could cope. It highlights another aspect of the wider delivery model relating to guidance concerning the control of infection where the guidance issued is open to interpretation by the local infection control lead. Neither the healthcare planning nor infection control roles have specific qualifications and combined with 'guidance only' status for infection control it is in these areas that the wider project delivery system needs to address the situation.

10.5 A Clarification on the Healthcare Design Process and Design Management Stages

As stated previously hospitals differ from other building types due to their complexity combined with being part of large property portfolio of a major public client. This creates a relationship between a wider delivery system which has the ability to set standards and guidance and delivery of individual projects.

The RIBA Plan of Work has been revised several times since its introduction in 1964 and now includes Stage 0 relating to Strategic Definition. Table 47 sets out a comparison of these through the temporal periods.

Table 47 Comparisons of RIBA Plans of Work

RIBA Plans of Work							
	1964	**2007**		**2013**	**2020**	**Design Stages**	**Project Stages**
	Temporal Periods 1 ,2 and 3	**Temporal Period 4**		**Temporal Period 5**			
			0	Strategic Definition	Strategic Definition	Pre-design	Pre-design
A	Briefing	Appraisal	**1**	Preparation and Brief	Preparation and Brief		
B	Feasibility	Briefing					
C	Outline Proposals	Concept	**2**	Concept Design	Concept Design	Concept Design Level 1	Concept Design

							Preliminary Cost
D	Scheme Proposals	Design Development	**3**	Developed Design	Spatial Coordination	Design Development Levels 2 &3	Design Development Project Planning
E	Detailed Design	Technical Design					
			4	Technical Design	Technical Design	Work Package Design	Work Package Design Final Cost Approval Procurement
F	Production Information	Production Information					
G	Bills of Quantities	Tender Documentation					
H	Tender Action	Tender Action					Manufacturing and Construction on Site
J	Project Planning	Mobilisation	**5**	Construction	Manufacturing and Construction	Design in Construction	
K	Operations on Site	Construction to Practical Completion					
L	Completion	Post Practical Completion	**6**	Handover and Close Out	Handover		
M	Feedback		**7**	In Use	Use	Design Feedback	Design Feedback

The most significant changes taking place between Stages E and H (or as it is now defined 3 and 4). What these stages reflect is in a linear sequence of design stages, where one activity is completed before the next one starts. This is what happens in design, bid build where contract award is an easily visible milestone. It does not reflect what happens on a design and build project where the contract is awarded before all the work packages have been completed and varying levels of design exist. Both Hughes (2003) and Zambelli (2017) highlight issues with the technical design stage.

The RIBA Plan of Work Overview 2020 states that there should be no design activities in Stage 5 but recognises that Stages 4 and 5 will overlap as indicated by the shading in Table 45. The existence of this overlap indicates the need for integrated design management and although design is deemed not to exit during Stage 5 there is still a requirement for designers and design managers to be involved. BSRIA (2018) has updated their guidance to a one section Part 4, rather than the previous three sections. It was this latter situation which caused problems in Case Study 5 where the consultant’s mechanical and electrical services design had not been signed off at Stage 4 before the commencement of Stage 5. During the due diligence period, when the Trust were reluctant for the services installation to be stripped out (the new contractor's preference), it was discovered that several of the proposed electrical distribution cupboards were too small to accommodate the switchgear being procured and without further derogations and changes to clinical areas could not be resolved without removing pipework installed in the ceiling voids. This demonstrates the importance of services integration and the need for completing design before commencing construction.

10.6 The Need for a Strategic and Integrated Approach to Design Management

As started previously hospitals are extremely complex and so there is a need for a strategic and integrated approach to their planning and design. Enyon (2013) sets out four design management stages with roles defined against each one:

- Project Definition Strategic Design Manager
- Project Procurement Pre-construction Design Manager
- Project Delivery Delivery/Site Manager
- Project Operation Strategic Design Manager

Referencing to project rather than design stages changes the roles and relationships and this model reflects what I experienced working for a contractor. It also reflects the roles in Case Study 4. The role of strategic design manager he suggests is likely to be that of a consultant rather than part of a contracting organisation where is the pre-project phase is described as statement of need, strategic brief and project brief and in the operation phase where it involves post occupancy evaluation.

Evidence from the case studies would suggest that although there are two roles, there are four design stages with some of the design management roles being carried out by the designers as identified by Emmitt (2007 and 2014). Figure 29 shows the six stages identified in the case studies with the wider delivery system stages in green and the project design stages in blue with the red arrows linking all the stages indicating the role of a design integrator.

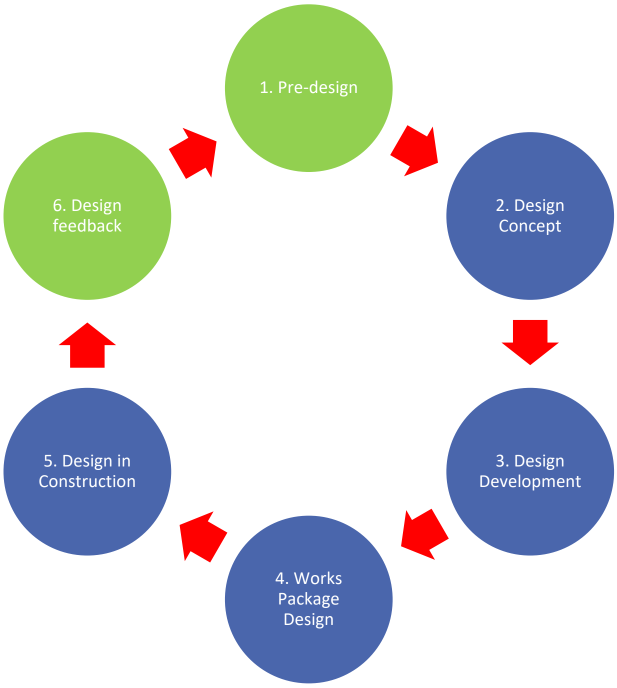


Figure 29 Relationship of Wider Delivery System to the Project System

10.7 Design Management in the Wider Delivery System

10.7.1. The Critical Centralisation of a Healthcare Design Management Role to Integrate Design Feedback

The first and the last stages in Figure # relate to the wider delivery system; briefing and post occupancy. Although each project may take several years there is still value in learning lessons from carrying out post occupancy to influence briefing for future projects. None of the case studies involved formal post occupancy studies but in carrying out the "Making Good Defects" Liability inspection after one year in Case Study 1, I was able to observe how the building was being used. It was also where I discovered the power of observation as a research method and how casual conversations with users revealed information which would not necessarily have been disclosed during formal or structured interviews. Due to the transfer to design and build as the architect there was no involvement in the Making Good Defects, so this opportunity was lost. However, as part of assignments relating to the MSc in Planning Buildings for Health, I revisited Case Studies 2 and 3 which is where I discovered the clinical planning issues in the Emergency Department of Case Study 2. In relation to Case Study 4, I was asked by one of the healthcare planners involved if I could arrange a visit as her involvement in the project ended at the end of the design development stage and she wished to see the completed project. Analysis shows design management has a much broader influence, logically design needs to come before construction and therefore whoever leads the project influences the design management. This includes the wider delivery system in the case of hospital design. In the prescriptive period design studies, standards and guidance were all produced by the Department of Health.

10.7.2. An Evidence-based Learning Platform to Integrate Post Project healthcare Design Management Lessons into Future Projects

Post Occupancy Evaluation was my starting point for this thesis, primarily as a result of the study I took part in Appendix A. The findings from this study I found disappointing as to me many of the lessons I had learnt over the years had not been incorporated in that project and I saw many problematic issues which could have been avoided if POE studies from previous projects had been published. A literature search relating to POE revealed it was sporadic over the temporal periods and generally not building type specific. In the 1960s the Scottish Home and Health Department had made an attempt to produce 'Building In Use' studies but this initiative lost impetus and now following the construction of over 50 nucleus hospitals and 60 PFI hospitals there are very few studies as to how the buildings have performed. One of the most recent POE studies, by Hay et al (2018), cites one of the barriers to POE as being related to Insurance and Liability where there is a fear professional indemnity insurance costs will increase if POE reports are published. This also links to the application of standards and guidance where in attempts to mitigate risk Trusts attempt to make HBNs and HTMs mandatory whilst at the same time desiring innovation.

The lack of post occupancy evaluation or evidenced based design to demonstrate the results of standards and guidance has failed to address these issues or raise the fact they have not been updated since 2013. This linkage of stages 1 an 6 is reflected in one of the few papers to investigate HBNs by Hignett and Lu (2008) is at the beginning of Temporal Period 4 who in turn quote LaFratta (2006) on the need for more room standardisation which is something which the wider delivery system can set out in the briefing process. Wanigarathna et al (2016) looked at performance-based specifications as an alternative to prescriptive standards and guidance to see if three hospital case studies achieved greater innovation using performance specifications with supplementary prescription and concluded that similar outcomes were achieved. The issue with the study was the case studies were not similar and two of them involved modular construction, something which benefits greatly from standardisation.

Case Study 5 and my involvement in carrying out a due diligence exercise highlighted the level of derogation from HBN the Trust was prepared to accept in order to justify their design. The starting point in their Trust Core Requirements of being fully compliant was completely unrealistic and did not align with their aspirations. I was told by someone who had observed some of the early proceedings the trust in fact ignored the HBNs and only inserted the clause as a perceived legal requirement.

Chapter 9 has summarised my experiences through five consecutive temporal periods building on a mixture of full-time project-based experience, part-time postgraduate study and involvement in ‘hospital tourism’ on study tours in the UK and Europe. In the absence of formal post occupancy studies, I have accumulated my own ‘lessons learnt’ which I think has helped me to persuade individuals to see things differently.

Post occupancy evaluation was something which was considered beneficial to all parties in the workshop discussion and it forms a part of learning. It is a means of knowledge transfer from project to project, but it is essential that its execution and format is controlled centrally to ensure consistency and is why I consider Stage 6 to be the responsibility of the wider delivery system along with briefing in Stage 1.

Case Study 1 demonstrates the benefit of having the wider delivery system being involved through all the stages in the role of project liaison. This also enabled design issues which arose on one project to be notified to other projects as in the case of the use of different grades of copper for water supply pipework. This liaison role was not only able to help individual projects but disseminate amongst projects.

10.8 Design Integration through Project Delivery

10.8.1. Clarification on Where Healthcare Design Management Integration Effort is Most Needed

Design is a continuous process throughout the project stages with the major activities taking place in the concept and development phases. Although the theory of the RIBA Plan of Work in 1964 was that all design information should be completed by tender stage in practice this was difficult to achieve as seen in Case Study 1. In healthcare projects with the high percentage of mechanical and electrical services this was never going to be the case as a result of the different levels of design completion by the consultants at the time of tender, something recognised by Cacciatori and Jacobides (2005). In Case Study 4 the contractor had difficulties engaging with the architect during the on-site compliance checking as a result of having front loaded the design fees.

Analysis of the case studies and literature concluded design management is currently in a fluid state and is still in development. What is certain is it occupies an important role in both projects and the wider project delivery. The definitions of design management include the roles and responsibilities of both the architect and the newer role of design manager within construction companies. The case studies describe how these have evolved and literature either focuses on looking back at how the architect carried out design management; when the architect was in charge of projects, the term design management was not used. This is borne out by Emmitt and Ruikar (2013) who date design management from circa 2000. Hansen and Olsson (2011) highlight the differences between design and construction where the iterative process in design is seen as adding value by creating the optimum solution, unlike in construction, where it becomes an expensive penalty as result of creating waste.

In Case Study 2, within the architectural team there was a design coordinator, a senior architect who acted like a project manager, organising workloads within the team for the project director. Unlike the project director who was an experienced healthcare architect, the design coordinator was not and as a result often misinterpreted the requirements. I was brought into the team to support the project director in providing healthcare knowledge and experience and ended up trying to act as a 'Design Integrator' working with both the architectural team and the contractor to the extent at one time some of the architects (without healthcare experience) thought that I was working for the contractor.

10.8.2. The Need for Oversight to Integrate Healthcare Design Management and Cost Management

The role of design management has developed through the temporal periods and will undoubtable change further with the increase in offsite manufacture. What both the case studies and literature demonstrated was the need for both integration and separation in the design process and that design management requires a design integrator who oversees the process from design concept through to completion of the construction phase. The value of continuity can be demonstrated as every time a different design manager takes over unless there is a robust transfer of knowledge there is a danger of misinterpretation.

What contractor led design and build did initiate was developments in design information management with the introduction of electronic data management systems and innovation relating to modern methods of construction. Once the 'suspicion' of trusting the architect had been overcome integration improved and some important working relationships evolved. In Case Study 2 issues with Schedule of Accommodation I resolved them with the Cost Manager (a QS role separate from that of a commercial manager) and together we formatted documents and procedures which were adopted in subsequent projects. The Cost Manager's role developed to include change control and could be defined as a Design Cost Manager. It became evident that within design management there are different roles which require different skills just as there are within the construction team.

It was not until Case Study 4 when I became part the Senior Site Management Team that design was represented at project meetings previously only the construction, commercial and services teams met regularly to discuss site progress. This was not the case on other projects within the company, design managers were still excluded. As my role developed as divisional design manager, I was able to set out a design management procedure which included design managers as part of the project team meetings integrating the role into team rather than just monitoring the design team's progress.

In order to prepare a concept design, designers require a clear brief and in the case of healthcare either one prepared by the wider delivery system or the hospital as client. Starting with either an incomplete brief as in Case Study 2 or conflicting brief in Case Study 3 resulted in critical incidents with mixed outcomes. In Case Study 2 the room layouts were compromised in shape but in Case Study 3 the client was able to resolve the brief following agreement with the wider delivery system. The following sections outline the role of design management which can ensure design continuity by integrating the different parties at different stages.

10.8.3. The Need for Primary, Secondary and Tertiary Healthcare Design Integration

The initial design stage is concept design where the architect in conjunction with the services and structural engineers translates the client's requirements into a building form for which an outline cost can be prepared for client approval. The design process of analysis, synthesis and exploration as driven by Gropius et al at the Bauhaus in 1919 focused on 'form follows function'. In 1960 Louis Khan's Richards Medical Centre introduced systems thinking Giurgola and Mehta (1976) identifying integrated systems (services and structure) and separating 'servant and served' spaces linked through communication systems. Habraken (1972) introduced the concept of open building as different levels of decision making in the building process in order to accommodate unforeseen changes and Brand (1994) promoted the concept of levels in conjunction with different periods of longevity, where the frame might last 60 years, the internal arrangement 25 years and room configurations less than 10 years. Initially this concept was applied to housing projects, but over the last 15-20 years the concept has been promoted in healthcare projects through studies by Kendall (2007, 2011 and 2019) including the Inselspital in Bern. Combining these two concepts of systems separation was partially achieved in nucleus design but due to the rigidity of the template, whilst accommodating flexibility it could not achieve future proofing. Hansen and Olsson (2011) identified the successful use of this layering approach at St Olav's Hospital, Trondheim, Norway and the Inselspital, Hospital de L'Ile, Bern, Switzerland.

The preparation of a schedule of accommodation is essential before concept design, it is also the baseline from which to check compliance and is required in order to create the open building concept levels which in this case relate to:

1. Departmental requirements and relationships to determine the Primary Layer
2. The room relationships and circulation within Departments – the Secondary Layer
3. The individual room layouts – the Tertiary Layer

The development of a schedule of accommodation to reflect these three layers was developed in Case Study 3, adopted in Case Study 4 and used in the due diligence check of Case Study 5. This zoning concept is outlined in Appendix L.

The ability to split the overall design into layers allows different architects and construction firms to develop each layer. The benefits of this design and construction process are due to the size of these projects where it becomes difficult for one firm of architects to have the capacity to carry out all three levels on major hospital projects and allows prefabricated modular units to be incorporated. What is important however is that the architects for each of the three levels requires to be specialist healthcare designers in order to understand the requirements of the other two levels and that the structural engineer and services engineers to carry out all three layers. The understanding of this layered approach to clinical design allows designers, contractors and suppliers the ability to incorporate the design requirements of off-site construction at Level 1, configure modules at Level 2 and supply components and equipment at Level 3 in the knowledge the systems will be integrated. In order to achieve integrated clinical functionality an effective design management process and healthcare design integrator needs to be involved.

The design in Case Study 5 reflected the layered approach by the appointment of three different architects:

- Primary: The frame and cladding: Architect A
- Secondary: The internal spatial arrangement: Architect B

- Tertiary: Room fit-out: equipment and fittings: Architect C

But in this case Architect A who was described as the ‘lead designer’ had no healthcare experience and had been chosen for their perceived skills as a ‘signature designer’ to create not only a functional hospital but a building of high architectural quality. Architects B and C were experienced healthcare architects, but if the primary system is not designed by a healthcare specialist it is difficult to incorporate the secondary and tertiary designs and as a result the three layers were not integrated, Architect A also failed to integrate the primary systems in relation to both the structure and the mechanical and electrical services designs. The lack of healthcare knowledge probably exacerbated this design level integration by a failure to understand combinations of large and small spaces, deep and shallow planning and underlying infrastructure of mechanical and electrical engineering services. This highlights the link between roles and layers.

Sinclair (2019) promotes the role of lead designer as an independent role within the project team, including the qualification they should be design experts in the relevant field supporting the open buildings theory. This is not however a role which integrates the design as it exists only in the design phase and is difficult to incorporate within contractor-led design projects. What is critical is that a Integrated design manager be involved through all six stages as identified in Section 10.6.

I have used the term Hospital Building Infrastructure to describe the main distribution systems for electrical power, data, water supply, drainage, heating pipework, ventilation ductwork, piped medical gases, pneumatic tube systems and automated guided vehicles. Some of these systems have large radial bends making integration more complicated and most of them are subject to a series of HTM documentation related to CIBSE regulations. The change from design-bid-build to design and build changed the dynamics of the construction team with many of the major contractors having ‘sister’ mechanical and electrical subcontractors within the parent group with which they formed Joint Ventures (JV). Figures 30 and 31 indicate how the contractor/designer relationships have changed.

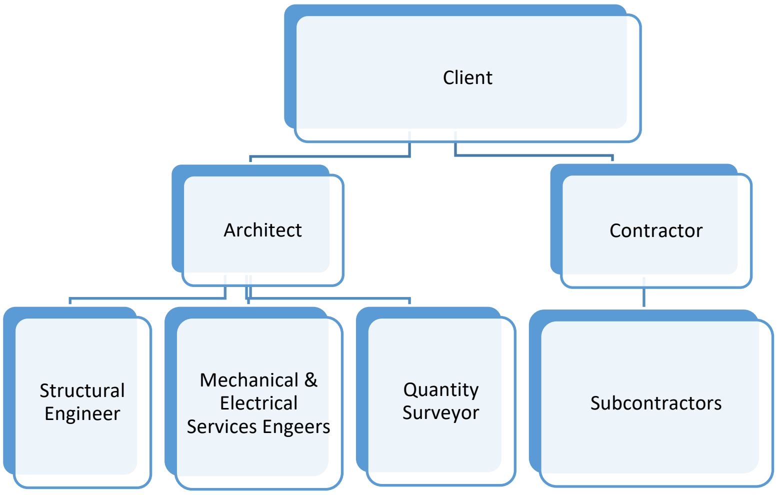


Figure 30 Traditional Design Team Relationships

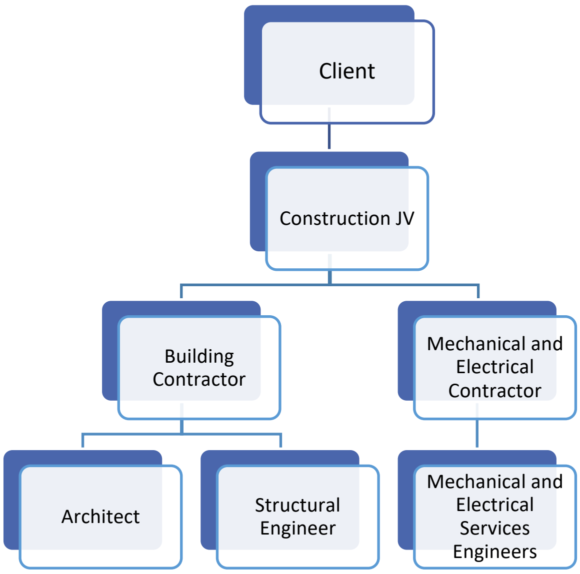


Figure 31 JV Design and Build Relationships

The separate appointment of the mechanical and electrical consultants by the JV subcontractor partner whilst strengthening their relationship created different forms of appointment where the architect and structural engineer were paid during the bidding period by the main contractor, the services engineers were not paid until financial close was achieved. The result was the engineers were designing to a minimum and this made design integration difficult. The difference between architect's working drawings and those of the services engineers was originally highlighted by Latham (1994) and further researched by Cacciatori and Jacobides (2005) who cited the difference in tender procedures and the fact that whereas the architectural design is usually tendered with a full bill of quantities as was the case in Case Study 1, the mechanical and electrical tenders consist of schematics and specifications with the successful subcontractors preparing installation drawings based upon engineers' schematics.

The integration of services is particularly important in healthcare design and construction where percentage cost of as increased from 25% to 50% of the total building cost over a period of 40 years. It highlights the high commercial influence within JV's to continue traditional working practices rather than integrate.

In Case Study 3 although BIM modelling was not in use and architects were not setting up integrated models, all disciplines were working with their own programme. The mechanical and electrical JV partners were using computer programmes to coordinate the services installation working with the ductwork subcontractor on site who was also designing in CAD. They had a small team of CAD coordination engineers who would take a 'snap-shot' of potential clashes and send them to us architects for discussion. They also had their own Design Manager, but his role was more of a 'Design Checker' examining the consultants' drawings.

Case Study 4 where the main contractor appointed all members of the design team following agreement with their JV partner demonstrated how the design team developed the design together whilst building a relationship with the specialist contractors proved beneficial and eliminated the previous reoccurring critical incidents.

The adoption of BIM was thought to eliminate some of these issues with the need for 'real time' single stage services design to take place rather than the two stage process but this proving difficult to achieve with the services design in Case Study 5 services with the lack of an integrated BIM model. Of all the case studies, Case Study 5 is the worst example of integration probably exacerbated by the fact that unlike the other PFI studies it was neither a JV or nominated subcontractors and the management of the Mechanical and Electrical services installations had been subcontracted to a management contractor with the subcontract orders placed by the main contractor introducing an additional level of integration. In Case Study 5 there were two services design managers; electrical and mechanical and whilst each one had a number of different subcontract packages to integrate the lack of overall design management resulted in a 'halo' an external feature in the courtyards having to be built to cover large distribution ventilation ducts from the plant room to the various departments. An additional 'mass barrier' was created as 'Level 4.5' to accommodate engineering plant which could not be accommodated within the plant rooms and which the Trust decided not to include in their area calculations causing a difference with the new contractor's offer which took time to resolve.

These examples demonstrate the need for integrated design management, how there is a potential for establishing it as in Case Study 3 and that there are several design management roles.

As noted by Hillebrandt (1984) the person in charge of large contracting firms tended to be civil engineers and this was the situation in these case studies. This led to a situation where the project director became directly involved with the structural engineer and the specialist subcontractor often bypassing the architect, creating a similar situation to that of the mechanical and electrical services. The majority of infrastructure projects relate to civil engineering with a civil engineer taking the leading design role, whereas in the majority of architectural building projects the architect takes the design role. This equates to Primary Layering in construction whereas architects are involved in all three layers. The bypassing of the architect in the case studies resulted in structural decisions which affected the secondary and tertiary layers were not considered and only by my 'interference' as it was seen at the time prevented expensive mistakes taking place. Three of the case studies had structural steel involving the same steel subcontractor/fabricator. I was only able to influence the team as the result of having carried out the role of supervising officer in Case Study 1 a project which had a fully integrated structure. Although predominately an in situ concrete frame, it did have a steel top floor designed by the structural engineer and a steel subcontractor whose managing director was a trained architect who had taken over the family business.

Cacciatori and Jacobides (2005) again in reference to Latham (1994) also cited issues with structural engineers' drawings and the reliance placed on steel fabricators drawings and explores vertical reintegration and the creation of 'one-stop-shop'. This was demonstrated in the case studies where the main contractor was developing a structural supply chain partnership of consultant and subcontractor similar to their JV mechanical and electrical partners, but it fails to integrate horizontally by engaging different architects and not integrating the design in the conception phase.

10.8.4 An Integrated Healthcare Design Manager must be Responsible for the Integration of Major Medical Equipment

Major hospital projects have long timescales during which time there are often changes in models of care and the introduction of new technology. In an ideal world the ability to make changes throughout the design and construction period is what users would like and some expect. This is something which can be achieved by taking a layered approach. No one can predict the future but to assume things will not change is unrealistic. Within a few years of the Medical Illustration Department being completed in Case Study 1 the use of digital technology had eradicated its requirement. Film processing and silver recovery in radiology has disappeared, but new elements such as automated guided vehicles have been introduced, and Appendix B demonstrates how over 40 years a simple medical gas provision has developed into a major item of medical equipment impacting on the building design.

Evidence based design has focused on the needs of people, patients and staff and how their environment aids their recovery, their ability to carry out duties and how this influences design. The need for adaptability to accommodate major changes to equipment both major medical equipment required in hybrid operating rooms or the introduction of infrastructure such as pneumatic tube systems has not been widely researched. The majority of academic papers relating to medical innovation concern issues around medical procedures with some reference to environmental conditions and the instances of surgical site infections but do not focus on how the equipment can be accommodated. Gobbi and Hasuan (2014) address a gap in literature relating to collaborative purchasing for the Danish National Healthcare System, related to major medical equipment which reflects issues contained within the case studies and highlights its importance and position within project delivery.

The installation of the medical gas pendants in Case Study 4 reflects the layering approach. At the Primary Level the pendant manufacturer was selected and installed as the base plates tend to be universal for different models., the Secondary Level when the services infrastructure was being installed the pendant supplies were determined and in the Tertiary Level the pendant components were selected by the client immediately before the pendant went into manufacture. The Trust produced a very clear equipment specification and early in the process I set up equipment working groups including all stakeholders to be able to make decisions regarding equipment at different stages in the project and incorporating them into the construction programme. Also, in Case Study 4, where the Trust achieved their expectations, the same philosophy was applied to trust installed equipment to the extent they were able to move into the new building within three weeks after handover.

There is an important contribution to knowledge in the investigation of critical incidence. The analysis of critical incidents has highlighted the identification of reoccurring issues which may have been resolved on one project, but the knowledge has not been transferred. The issues relating to integration have three common themes, Figure 32:

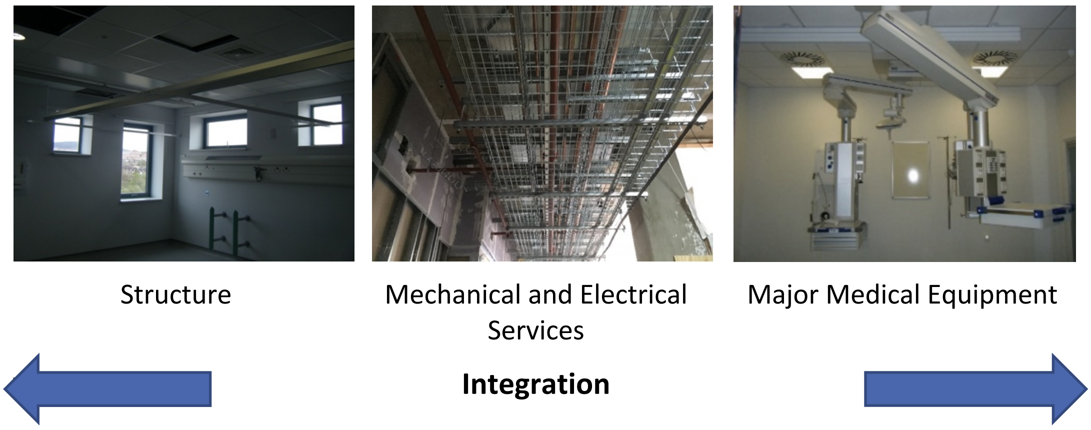


Figure 32 Integration with Space Planning

The three examples in Figure 33 reflect the effects of uncoordinated wind bracing on a standard four bed ward, the difficulties which will be encountered in trying to fix ceiling grids and the sophistication and coordination of installing medical gas pendants. Although of lesser monetary value than the mega projects described by Davies et al (2009) many large hospitals are more complex due to the large number of diverse stakeholders. layering of departments, high level of engineering services and require a specialist design integrator to pull all the threads together.

The case studies have demonstrated integration has deteriorated rather than improved with the alignment of designers and specialist subcontractors illustrating the need for further and more up to date research. The case studies have also demonstrated with the increase of this consultant/subcontractor relationship the role of an experienced design integrator was essential in bringing together existing members of the team who had the necessary individual skills and creating integrated teams.

10.9 Integrated Design Management

10.9.1 Achieving Lean Design through Integrated Design Management

Ballard (1993, 2008), Lichtig (2005 and 2010) and Jorgensen and Emmitt (2008) have all written on the subject of lean construction, the last planner system (LPS) and the difficulties in its application to design and construction. Olsson and Hansen (2011) highlight the difference between the design and construction processes being the iterative nature of design and outline how lean principles can be applied to design through a study of two major hospital projects. Mesa et al (2016) analyses a conceptual model of IPD and Lostuvali et al (2014) describe a single case study adopting best practice lean construction principles and the Integrated Form of Agreement produced by the AIA. Both papers involve major hospital projects of a size comparable with the major case studies in Case Study 4 of this thesis and therefore make a good comparison. Lostuvali et al (2014) suggested a Chief Engineer (CE) should be appointed to oversee the project, someone who is experienced in healthcare design and has experienced the whole process. They acknowledge it may be difficult to achieve this and this is 'work in progress'. They define two important elements: the need for a strong, well informed leader and effective management of information flow. Emmitt (2011) in an editorial on lean design management is convinced that more attention needs to be focused on early stages of lean projects. Whilst I would agree with this and think that there is evidence from the case studies to support this, some of the delivery methods present additional lean design issues by duplicating designs as in the case of PFI where Public Sector Comparators exist or in NPD where exemplars are produced. This not only prolongates the process, costs additional design fees but irritates the user stakeholders who have taken time to discuss requirements and develop a design only to start off all over again with a new team. This highlights the need for utilising a delivery method where activities are only carried out once.

10.9.2 How the Form of Contract has Affected Design Management

As stated previously design management is a relatively new discipline in construction and has developed as a result of the change from design, bid build to design and build. The main feature of this change is that this form of contract separates the designers from the client often reducing the architect's ability to translate the client's requirements into a successful design. A form of contract where the architect is directly involved with the client and the contractor should have the potential to combine the positive aspects of both design, bid, build and design and design and build and discard the negative.

Table 48 below sets out an assessment of 10 project elements in relation to the types of contract used and the potential for using IPD

Table 48 Comparison of Contract Types

	Design Bid Build		**Design and Build**		**IPD**
	Nucleus	**Case Study 1**	**Case Studies 2-5**	**Design Team Novation**	
Integrated design team working					
Stakeholder engagement (users)					
Design flexibility					

Use of standard components					
Early contractor engagement					
Project Management expertise					
Programming					
Quality control					
Cost certainty					
Shared project risk					

Each of the elements is assessed in terms of red, amber and green where it is not present in red, it partially exists in amber and can be achieved in green. The results of the case study analysis are outlined with a bold black line in for comparison. These can then be compared with nucleus which is a rigid system, the design and build situation where the client has novated the design team (an example being the POE study and P22 projects using NEC 3) and IPD from literature studies, Lostuvali et al (2014) and Mesa et al (2016).

Design Bid Build show as comparison between nucleus and Case Study 1 reflects the difference between adopting a rigid template with predetermined room layouts reducing the requirement for user engagement. The Design and Build comparison between Case Studies 2-5 and the situation where the design team has been novated by the client rather than selected by the contractor shows benefits regarding programming and the sharing of project risk. Programming in the sense that the design programme is separate from that of the construction programme taking cognisance of an iterative design process as opposed to a sequential process, Hansen and Olsson (2011). The use of NEC3 in the P21/P22 projects incorporates a 'pain/gain' share between the client and the contractor which partially reduces the risk of only one party being responsible

The comparison between Case Study 1 and Case Studies 2-5 in Figures 33 and 34 highlights several issues:

- Integrated team working, in Case Study 1 the team was chosen by the wider delivery system and was able to work together to develop an integrated design before engaging with subcontractors.

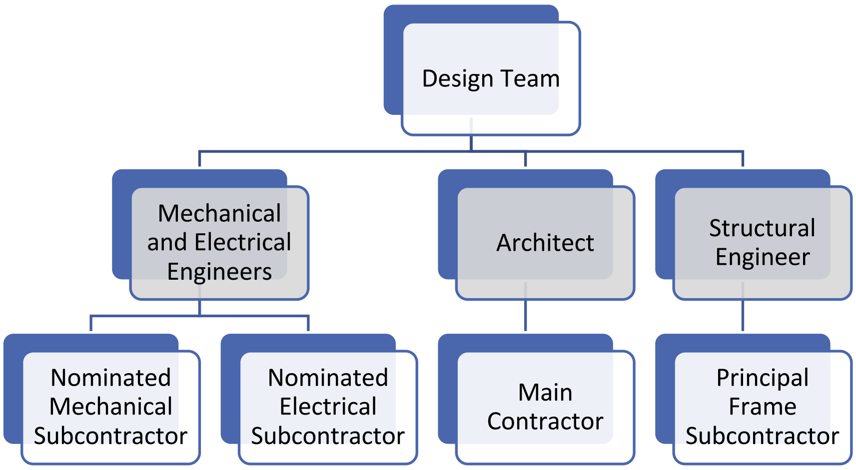


Figure 33 Case Study 1 Team Organisation

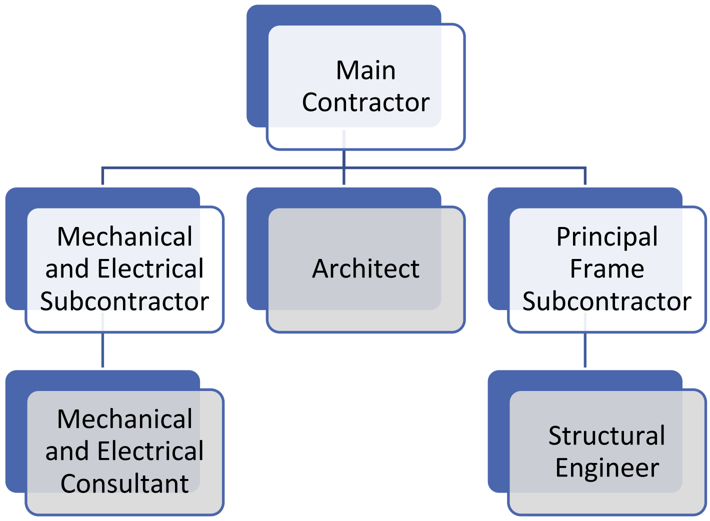


Figure 34 Case Studies 2-5 Team Organisations

In Case Studies 2-5 the contractor appointed the designers and was able to influence the design, but often at the expense of design integration due to 'mini' design teams within the mechanical and electrical services and the structural elements.

- Design flexibility reduced in Case Studies 2-5 due to severe change control procedures designed to discourage the client and retain the principles of design and build.
- The early contractor engagement brought project management benefits relating to large scale projects and the financial input required to invest in electronic data management systems

- In relation to programming, in Case Study 1 design programming was easier to manage than in Case Studies 2-5 where the contractors tried to tie design programmes to their subcontract programming often failing to appreciate the need to complete the design before the subcontract information could be released. There were also the instances in Case Studies 2 and 3 where the contractor introduced phased completion into the programme without realising that the phases could not function independently. The contractor's construction programming in design and build was however more sophisticated than that in design, bid build tenders which often gave rise to contractor's claim opportunities, Rooke et al (2004).
- A major difference related to quality control, in Case Study 1 the architect and design team were responsible for ensuring quality with the appointment of a Site Architect, Resident Engineers and Clerks of Works paid directly by the client. In Case Studies 2-5 the contractor was responsible for quality control with no on site quality control on behalf of the client. Although there were no major issues and in Case Study 2 the contractor decided to pay the design team for a site architect, resident engineer and services engineer together with two clerks of works, this was unusual, a major problem at Edinburgh Schools PFI (1998-2005) which resulted in a wall collapse in 2016 and a review of 17 schools in the city was the result of poor quality control by the contractor.

The transfer of risk from the client to the contractor which is appealing to clients is no longer seen as such by contractors as the design of major hospitals involves multiple stakeholders and 'experts'. Whilst this type of building is increasing in complexity and requires specialist knowledge the engagement of a multitude of 'experts' increases fragmentation and makes integration more difficult highlighting the need for integrated design management carried out by professionals with a design training. In Case Study 1 the architect and the mechanical and electrical services engineers participated through all the project stages whereas the structural and civil engineers had completed their work by the time the frame had been constructed and don't see the completed project. Hillebrandt (1984) recognised that in many large construction firms the role of project manager/ project director is carried out by civil engineers. The transfer from design bid build to design and build in a short period of time failed to allow time for the development of design management and contract administration within the construction companies and has resulted in people being allocated roles in design management rather than being trained for the new roles or recruited from design disciplines as demonstrated in the case studies. Design roles were created within construction companies at preconstruction level but then transferred to site design management roles with the loss of continuity. Without a detailed transfer of project history, knowledge is lost, and a weak link is created. The preconstruction team knowing that their involvement has ended, move on to the next project and the site team are too busy planning the construction to make a detailed study of the project background. Similarly, at the end of the construction works, the site team are anxious to move to the next project and fail to carryout project closure meetings related to lessons learnt.

10.9.3 Design Management Roles and Responsibilities

In all of the case studies there have been issues with competencies and capabilities. Some relate to the fact that for many roles there are no formal qualifications which means when establishing teams, the knowledge bases will vary.

The other issue with competencies and capabilities related mainly to ensuring the job descriptions and qualifications matched the roles that people had been allocated. It stems mainly from issues relating to availability of staff and the underlying construction industry military style of management where there is a strict command hierarchy and job titles relate to 'army ranks'. There is also a slow change in enforcing qualification requirements. Despite company job profiles requiring professional qualifications, unqualified staff were appointed causing many of the critical incidents.

Following the cases study analysis, the design activities have been tabulated in Table 49 through the project stages identifying who carried out the roles and who in an integrated model should carry out the roles and in Table 50 a description of the roles and responsibilities.

Table 49 Critical Evaluation of the Changing Roles of Design Management

Seq.	Design Management Activities	Design Management Integration Literature	Responsibilities			Stage	Design Management Role
			Traditional	**PFI/ Design and Build**	**IPD with Design Integrator**		
1	Outline Design Brief	Nicholas, Blyth & Worthington, Chandra & Loosemore, Kelly & Male	Client	Client	Client, Healthcare Planner	Stage 1. Pre-design	Design Integrator
2	Detailed Design Brief (Schedule of Accommodation)	Phiri, Codinhoto,, Enyon , Kamara & Anumba, Emmitt	Client	Contractor	Client, Healthcare Planner and Architect	Stage 2. Concept design	Design Integrator
3	Design Cost Plan	DH Healthcare Premises Cost Guides (2010) Smith et al (2004)	Client	Contractor	Client, Architect, Contractor	Stage 3. Design development	Design Cost Manager
4	Design Information Management pre contract	Construction-related Briefing and Dynamic Project-related Requirements Management (4.3.1) Olander, Fellows, Thomson, Collinge & Harty	Architect	Contractor	-	Stage 3. Design development	Design Information Manager (BIM Manager)
5	Design Interpretation of Client Requirements		Architect- Design Team	Architect/-Design Team/ Contractor	Architect- Design Team	Stage 3. Design development	Design Coordinator (architect)
6	Design Coordination	Cacciatori & Jacobides, Giurgola and Mehta	Architect	Architect / Contractor	Architect	Stage 3. Design development	Design Coordinator (architect)
7	Design Integration: Level 1: Zoning	Open Building Concept, Kendall, Olsson and Hansen	Architect	Architect	Architect	Stage 3. Design development	Design Coordinator (architect)
8	Design Programming	Sector-wide construction industry change and project-based business models to drive success Kelley & Walker (1959) Critical path analysis	Architect- Design Team	Contractor	Architect and Contractor	Stage 3. Design development	Design Manager
9	Design Phasing		Client/Architect	Client/ Contractor	Client, Architect and Contractor	Stage 3. Design development	Design Manager
10	Design Integration: Level 2: Departmental	Open Building Concept, Habraken, Kendall, Olsson and Hansen	Architect	Architect	Architect	Stage 3. Design development	Design Coordinator (architect)
11	Design Integration: Level 3: Room layouts		Architect	Architect	Architect	Stage 3. Design development	Design Coordinator (architect) and Design Manager

12	Design Specification	Coordinated Project Information - CCPI	Client/ Design Team	Client/ Design Team/ Contractor	Client/ Design Team/ Contractor	Stage 3. Design development	Design Coordinator (architect)
13	Design Verification-Traditional		Architect – Design Team	-	-	Stage 4. Work Package Design	-
14	Design for Nominated Subcontracts		Architect – Design Team	-	-	Stage 4. Work Package Design	-
15	Subcontract procurement		Contractor	-	-	Stage 4. Work Package Design	-
16	Work Package Design	Design management and innovation strategy, Enyon, Emmitt& Ruikar Hughes, Zambelli, Sinclair	-	Contractor	Contractor	Stage 5. Design in Construction	Design Manager
17	Design Verification- Design and Build/IPD		-	Architect – Design Team	Architect/Design Team and Contractor	Stage 5. Design in Construction	Design Coordinator, Design Cost Manager and Design Manager
18	Work Package Procurement		-	Contractor	Contractor	Stage 5. Design in Construction	Design Manager
19	Design Information Management post contract: Architect to Contractor	Den Otter & Emmitt, Jallow	Architect	Contractor – Design Information Manager	BIM Manager	Stage 5. Design in Construction	Design Information Manager (BIM Manager)
20	Design Information Management post contract: Contractor to Subcontractor		Contractor			Stage 5. Design in Construction	
21	Design Change	Shipton, Walter and Veloso, ward and Chapman, Koppenjan and Klijn	Client	Client/ Contractor	Client	Stage 5. Design in Construction	Design Integrator, Design Coordinator, Design Manager and Design Cost Manager
22	Design Compliance Checking	AJ Site Architect's Guide, Enyon, Emmitt & Ruiker	Architect – Design Team	Contractor	Architect/Design Team and Contractor	Stage 5. Design in Construction	Design Coordinator and Design Manager
23	Design Validation	Law	Client	Client	Design Integrator	Stage 5. Design in Construction	Design Integrator
24	Design Feedback	Hay et al, Carthey, Brand, Bordass,(4.3.6)	Client	Client	Design Integrator	Stage 6. Design Feedback	
	Overall Design Responsibility		**Architect**	**Contractor**	**Design Integrator**		Design Integrator

Table 49 indicates how the procurement/delivery model is fragmenting the design management role. In traditional procurement roles are very clear but in design and build the roles move between the architect and contractor and elements which require design input are unwittingly allocated by the contractor to other disciplines within their team who have not understood the design process and mistakes are made. Any mistake which needs rectifying during the construction period inevitably results in additional cost. Although the contractor has overall responsibility for the design contractually, the subcontracts are set up to transfer risk and none of the parties want to take responsibility. Currently the Grenfell Inquiry (Construction Manager Magazine) is highlighting this issue. Setting out integrated design management roles is a potential route to reducing this problem and the adoption of integrated project delivery could ensure that the three main parties; client, designer and contractor are always involved and share risk. Table 50 outlines the roles in forming an integrated design management team;

Table 50 Integrated Healthcare Design Management Roles and Responsibilities

Integrated Healthcare Design Management Role Function	Description of the Role
Design Integrator	Architect who is a specialist in the particular design field who is appointed by the integrated delivery team (client/architect/contractor) to ensure that the design is coordinated at all stages in the process and that the relevant stakeholders are involved. Acts as an interface between the project delivery and the wider system.
Design Co-ordinator:	Architect who is responsible for integrating the structure and mechanical and electrical design requirements and client equipment with the spatial planning requirements in the conceptual, developmental and technical design in consultation with the design cost manager and the design programme manager.
Design Cost Manager:	Quantity Surveyor employed by the constructor with responsibility for providing cost analysis throughout the design process to the designers and once construction has started monitors and reports on cost control and design changes.
Design Programme Manager	Construction Planning Engineer employed by the constructor to help prepare the design and construction programme and to provide advice to the designers relating to buildability and site logistics.
Construction Design Managers	Check incoming design information and interface with the work package managers and commercial teams in the procurement and management of subcontractors.
Design Information Managers	part of the constructors’ design management team responsible for data management and ensuring that the right information is communicated to the right people at the right time

In the case of healthcare projects, it is highly unlikely the roles outlined will be part of a single organisation nor is it necessarily advisable. Constructing the Design Management team from across the client, design and construction organisations ensures a level of quality checking which has proved difficult in design and build when no independent check took place as in the case of Edinburgh Schools PFI. Recognition of the role of design management within the wider delivery system avoids the appointment of independent advisory consultants which in turn aids lean design management, but this relies on the Department of Health recreating an organisation which can set standards and guidance, provide support and advice to clients in terms of supply chain selection and monitor projects through all the design stages. This would include the new role of a Healthcare Design Integrator who can integrate between both the horizontal and vertical systems.

What tables 49 and 50 demonstrate is that design management is multi-disciplinary and also straddles the different parties like a matrix. Additional information is contained in Appendix F.

10.9.4 The Role of a Design Integrator

Winch (1998) stated that construction has two separate systems integrators; the architect in design phase and the contractor during construction. This project delivery approach was true in temporal period 1. This contrasts with Davies et al (2009) who identify a single-systems integrator, again reflecting a later period, however no review has been made across delivery models. This longitudinal study provides case study analysis of the critical incidents. It identified the systems integrator who had resolved or instigated integration, was in most cases related to the architect or a design manager trained as an architect. This included critical incidents during the construction phase indicating design integration does not finish once design has been completed.

Barlow et al (2008) concluded in PFI where the SPV might be considered as the systems integrator and in the early healthcare PFIs the indications were this did not happen, and it was more of a hindrance. Although the reference was to the first wave PFI projects having worked through all versions of PFI I would agree there was no evidence to suggest the SPV acted as a systems integrator. Barlow et al (2008) also identified the need for a systems integrator who could integrate the design and construction. This confirms the importance of an integrated role – a integrated healthcare design integrator.

In support of Davies et al (2009) when the first wave PFI projects first started contractors did introduce management mechanisms designed to integrate the team but when critical incidents started to occur, they turned to the architect to solve them even if perhaps unwittingly they had caused them. The main areas related to the integration of the structure, the mechanical and electrical engineering systems and major medical equipment, all aspects which would normally have been carried out by the architect as supervising officer.

Case Study 5 demonstrated the need for a design integrator to ensure the design is fully coordinated at all levels as the contractor's design managers were left to interpret the design requirements to the best of their abilities without the benefit of a fully integrated design.

The lack of consistent definitions of healthcare design management and the role of a design manager within healthcare delivery was common both to the case studies and literature. In literature clarity is expressed by Emmitt and Ruikar (2013) and Enyon (2013), but my experiences in practice, through the case studies, did not reflect the theoretical situation. In Case Study 1, where the title design manager was not used, I first discovered that unlike design teams where it was simple to identify roles and responsibilities, construction companies adopted a hierarchy based upon military management styles where individuals had a 'rank' and a different job title making it difficult to identify their professional backgrounds. The designation 'design manager' in the subsequent case studies was used to describe individuals from various disciplines, and in the early projects the majority of them I met had no design training and no concept of the overall project requirements. Some from civil engineering backgrounds, had very good management skills and were able to set out systems and processes but, did not understand the iterative nature of design and had difficulties with the fitout stages and the integration of mechanical and electrical services as they were used to leaving projects and move to new projects once the frame had been completed. In the early case studies the emphasis was on design information management which like requirements information management should not be confused requirements management as it requires different skills.

The size and complexity of major hospitals make it difficult for a single project architect to be able to control every aspect of the project including the contract management. In Case Study 1 the contractor's commercial manager at the end of the project told me that it was probably the largest project one person could handle. Before the project started on site, I was also told by another architect working in a similar role on another large hospital project, that although he had an additional site architect, his average working week was over 54 hours compared with the standard 35 hours. It was also a lonely role as all ultimate decisions had to be made by the supervising officer.

In comparison with architectural practices, major contractors were used to working in large teams, the same commercial manager also told me the company employed 32 quantity surveyors to prepare a contractual claim against a client and architect on a large office development. The first PFI project Case Study 2 was much larger than Case Study 1 in terms of number of rooms, not complexity but did require a large architectural team once the project reached preferred bidder. In order to build a large team, the office had to recruit a large number of staff, mostly young architects and technicians with no healthcare experience who were then split into teams to develop different areas of the building. The design was also split between the internal – healthcare layouts and external envelope. This split which also occurred in Case Studies, 3, 4 and 5 caused issues in all four projects as a result of the external envelope designers not understanding the functional layout of the building. It is not the same concept as layering but does demonstrate the need for a concept designer to understand the layering principles. It also demonstrated the need for strong design management both by the architectural and contractors' teams. The system needs to facilitate this to ensure project failures do not occur and there are assurances and standards that establish an integrative design and design management principle.

10.9.5 Moving Towards Integrated Project Delivery and Integrated Design Management

Mesa et al (2016) set out a matrix to compare different forms of delivery forms on supply chain relationships. I have developed a similar matrix in Table 51 to demonstrate how the case studies have performed over the temporal periods relating them to predicted outcomes accordingly to the type of contract. The expectations of all of the contracts should be the same, with the exception of gain/pain which are not part of design, bid, build or design and build.

Table 51 Integration Comparison of Case Studies Across the Temporal Periods

	Design Bid Build			**Contractor Led Design and Build**					**Procure 21/22**				**IPD**
Case Study	**PR**	**CS1**	**CS6**	**PR**	**CS2**	**CS3**	**CS4**	**CS5**	**PR**	**CS7**	**CS8**	**CS9**	**PR**
Integrated Design	E	Y	Y	E	P	P	Y	N	E	Y	P	N	E
Integrated Construction	E	Y	Y	E	P	Y	Y	N	E	N	P	P	E
Integrated Structure	E	Y	Y	E	N	Y	Y	N	E	Y	P	N	E
Integrated Services	E	Y	Y	E	P	Y	Y	N	E	Y	P	N	E
Integrated Equipment	E	Y	Y	E	N	P	Y	N	E	Y	Y	N	E
Design Integrator	E	Y	Y	E	N	P	Y	N	E	P	P	N	E
No-blame culture	E	Y	Y	E	N	P	P	P	E	P	P	P	E
Gain/Pain Share	**N/A**	N/A	N/A	**N/A**	N/A	N/A	N/A	N/A	E	Y	Y	Y	E

Key: E: Expected, Y: Yes, N: No, P: Partial, PR Predicted, CS: Case Study

The results from the case studies did not fully reflect the predictions; the design-bid-build case studies demonstrated high levels of integration, which would have been expected, but the common belief that a blame culture existed did not happen. However, both projects in this category involved the same architect as design integrator and the same construction company. Case Study 2, where the direct client/contractor relationship was deemed to reduce the no-blame culture, existed in a different form where the contractor blamed design for causing delays. The level of integration was not achieved through the lack of a design integrator. Case Studies 3 and 4 still involved a level of blame culture, where again the focus was on blaming design, but this was mainly due to certain individuals. The level of integration improved by the intervention of a design integrator and in Case Study 4 the results closely reflected the expectations of an IPD. Case Study 5 was the worst example of integration and although the project is now being completed using an NEC 4 contract, similar to Procure 22, it is unlikely other than the pain/gain share, which is built into the contract, the benefits of this type of contract will be achieved. The Procure 21/22 studies all suffered from the lack of a design integrator.

The subject of systems integration and PFI in literature appears in Temporal Periods 3 and 4 mainly in relation to large infrastructure projects such as Terminal 5 Heathrow, the London Olympics and more recently Crossrail, although the perceived potential success of Crossrail is beginning to be questioned as a result of delay and cost overrun which is ongoing. Davies and Mackenzie (2014) examine the construction of projects for the London Olympics (2012) as an example of 'meta systems integration' taking integration to a higher level. Hospital projects (even large scale) do not command the same capital cost values as those of major infrastructure and as a result do not feature in research associated with what is designated as 'complex mega projects'. As stated in the introduction I do not consider hospitals should be included with major civil engineering projects as infrastructure as they involve a higher level of design complexity including the integration of their own infrastructure. Literature references to major hospital projects although they have been a major feature of the PFI procurement programme are scarce.

There is little evidence in literature the change of model has improved the concept of lean construction and the case study analysis does not support this particularly in relation to lean design. The American model of Integrated Project Delivery, where a tripartite agreement of client, architect and contractor, is supported by a joint project insurance has been successfully used to deliver lean construction on major hospital projects for Sutter Health in California.

NEC4 Alliancing proposal has the option to include a designer as a Tier 1 partner, unlike NEC3 whereby the designer is working for the contractor, as a Tier 2 subcontractor precluding direct contact between architect and client. The case study analysis highlighted the problems with the designer being a subcontractor. Project 13 is related to NEC4 and was also developed by ICE introduces an integrator to connect the key supplier and key advisor with the supplier and advisor. This model designed for major engineering infrastructure does not reflect the different levels of design and complexities involved in major hospitals projects.

The adoption of NEC4 in healthcare as in Case Study 5 involved adapting the design and construction process to fit the contract rather than a contract designed to suit the process.

The recent structures involve a high level of duplication, often three design teams: client advisors, contractor and independent tester. This a waste of resources, it is also quite frustrating for designers and in Scotland the NPD route involves one set of designers producing a scheme having consulted users, only for several contractors' teams trying to develop different schemes. This route does not represent lean design.

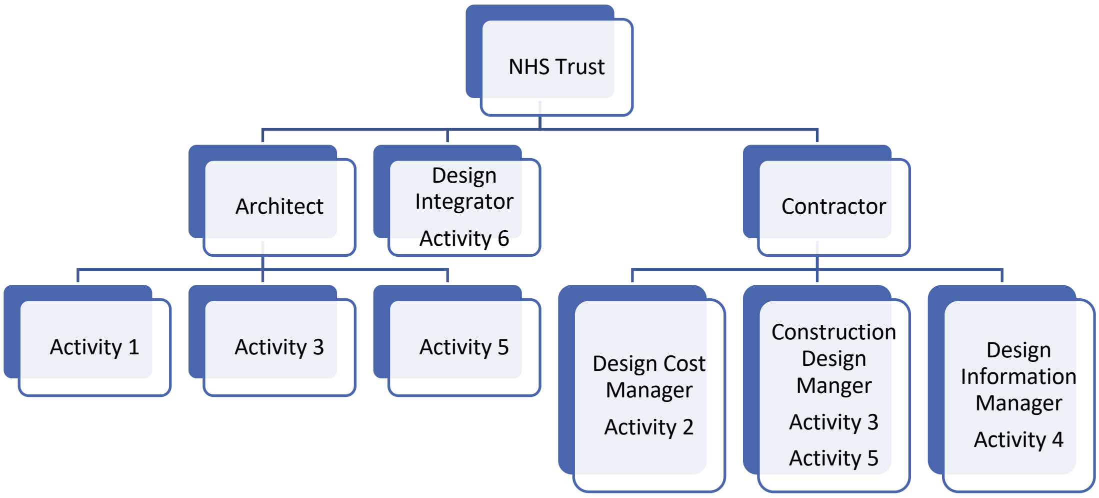


Figure 35 Integrated Design Management Model

Figure 35 indicates an integrated model which will require a new form of contract which can accommodate partnering with the lead designer (architect) and the managing contractor being equally responsible to the client. The JCT roles were very clear in the conditions of contract and a new form of contract needs to include this. The roles need to be reviewed in light of the 25 years of PFI where roles have changed. The temporal periods demonstrate how skill bases have changed and where activities once carried out by the architect are now carried out by the contractor have been lost by many architects and we should not turn the clock. We need to learn and appreciate where these skills are best located to maximise performance. Table 52 outlines the six main design management activities, comparing the traditional and design and build models with a proposed integrated approach where the architect and contractor both take responsibility for quality control and where a Design Cost Manager rather than a Commercial Manager is involved with the contract administration. It also introduces the role of design integrator appointed by the wider system to monitor design progress through all the stages.

Table 52: Activity Comparisons

Activity	Traditional	Design & Build	Proposed Integrated Model
1.Coordinating and Issuing Information to the Contractor	Architect	Architect	Architect
2.Contract Administration	Architect	Contractor – Commercial Manager	Architect and Design Cost Manager
3.Site Inspection and Quality Control	Architect	Contractor -Construction Manager	Architect and Construction Design Manager
4. Issuing Information to Site Team	Contractor	Contractor -	Contractor – Design Information Manager
5.Checking Information	Contractor	Contractor – Design Manager	Architect and Construction Design Manager
6. Monitoring Design Progress	N/A	Contractor – Design Manager	Design Integrator

10.10 Longitudinal Learning

A good example of longitudinal learning relates to the nucleus system, which was abandoned in the 1990s, not as a result of the introduction of PFI (as suggested by Singha (2020)) but its inability to adapt to accommodate emerging requirements. Ironically the move towards contractor-led design and build was ideally suited to design and build as it was a good example of systems integration; spatial design, with structural and services integration based on a static brief, standard components and a standard template. The standard template failed despite twice during its lifetime having its size increased. Ultimately it could not cope with changes to models of care and the introduction of new technology and medical equipment. The move from a mixture of multi-bed wards (ranging from 4-10 beds) and 6-8 single rooms to wards with 100% single rooms. Added to this the size of the single room has increased from 10 to 19 square metres. Departments such as operating theatres and radiology became difficult to plan in such constrained design parameters and the 1986 version of the template for a theatre layout could not function properly and broke the basic nucleus principles by presenting a layout without the structural grid which when superimposed on the layout would have resulted in having freestanding columns within the operating room and the corridor. The lack of stakeholder engagement due to the static briefing resulted in poor satisfaction with clinical users.

In the aim of improving construction performance this approach to systems was abandoned as a result of one element and in subsequent temporal periods efforts have been made to recreate some of the other elements without understanding the principles of systems integration. However, nucleus should not have been dismissed in its entirety as it was in the 1990s, the fundamental principles of systems integration should have been retained together with standard components, but without the rigid template. Stakeholder involvement has been demonstrated through the case studies to highly influence successful project outcomes together with a level of dynamic as opposed to static briefing.

Since the 1990s prefabrication or 'Off-site' construction is now seen as the future of construction and certain large components have already been incorporated in many of the hospitals built since.

Tracing the two major components of Temporal Period 1, design-bid-build and the nucleus building systems which were discarded rather than adapted/revised through the subsequent temporal periods indicates a gradual moving towards many of the features of the delivery model and systems integration sending a clear message that models and systems may be broken but they are not irreparable. The last temporal period I described as disintegration but before abandoning it for an untried healthcare model lessons need to be learnt.

Longitudinal learning provides a potential contribution to knowledge. As demonstrated through the temporal periods it takes time to adjust to new methods of working and new roles and responsibilities as well as developing skills and gaining experience. Comparative research across periods will draw out different results. The studies by Davies et al (2009) referring to the likely success of Crossrail no longer appears to be the case following the Channel 4 Documentary in 2019 as this project is currently both over cost and running late.

Longitudinal learning allows the emergence of patterns to be observed and if, as it has been described, construction is cyclical and can be used as an indicator of potential changes. The use of retrospective auto-ethnography provides a view of 'hindsight' into what happened, how things could have been improved or prevented and as such is an important methodology.

10.11 Summary and Contributions to Knowledge

It is clear from the case studies that a change needs to take place which will involve a form of integrated healthcare design management and that literature tends to relate to specific issues rather than address the subject as a whole from different healthcare disciplines. There is no clear integrated healthcare delivery and design management pathway as the change from design, bid build to design and build has not fulfilled expectations.

The findings from the longitudinal analysis of the case studies suggested contributions to knowledge in relation to the critical incidents, determining patterns over the temporal periods and how they had arisen due to changes in project delivery and design management. The following contributions are made:

1. Longitudinal learning – Advanced understanding of the system and its impact on project delivery has been shown. The literature review found little evidence of the use of auto ethnographic approaches post-career and in the absence of post occupancy evaluations there is no evidence of what took place unless more retrospective auto ethnography takes place. When failures occur 'deep dive' exercises within organisation are needed to find the cause, but this is not usually shared. There is a benefit for future generations to learn lessons from past projects and build knowledge to avoid repeatable mistakes. Results of post occupancy evaluations are often too late to influence briefing for new projects which highlights the need for more integration between the wider delivery system and project-based efforts.
2. The identification of critical incidents and the use of systems integration as a means of analysis has contributed learning from projects that are technically sophisticated to create a healthcare design and design management integration framework that allows critical incidents to be evaluated in terms of cause, effect and resolution.
3. The need for greater integration between the wider healthcare systems and project design management is demonstrated by the importance placed on standards and guidance in all projects but is currently subject to interpretation.
4. The combination of layering theory from open building concept with the adoption of a structured schedule of accommodation and reclassification of medical equipment has the ability to improve operational healthcare design integration and enable the integration of prefabricated products and modular construction.
5. A further outcome was a fifth potential sub contribution to knowledge relating to the creation of long-term hospital integration alliances, addressing critical incidence, establishing the best people for task roles and able to incorporate the findings into new standards based on layers and innovation. new delivery models must appreciate

the unique healthcare setting and the complex interaction of these roles both in terms of organisational roles and individual roles.

Chapter 11 Conclusions and Recommendations for Temporal Period 6 Dynamic Integration

11.0 Temporal Period 6 Dynamic Integration: Conclusions and Recommendations

11.1 Achievement of Aims and Objectives

In conclusion this thesis has identified five temporal periods in the development of major hospital projects over a period of 40 years including the introduction of PFI, through its development and finally its demise. It has focused on the effects of design integration and project delivery and the outcomes in relation to the delivery of client requirements. It has looked at systems integration both within the project delivery phase through design integration, stakeholder integration and construction integration and in the wider delivery system of how to deliver healthcare. It has also examined what effect the requirements crunch point within individual project delivery has had on the outcomes and whether its existence and timing influences project success.

The objectives stated in Chapter 1 and their achievements have been detailed in Table 53 below:

Table 53 Achievement of Research Objectives

	Research Objectives	Achievement of the Research Objectives
1	To determine the level of integrated design required and its relationship with integrated project delivery	The case study research determined that there were reoccurring issues with design integration in relation to not only the structure and services but with the installation of major medical equipment. From literature a link was established through the concept of lean and layering to integrated project delivery. This resulted in developing a levels and layers approach to healthcare design.
2	To investigate existing projects and their delivery methods	The research identified critical incidents and positive integration in five case studies which were then analysed to determine what influence the different delivery models had on the outcomes. The occurrence of the RCP was also analysed to assess the level of client satisfaction and at what stage in the project it had taken place. The choice of delivery model was preselected by the wider delivery model.
3	To determine the role of Design Management in Integrated Design	The case study research determined a need for a framework for Integrated Design Management. All of the case studies displayed issues with integrated design and the literature review highlighted different interpretations of design management with design managers having a variety of qualifications. Through the longitudinal study it became apparent there are several levels of design management required with different design management roles within both the project team and the wider delivery system.
4	To determine the systems integrator(s)	The initial objective referred to systems integrator, but through the research it became apparent this term should be changed to design integrator. There was evidence in three of the case studies as having someone fulfilling the role of a design integrator but not defined as such. Two of the cases studies showed no evidence of a design integrator and demonstrated serious integration problems.

5	To identify and develop an integrated approach for the delivery of major hospital projects which will meet client requirements	The case study research identified characteristics which were more likely to deliver client requirements and following the literature review an integrated design management approach incorporating open building concepts and healthcare zoning which could achieve Integrated Project Delivery.

A key factor which emerged during the research relating to project success is the engagement of the 'right people for the right job'. Even if the project is well structured, adopts tried and tested procedures, engaging people with the wrong skills or capabilities can result in difficult situations and potential failure. It highlights the need for setting up new courses to cater for new and future requirements.

The literature survey demonstrated the existence of 'silo mentality' examining in great detail individual aspects relating to project performance, such as delivery on time and within cost, but few focused on the 'big picture'. No one aspect of a design and construction project is an island, projects rely on cooperation and integration of different processes and people.

Despite the fact nearly 60 PFI hospitals costing over £50million (Wikipedia, referenced June 2020) have been built since 1997 no POE studies have been published, there are a handful of academic papers on the subject of PFI hospitals, notably by Caldwell et al (2009) comparing a first wave PFI hospital with London Heathrow Terminal 5 looking at procurement. This thesis attempts to bridge the gap in knowledge through a retrospective longitudinal study so that lessons can be learnt before embarking on a new delivery process and establishing what support is required from the wider delivery system.

11.2 Limitations

The research set out to find out how project outcomes could be improved for major hospital clients, through a literature review relating to client satisfaction and the influencing factors. Then by researching my past project experiences through a longitudinal study of temporal periods.

Research however is always limited by the methodology it applies. In this thesis it is somewhat experimental in it adopted a form of autoethnography which is retrospective for four of the temporal periods with the final period involving action research using grounded theory methods. The research is predominately qualitative with a small quantitative study in period 5 which may have resulted in researcher bias.

The subject matter is multi-facetted, and it has been necessary to spread the literature search wide in order to them draw in the factors which ultimately affect project delivery and client satisfaction. There are however three major influences which have not been included as they would be common denominators, they are:

1. Political influence: the study relates only to major NHS hospitals;
2. Financial models: all the projects ultimately require HM Treasury approval; and,
3. BIM: is a tool for aiding integrated design but does remove the process and understanding required to achieve integration.

The concept of a Requirements Crunch Point which was first considered in the early stages of this thesis as a pivotal milestone was demonstrated to exist within the case studies and the post-occupancy evaluation study. The earlier it occurred the more likely it was to achieve client expectations. As the thesis developed the focus moved towards design integration and layering when it became apparent that the RCP aligned with the transfer from an iterative design process to the more sequential delivery process. It identified a gap in the literature.

11.3 Contribution to Knowledge

The contribution is made to integrated design management and its unique application for the design and construction of major hospitals to deliver client requirements. Design management, as a separate discipline in construction, has only been recognised within the last 20-25 years and systems integration, although established in hospital design as part of nucleus since the 1970s had not identified as such, from integral components to delivering integrated design management. In the wider architectural field, the concept of open building has defined three layers of design related to adaptability over the long-, medium- and short-term time frames, something that is very pertinent to healthcare design, which needs to cope with advancing technology and new models of care. Major hospitals are also multifunctional catering for a diverse range of facilities creating a different layering model.

The contribution to knowledge is the identification of levels of integration, by whom and at what time during project lifecycles and its relationship with the wider delivery of hospital projects and the requirement for design integrators within both the project and wider delivery systems.

This is demonstrated as a result of a longitudinal study of multiple case studies of similar size and complexity during five temporal bracket periods spanning 40 years analysing critical incidents and positive integration which occurred. Four of these case studies are retrospective abductive auto-ethnographic and relate to my role as an architect and a design integrator in different project delivery models.

Through the analysis of the critical incidents and positive integration the lack of integrated design management and an understanding of roles and responsibilities became apparent. Confusion exists in relation to job descriptions and qualifications relating to the project roles and the transfer of responsibilities due to changes in procurement methods and subsequent changes to contract administration roles and in order to successfully deliver client requirements the right people, at the right time and in the right place need to be identified.

At the same time systems integration at project level, instead of developing with design management, started to disintegrate. The temporal periods also reflect what happened in the wider delivery system where a fully supported UK government system has gradually been eroded.

In summary this research has contributed a new integrated design management systems approach to deliver major hospital projects which will provide clients and users with the state-of-the-art facilities they require. The following provide detailed characteristics of this contribution.

11.3.1 Critical Incidence in Developing a Design and Design Integration Framework

The analysis of the critical incidents highlighted the importance of design in all stages of the project which led to the development of a design integration framework involving different design management roles at different project stages.

11.3.2 Longitudinal design and design management integration and learning periods that understand the impact of the wider delivery model on project delivery

The progression through the five temporal periods has led us from the demise of traditional architect led procurement, design-bid-build through three waves of contractor led design and build PFI procurement over a thirty year period to a point where change needs to take place and a new delivery model is required.

The move from architect led to contractor led where integration and less confrontation was envisaged did not happen and a form of partnering, where all participants can demonstrate and acknowledge each other's respective skills, should be put into place. The case studies demonstrated the major player in resolving issues was an architect by background as the incidents invariably involved design, indicating an architectural rather than a civil engineering contract should be developed. Architects are trained to be involved in all the project stages of building projects whereas civil engineers usually have limited involvement in the briefing stages and once the frame has been constructed their project involvement ends.

11.3.3 An integrative design and design management role that aligns architecture, structure, mechanical and electrical engineering, clinical, planning, equipment, innovation, and buildability

The need for the introduction of a healthcare design integrator to oversee the design through all the stages who would be an experienced healthcare designer with construction project skills who can interface with all stakeholders and the wider NHS wider delivery system.

11.3.4 Layers/levels Approach to Healthcare Design

Combination of an open building concept relating to building layers of primary, secondary and tertiary systems with healthcare building zones, cluster and activity zones which sets out healthcare planning principles, allows for future proofing, has the capability to maximise scarce resources and can accommodate modern methods of construction.

11.3.5 Hospital integration Alliance to include clients and their suppliers, designers, contractors and policy makers working together

The proposal for a new alliancing delivery model for health care projects utilising approved suppliers, contractors and consultants selected by the NHS wider delivery system. An alliance involving designers and a managing contractor as partners with a healthcare design integrator to ensure design continuity and monitoring throughout the project lifecycle. A simple structure eliminating duplication of advisors and consultants which has the capability to promote lean design.

11.3.6 Overall Contribution to Knowledge

This thesis has used retrospective auto-ethnography in a longitudinal study. The overall contribution to knowledge is the identification of integrative healthcare design which enables learning from critical incidence, learning over the long term, innovation through role integration and systems separation into layers and levels which can be delivered through integrated project delivery and a healthcare design integrator. It is original as it describes my experience over a long time period and brings together different aspects of healthcare design and delivery into one integrated delivery model.

11.4 Impact and Dissemination

The early 1990s saw a major change in delivering healthcare, not only in terms of hospital building but in how the service was delivered. Now nearly 30 years later, new challenges necessitate another change. Some of the changes adopted in the 1990s and 2000s have not fulfilled their expectations and new methods need to be put in place. Cacciatori and Jacobides (2006) identified elements of disintegration in design and construction and set out to propose how these could be integrated through a vertical reintegration one-stop-shop. Unfortunately, the case study analysis demonstrates otherwise, isolating the architect from the role of design integrator by setting up supply chains and relationships where the primary links are between individual designers and their specialist subcontractor rather than through the lead designer.

This time however we need to learn lessons from what has happened, otherwise there is a danger of history repeating itself and old ideas being rebranded without investigating why they failed the first time around.

11.4.1 Impact on the Project Delivery System

By the end of Temporal Period 5 project delivery systems for major hospitals were in disarray, and a new model needs to be established. There is now an opportunity for a new project delivery model, one specifically designed to deliver healthcare, be adopted. One which is less confrontational, promoting partnership arrangements and which can deliver the latest technology on completion and with acuity adaptability and future proofing. I would like to think some of the findings from this thesis could contribute to this new method of delivery.

11.4.2 Dissemination

To date, few of the research findings have been disseminated to a wider audience. A number of conference papers related to the integration of stakeholders and major medical equipment and the requirements crunch point have been presented. A workshop involving inviting representation from both the project delivery and wider delivery sectors took place where the thesis findings were presented, and it is the intention that the findings will be published in due course.

Conference papers and workshop presentations include:

- Astley, P.D., Symons, A.W. and Mills, G.R.W. (2015) Rates of Change – Design Evaluation of Rapid Clinical and Technological Advances in a Children's Surgical Unit, ETH Zurich

- Symons, A.W., Mills, G.R and Roberts, A., (2016) Stakeholder Integration and Its Relationship with the Requirements Crunch Point in the design of Major Hospital Projects, ID@50 Bath
- Symons, A.W., Mills, G.R and Roberts, A., (2017) Integrating Stakeholders in the design of Major Hospital Projects, IRNOP, Boston, USA
- Symons, A.W. (2018) The Effects on Delivery Models on the Requirements Crunch Point: the case for integrated project delivery, EuHPN, Gothenburg
- Symons, A.W. (2020) Integrated Design and Project Delivery for Major Hospital Projects, UCL, London

11.5 Recommendations

The findings from this research indicate we are now entering into a new temporal period, one I would hope could be described as dynamic integration, where clients, designers and contractors work together and plan for the future. The recent Covid-19 outbreak has changed people's lives in a way that could not have been envisaged and has highlighted the need for flexibility within healthcare design. A holistic approach from the wider delivery system is required to ensure new models of care be developed in line with design levels and layering principles which can benefit from off-site manufacture. New delivery models need to take cognisance of all aspects and not just address single issues one at a time as was the case in the decision to change public procurement to PFI and Design and Build in the 1990s.

At the workshop held in March 2020 there was strong support for national healthcare standards and guidance and for some a preference for 'Flexible Prescriptive Integration'. The following sections outline how this could be achieved in terms of research and practice.

The ongoing inquiry into the fire at Grenfell Tower has questioned many different members of the construction industry from project managers, design consultants, specialists, contractors, subcontractors and material suppliers and what comes across to the public is the industry's fragmentation. No one wants to take responsibility and instead they blame each other. It has highlighted a lack of competencies and poor education together with a set of outdated building regulations. Paul Hyett, past president of the RIBA described "The design and build process as creating "disorder' within the construction industry" giving evidence as an expert witness. Construction Manager, 5 November 2020. This supports many of the problems described in the case studies and surely with the significance of this disaster will instigate changes in the construction industry.

11.5.1 Recommendations for Research and Development

This thesis has demonstrated the need for integrated design management and healthcare design systems within both the project delivery and wider delivery systems. From the data I have collected over the past 30 years I have identified the following areas of research:

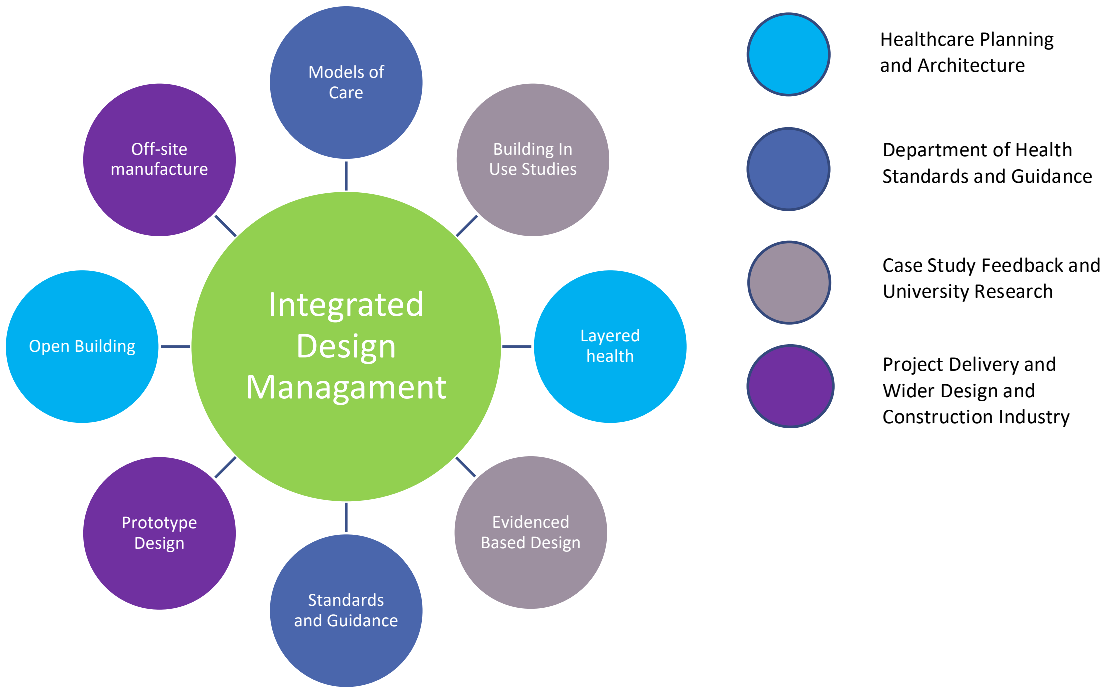


Figure 36 Integrated Healthcare Design Management Research

The different areas of research have been grouped together in Figure 37 to identify how the various organisations need to develop their own areas of expertise and how they contribute to the overall field of integrated design management. The following recommendations are suggested for both quantitative and qualitative research:

1. Carrying out building in use studies (post occupancy evaluations) on all major hospital projects including those carried out to date in terms of functionality, client satisfaction and project governance as well as energy efficiency. Analysing the occurrence and nature of the RCPs and its effect on project outcomes.
2. Developing evidenced based design for future design guidance.
3. Developing new guidance and tools to aid briefing requirements – a replacement for ADB which can deliver for all stakeholders.
4. Developing standard components and building systems framework.
5. Ethnographic research into behavioural attitudes within the construction industry and how these can be improved.

Designers and constructors need to collaborate and publish research which can be feed more quickly from research to industry in particular post occupancy evaluation something which they can learn from the medical profession who publish findings timeously in their professional journals.

In relation to theoretical recommendations and developments I would like to see would be more research into the use of advanced digital technologies where architects and designers can comment remotely on-site activities and respond quickly to problems which have occurred thereby reducing potential delays and rectification costs.

11.5.2 Recommendations for Practice and Industry

In the first temporal period the Department of Health and NHS Estates played a key role in the design of new hospitals and provided an extensive range of standards and guidance. They also monitored projects and gave advice to NHS Trust, but over the subsequent temporal periods the level of support has reduced. They were responsible for strategic healthcare. Again, Case Study 5 demonstrates the decline in adherence to HBNs with its high proportion of derogation. In the workshop I presented on Integrated Design and Project Delivery for Major Hospitals there was general agreement on the need for prescriptive standards and guidance, with a representative from NHSI advocating a return to “prescriptive integration with flexibility” including a nucleus style approach to standard rooms. Since Temporal Period I the updating of HBNs has been mainly out-sourced due to dismantling of NHS Estates and this has led in some instances to inconsistencies. Some of the guidance documents such as HBN 00-09 Control of Infection are open to interpretation and consideration should be given to bringing into legislation in line with fire regulations and accessibility.

Just as turning the clock back would be unrealistic as returning to design-bid-build would be for project delivery and it would take considerable time to re-establish NHS Estates, there are opportunities for the Department of Health to take back responsibility for the wider project delivery.

A more user-friendly tool kit for the specification of equipment with a language which everyone can understand – users, designers and the construction team should be developed nationally in conjunction with standards and guidance in consultation with the professional bodies and contractors. A review needs to take place of the Activity Data Base (ADB) which is the main briefing total used for designing and equipping hospitals. There are two aspects of change required:

1. Redefinition of categories to reflect procurement of major medical equipment.

2. Simplification of component coding to make it understood by all stakeholders, designers, suppliers and installers.

Currently there is a need for understanding terminology especially Group 3 and 4 equipment and their implications. There are also issues with clients procuring and maintaining major medical equipment (either through a planned scheme or an equipment leasing agreement).

This is an example of something which could be carried out relatively easily but would make a considerable impact on project outcomes.

The recommendations are summarised as follows:

1. The Department of Health to take responsible for strategic healthcare planning and appoint a systems integrator to ensure that policy is disseminated to all NHS Trusts;
2. The Department of Health to set up an 'in-house' organisation with a systems Integrator, Figure 37 to bring together the different systems:

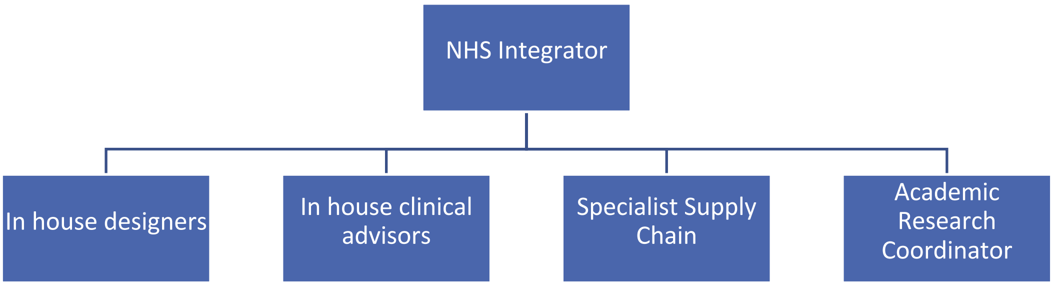


Figure 37 Healthcare Delivery Integrator

3. The 'in-house' team of designers and clinical advisors to prepare and issue standards and guidance which can be used by project teams, developing frameworks which can accommodate layering and repeatable rooms;
4. The 'in-house team' to liaise with external advisors in the specialist supply chain and with academic research to develop new guidance;
5. The 'in-house' team to co-ordinate academic research, instigating knowledge transfer through POE, evidenced based design and promoting innovation;
6. The Department of Health to promote the setting up of an Association/Institute of Healthcare Planners with professional qualifications necessary to provide a uniform level of advice to Trusts;
7. Develop multi-disciplinary courses to encourage integrated healthcare design and enable professional qualification for the roles required to deliver projects; and,

8. The Department of Health to consider making control of infection part of legislation.

Within the wider design and construction industry there needs to be more focus on creating forms of contract to suit healthcare projects rather than utilising contracts which create either conflict, fail to accommodate the subcontract relationships required for the design process, or have been developed from engineering rather than building projects. The design and construction industry also need to ensure that professionally qualified staff are engaged and trained

1. Developing a form of contract within JCT or adapting the NEC 4 Alliancing version to allow Integrated Project Delivery (IPD) which can accommodate direct relationships amongst the client, the architect and the constructor, ensure punitive change control clauses are avoided and one which can utilise Integrated Project Insurance as a means of creating a no blame culture.
2. In the Design and Construction Sector the setting up of an Association/Institution related to Architectural Design and Construction Management to regulate professional qualifications and roles.
3. The Construction Industry has many professional bodies, some of them competing with each other for membership, and at the same time there are many large players who do not participate. The problems highlighted by lack of competencies and experience and silo working even within teams indicates a need for clear understanding of who is required when during the project, and what is required of them. There is therefore a need for the design and construction industry to focus their activities on how best to work together recognising each other's strengths and weaknesses.

The findings from the case studies have demonstrated a need for change in how we deliver projects. Starting with a prescriptive approach to briefing design requirements for hospitals and adopting traditional procurement methods through a process of self-regulation which introduced the practice of derogating from existing standards and guidance and at the same time reversed traditional roles as a result of contractor-led design and build contracts. Whilst some of these changes and developments may have been with the best of intentions Temporal Period 5 indicates the transfer of risk to contractors may have gone too far and there is evidence of reluctance by contractors to continue this practice demonstrated by increased costs to protect against risk and declining to tender projects. So, what do we need from this new delivery model and how can we deliver this? The following recommendations are made in relation to the delivery of projects within the healthcare sector:

1. Appoint a Healthcare Design Integrator as in Figure 38 to the project who is involved through all the project phases and can convey the client requirements to the designers and contractors. This individual needs a background in healthcare design and construction with relevant qualifications.

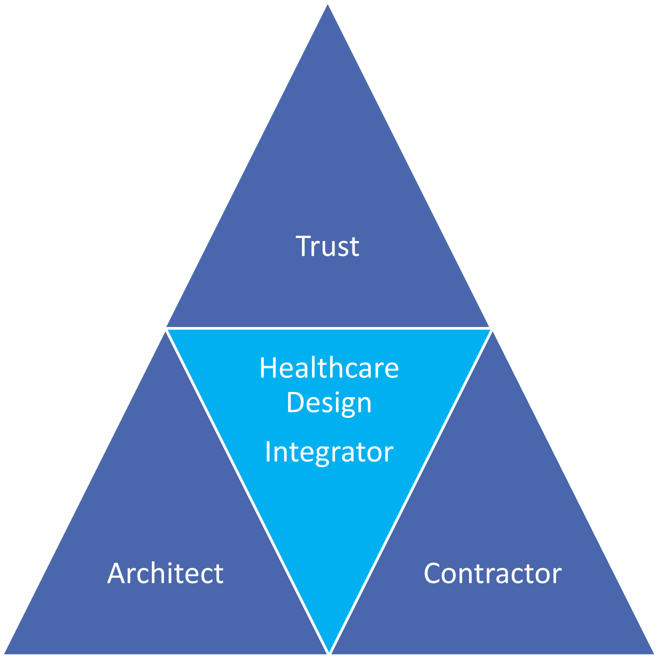


Figure 38 Healthcare Design Integrator

2. Create an integrated design management team which can deliver on time, cost and quality and ensure the design is fully integrated including a design cost manager.
3. Ensure that the project team with the relevant competencies and capabilities.
4. Set out an integrated design management plan for all phases that sets out roles and responsibilities, integrating the different levels of design integration and creating a fully integrated BIM model.

11.6 Personal Reflections

In Chapter 1 I included ‘my journey’ outlining my career and the adoption of an auto-ethnographic methodology which was mainly retrospective in terms of case study analysis following my project-based experience chronologically. A reflective theme concludes each chapter summarising how I felt before moving onto the next project. It seems fitting therefore to conclude this thesis with some final reflections.

It was difficult at first returning to academia, particularly regarding understanding philosophy (something which I had not done during my undergraduate and masters' degrees) I enjoyed the challenge. I also realised through carrying out the literature review that I had used theories relating to systems integration and design integration but had not been using that terminology. During my architectural studies I developed a strong sense of design integration, following the principles of Louis Khan and was fortunate to work on complex projects which included the integration of the structure and engineering services.

As I was drawing it to a conclusion the incidents in Chapter 9 started to take place which related to project outcomes and failures in the wider system. I also had the opportunity of working on Case Study 5 which provided quantitative evidence linking the project delivery system to the wider system. In the process of completing writing up this thesis yet again something has happened – Coronavirus. The significance of this to the findings of this thesis emphasises:

1. The need for the Department of Health to act as Systems Integrator to the Wider Delivery;
2. The need to bring control of infection into legislation and not leave it to individual trusts to decide; and,
3. The recognition of Open Buildings design philosophy and layering as a means of creating acuity adaptability in the face of changing healthcare requirements.

Finally, having completed this thesis I would like to continue with research into some of the issues raised as I still have a strong passion for promoting and implementing integrated design and project delivery as a means of delivering client requirements and expectations.

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Appendix A: Healthcare Studies

1. Nucleus Hospital Design

The Nucleus hospital system was developed in the 1970s in partnership with the NHS in response to the economic climate. The 1960s saw a period of expansion in hospital building due to the poor condition of the Healthcare Estate and the requirement to provide modern facilities. The Department of Health's Work Group was set up to act as a central co-ordinator, to undertake development and provide guidance and advice. There was also a trend towards standardisation. Standard designs and briefing material for hospital departments evolved and the Department produced the 'Best Buy' design for a standard whole hospital followed by the 'Harness' design for a hospital built up from standard departments.

The Fuel Crisis in 1973 alerted the government to the need for energy efficient design and this together with the subsequent economic crisis of 1974 gave rise to economies in both capital and revenue expenditure, resulting in the Public Accounts Committee (PAC) Directives to reduce both contract size and duration.

At the same time NHS Re-organisation in 1974 saw a decrease in NHS Planning Expertise and Government Policy was moving away from the provision of large-scale hospitals such as Greenwich in favour of small developments, giving rise to the creation of the 'District General Hospital (DGH)'.

The changes in the economic climate of the 1970s and other policy developments meant designs drawn up in the more affluent and expansive sixties could no longer be afforded and new ideas were needed to satisfy the remaining demand for hospital developments, the result was the development of nucleus which was a system that could be expanded as more money became available.

It was influenced by previous developments such as 'Best Buy' which advocated:

- Standard hospital design;
- Economic policy – costing policies; and
- Planning and Construction guidance.

And then 'Harness' which added the concept of 'standard departments' the contents of which were developed and produced in the form of 'Hospital Building Notes. It produced a systems approach and the concept of flexibility utilising a plan form which could be developed in phases.

Capricode was being developed in parallel to help cost projects and control the way in which capital projects were procured. It produced Departmental Cost Allowances, imposed project cost limits and introduced a system of cost control which could monitor and audit how projects were progressing.

The Department of Health and Social Security (DHSS) listed the benefits as follows:

Time: Briefing and planning time was reduced significantly due to elimination of the preparation of policies, schedules of accommodation, equipment schedules and design solutions and it took less time to brief design teams.

Expertise: Better use of scarce planning expertise was achieved through adoption of standard designs or modified designs already produced by others. Innovations in one project may be of value to other health authorities.

Financial: Fees for design consultancy were reduced (repetition) and there were savings in NHS staff costs arising from reduced workload in the project/design team. More predictable project capital cost control was achieved as designs have been produced to DCA (Departmental Cost Allowances) standards and revenue savings can be achieved. An example of this is the energy efficiency of the cruciform template and the possibility of direct application of guidance from the Low Energy Hospital Study. Building tenders also benefited from inherent buildability of the building form and reputation of Nucleus in the building industry

Flexibility: There was a fast response to fluctuations in the capital programme.

Quality: More time was available to designers for attention to detail than for designing one-off schemes. Evaluation of and experience from other similar schemes can reduce briefing, design and commissioning errors.

Bench Marking: Nucleus had become a target or standard with which to compare one-off projects it evaluated and compared of Nucleus against other designs and has been a source of data for producing guidance and standards for the NHS. It also provided a valid model hospital design for use in Low Energy Hospital Study (LEH), fire and means of escape, and other research projects

The 7 Principles of Nucleus

1 Future Proofing for Growth

The hospital was required to be designed to allow for growth, both phased and unforeseen – in the case where new technologies were introduced such as the provision of an MRI Scanner- This gave rise to the concept of a hospital street where new units could be plugged in as and when required.

2 Departmental Relationships

In order to improve efficiency and provide good patient care it was necessary to locate the hospital departments to ensure that good functional relationships were achieved and that compatible departments were clustered together. This led to horizontal developments.

3 Fire Strategy

The issue of fire safety in hospitals was becoming increasingly important. Building Regulations were becoming standardised in England and Wales and there was a move towards the removal of Crown Immunity for Public Buildings which meant that new hospitals had to comply with terms of the Building Regulations which included means of escape from fire. Compliance with travel distances, and the use of fire stairs although physically possible was not practical for in-patients or patients undergoing treatment or surgery – taking the patients down a flight of stairs was more likely to kill them than the effects of smoke!

This led to the concept of horizontal evacuation, where one ward could evacuate to the adjoining ward and helped develop the hospital street. It also set out the principle of avoiding the location of 'high life risk' departments such as theatres being situated above the boilers, or wards above the hospital kitchen.

4 Economical in Cost Terms

As the system was developing in an era of economic restraint, efficiency of building shape was fundamental and as such the area to perimeter ratio was very important – the cheapest building form being a cube. Two restraints were imposed

- Maximum of 3 storeys
- Limiting strip dimension of 15 metres to allow for the maximum use of natural light and ventilation

The proportion of the rooms were also related to the activity spaces in the HBNs, and by designing rectangular rooms of similar depths in the cruciform template lead to economical circulation percentages, net useable space was maximised.

There was also the segregation of clinical areas from low cost utility areas.

5 Flexibility – Grid Selection and Zoning

In order to cater for flexibility in terms of choice of content it was deemed necessary to have an overall master grid – based on the limiting strip dimension of 15 metres which could allow for the most economical solution for each building but would have overall compatibility - the template was stretched to a grid of 16.2 metres (15.9m face to face internally) and could accommodate three bays of 5.4m or two bays of 8.1m.

With the use of the hospital street main communication routes could be separated both horizontally and vertically from within department areas.

6 Engineering Philosophy

This was one of the most important basic principles which was outlined in great detail (Nucleus Designers' Handbook 1986 and Nucleus Building and Engineering System). Service zones are set out with an engineering philosophy compatible with overall aims of economy and flexibility using economic lengths of service runs and creating vertical services risers located on the hospital street which distribute main services from the plant room without penetrating individual departments. Plant rooms are located on the top floor and provision is limited to immediate and specific departmental needs e.g. Theatre Plant located above Theatres.

As a result of these first 6 basic principles developed the 'Nucleus Template' a cruciform shape of 1000 square metres based on a 16.2m master grid which could accommodate a whole department such as a 56 bed ward unit (2 x 28 beds) or a 4 operating theatre complex. It could also be subdivided to provide a cluster of smaller departments –although primary access could only be provided to two of these departments due to the nature of the template. Figure 39

The templates then 'plugged' into a hospital street 3 metres wide where stairs and lifts were also located.

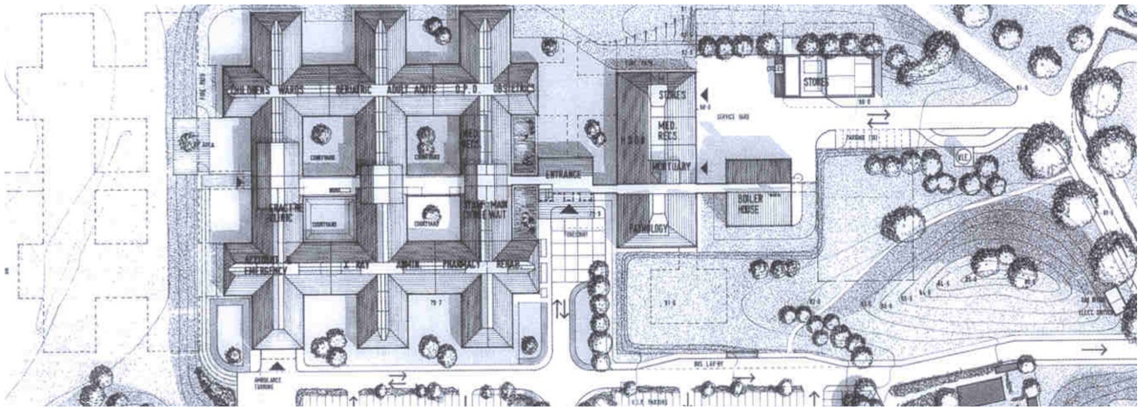

Figure 39 Layout of a Typical Nucleus Hospital

7 Aesthetic Considerations

The seventh basic principle was that the building form should be flexible enough to blend into, not dominate, its environment, it should be domestic in scale and have an overall geometry to give visual consistency to a wide range of functions.

It is this last principle which has caused the greatest architectural debate and sets it apart from the other six. The other principles can all be quantified in some manner or other and are more ‘objective’, design is and always will be subjective.

And whereas it might be desirable for each hospital to have the same facilities and layout, there is also the desire that every hospital is unique, it is serving its own community and requires to be identifiable with that community.

2. Post Occupancy Evaluation of a Children’s Medical Centre

2.1 Background information

The Trust is constructing a Children’s Medical Centre which is being completed in two phases. The first Phase 2A was completed in December 2011, and became fully operational by June 2012 and is the focus of this study, The Children’s Medical Centre is intended to support the Trust’s implementation of a new model of care for children’s specialist services by providing: 84 inpatient beds, 6 day-case beds, 10 haemodialysis stations; three theatres and one hybrid angiography suite; facilities for echocardiography, ECG and lung function testing.

The building also accommodates restaurant and kitchen facilities for the whole hospital. A new Combined Heat and Power plant has been installed which is planned to service the whole site in due course. Other facilities include a centralised staff changing area.

The building was procured using the design and build procurement route. This meant that the contractor took prime responsibility for both the design and construction of the buildings. The architect was originally employed directly by the Trust and then novated to the contractor. The Trust has retained responsibility for the performance and maintenance of the building during the operational life of the building.

The project was funded by a combination of charitable donations plus £75 million of exchequer money. The 2007 Full Business Case (FBC) stated that Phase 2A would cost £95,688k for approvals purposes. The forecast outturn cost including optimism bias (approximately 4.7%) but excluding VAT was £125,665k. The FBC went through the capital approvals process in order to secure exchequer funding the NHS and the Department of Health (DH) approved the FBC in 2007.

2.2 Methodology

The data collection was carried out over a period of four months. The trust was able to provide a large amount of project data resulting in the first stage being a desk top analysis for both the project governance and the building in use. A preliminary walk round the building led to an initial feel for how the building was performing, it identified areas which were either being under or over provided for and ones which had changed use. This enabled the team to propose areas where activity observation studies and room reviews should be carried out. Semi-structured interviews were carried out relating to project governance. The questions were taken from NHS documentation and assessed using a Likert scale. The building walk round and observation studies also gave the opportunity to talk to staff members and these informal non-attributable interviews provided a valuable insight into both the project governance and the building in-use.

2.3 Project Governance

A clear project structure was set out in the FBC. The Chief Executive was the Senior Responsible Officer (SRO) with a Project Director (PD) being accountable to the Trust Board. It was reported however that the SRO devolved some of his duties to the PD resulting in the PD sometimes chairing the board meetings to which he should have been reporting. Three people then had the title Project Manager (PM) responsible for clinical planning, estates and construction. The PM for construction was from an external project management company and the link between the Project Board (PB) chaired by the Project Director and the Design and Build Contractor.

The lack of one PM reporting back to the board became apparent following the building in use study but was not evidenced in the semi-structured interviews as the majority of the respondents (11 people were interviewed) scored the project management highly. In each case this was a score related to 'their' project manager. The question which received the highest number of 'can't say' related to overall stakeholder engagement and this accounted for 36% with no one either strongly agreeing or disagreeing. Within the 'three silos' project management, project leadership, stakeholders and risk all scored highly in the strongly agree and agree categories.

The report recommendations included having:

- Defined separate roles for the SRO and Project Director,
- One Project Manager
- Improved stakeholder engagement – include all stakeholder groups; clinical, estates, technical and financial
- Adopting robust change and risk management systems

2.4 Building in Use

The building in use studies looked at five areas:

1. Clinical Activity Observation Studies
2. Storage and Materials Management
3. Building in Use Changes
4. Catering – Restaurant and Kitchens
5. Equipment

2.4.1 Clinical Activity Observation Studies

This study looked at how the clinical support rooms (clean and dirty utilities) were being used both by staff working in the rooms and staff moving between patients and the support rooms. It found that the locations of the support rooms were good in relation to the patient rooms, but there were problems with both the clean and dirty utilities.

Introduction of Automatic Dispensing Cabinets (ADC) in the Clean Utilities, Figure 40 had changed the nurses' working practices and instead of taking a medicine trolley containing drugs for all of the patients to the rooms, each nurse has to collect drugs for each individual patient from the ADC administer to take to the patient and then return to the ADC for the next patient. The system is designed to reduce errors and wastage – it has proved successful in the operating theatre department, but the ward staff all expressed dislike of the system. The equipment was selected by an equipment specialist sub-contractor employed by the trust without full consultation from nursing staff which does not help the situation. It can be evidenced from the desk top study that it was not included on the room data/layout sheets at contract stage. It was also installed without regard for the pneumatic tube system (PTS) as the diameter of the tubes of the installed system can only be used for pathology and not pharmacy services. The room also contains a stainless-steel sink for washing trays in association with syringe trays for giving injections and taking blood samples which contravenes the principles of clean and dirty. Only a clinical wash hand basin for hand washing should be in this room.

Figure 40 Clean Utilities

The Dirty Utilities, Figure 41 were generally overcrowded with equipment and 'smelly'. One of the reasons for this is the use of standard Activity Data Base (ADB) sheets for equipment. The equipment supplied within the room relates mainly to adult patient requirements and not children. For large periods of time it is babies and infants who occupy the wards and therefore nappies are required. These cannot be destroyed in the macerators provided and hence are stored in disposal bins hence the smell. The ward Cleaners' Room is situated at the entrance to the ward – out with the security doors and consequently the Dirty Utilities are being used to store cleaning supplies. Cleaning is a Facilities Management function and should be separate from nurse working areas.

Figure 41 Dirty Utilities

2.4.2 Storage and Materials Management

This study covers all rooms designated as 'stores' and ones which have 'storage units' such as the clean and dirty utilities including fixed, moveable and mobile storage and did not include patients' rooms. There were no equipment layouts for the rooms, again after the contract had been let the equipment lists had been edited and all the moveable and mobile equipment transferred to the Trust's equipment supplier. Each ward/department had a number of stores varying in size and usage. In some areas the consumables were located in several different stores, making material's management extremely difficult. There was a lack of consistency regarding type of storage unit and generally rendering the storage system inefficient. Part of the study also included an analysis of the computer read outs from the Automatic Dispensing Cabinets.

On each ward one of the internal stores was being used as the Ward Sister's Office as at the design stage it had been decided due to a shortage of space that a dedicated Sister's Office could be deleted, and the Sister could work in the Open Plan Office Area. This proved to be unworkable and a separate space was required. The room chosen was in the ward core – good in terms of location, but poor in terms of environmental conditions – inadequate ventilation, no visual contact with the ward, and no natural or Category B lighting required for using computer. By contrast medical equipment was being ineffectively stored in a room with large windows to the outside, Figure 42

Figure 42 Storage Facilities

What this demonstrates is the need for a storage strategy and to provide layouts for stores and review them as a whole and not wait until the building is completed and fill them on an ad hoc basis. Many of the stores had room labels which did not match with their contents – signage being carried out by another team.

One common theme was the utilisation of a store as a Sister's Office as mentioned previously, but there are other examples of stores being used as offices, showers being used as stores and assisted bathrooms being used by parents. The latter being completely unsuitable as the room is crowded with equipment and contains an adjustable height bath for assisted use – extremely difficult to use as a bath or shower by able bodied adults. The use of assisted baths is extremely limited as the majority of patients are babies and young children and all the rooms have en-suite showers.

There are provisions for parents showering in the facilities at the ward entrance, but this is not close to their children. This again demonstrates the rigid adherence to ADB.

During construction the clinical users proposed changing the function of the Renal Ward, Figure 43 and Table 48 including outpatient dialysis facilities. Due to the change procedures in the contract, it was decided to be too costly to reconfigure the layout and instead a four Bed Room was turned into six Bed Dialysis Stations and four single rooms used as single dialysis stations. This led to unsatisfactory working arrangements as in order to reach the inpatient beds one had to pass through the Dialysis Unit. Given that the ward is designed with two corridors it would have been much easier to use one as the Dialysis Entrance and the other as the Ward Entrance. It would also have provided better use of the en-suite showers as dedicated facilities are not required for outpatient dialysis.

Figure 43 Ward Layout

Table 54 Room Changes

Table 1: Room changes			
Room number	**Designed room use**	**Current room use**	**Comments**
N7146	Quiet room	Sensory room	Check environmental conditions
N7118	Store	Office	Changes to Mechanical and Electrical Services need to be carried out to reflect new room occupancy
N7144	Play room	Adolescent recreation room	Acceptable -similar function
N7148	Adolescent recreation room	Play room	Acceptable -similar function
N7138	Breast feeding room	Not used	Opportunity
N7134	Linen store	Buggy store	Acceptable -similar function

2.4.3 Catering – Restaurant and Kitchens

The kitchens are located at Level 0 and serve both the restaurant and cafeteria at Level 2 together with the inpatient wards on Levels 1,4,5,6 and 7. The reason for looking at this department is that since the design was completed the Trust's requirements have changed. The kitchens were designed as full preparation and cooking facilities, but in a link up with another hospital and off-site food preparation, it has meant that some of these facilities are not being used. There is a full butcher's preparation area but this has never been used as all meat is pre-prepared supplied to order.

There are also problems with transferring food from the kitchens to the restaurant serveries. Two 'dumb waiters' were installed, but these are considered useless as the main requirement is for a lift which can transport heavy items such as bottled drinks. The result is that kitchen porters have to use the main lifts instead and wheel them through the public areas of the restaurant to reach the serveries. Also, at any one time, one of the dumb waiters is out of action.

Stockroom sizes have not been accurately calculated and automated supply systems are causing problems with over ordering as the standard unit for some items is 100 and perhaps only 80 is required resulting in poor stock control. There are problems with refrigerated products cold rooms and freezers where fans kick in to automatic defrost and food perishes.

The issue is compounded by the fact that compressors are in the ceiling void and cannot be accessed easily in what is a very busy working area.

There are also problems with restaurant – the use of hard finishes makes this area very noisy. The serveries are badly laid out, with some retrofitting resulting in awkward access for the staff moving between tills.

<u>*2.4.4 Equipment*</u>

The Trust has used the standard NHS-ADB method of classifying equipment. Group 1 with the contractor supplying and fitting, Group 2 the Trust supplying and the contractor fitting and Group 3 the Trust supplying and placing in position large items of equipment.

The photographs in Figure 44 show typical examples of Group 1,2,3 and 4 equipment. With the advent of more mobile storage systems the traditional ADB categories no longer reflect who supplies and installs together with the decision to remove the equipment from the architects' ADB database on contract award the result is that many former Group 1 items, which were fixed have been replaced by mobile or moveable units.

Group 1 Group 2 Group 3 Group 4

Figure 44 Equipment Groups

The evidence of this can be seen in rooms where redundant power and data outlets occur. The electrical systems having been set out to reflect fixed cabinetry. Wall mounted urine test cabinets have been provided in the dirty utilities just because they were listed on ADB sheets – these remain un-used as they have been replaced by electronic testing kit which sits on a worktop. One of the other problems with ADB is its inability to cope with new technologies in medical equipment means that it can no longer categorised as Group 3. Transferring it to Group 1 does not solve the problem as it needs both the input from designers/ constructors and medical staff. The example below Figure 45 of the Hybrid- Angiography Theatre where radiodiagnostic equipment is installed in an operating theatre.

Figure 45 Hybrid Operating Room

Unfortunately, in this instance due to the physical requirements for this type of theatre which is used for cardiac surgery, it cannot be used for other types of surgery. As the theatre did not have sufficient theatre usage, the Trust decided to transfer the equipment to the radiology department to allow it to be used for conventional surgery. The decision was made more difficult due to the equipment having been funded by the Trust's charity.

3. Medical Infrastructure and Major Medical Equipment

3.1 Medical Gas Pendants

Table 55 Stakeholder Involvement with Medical Gas Pendants

Case Study 1		Case Studies 2,3 and 4	
1. Flexible Gas Pendant	**2. Rigid Gas Pendant**	**3. Articulated Single Arm Pendant**	**4. Articulated Twin Arm Pendants**
			
1980s	1990s	2000s	2010s
Stakeholders	**Stakeholders**	**Stakeholders**	**Stakeholders**
Anaesthetist Architect Mechanical Services Engineer	Anaesthetist Surgeon Architect Mechanical Services Engineer Electrical Services Engineer	Medical and Nursing Staff Trust Equipment Manager Architect Mechanical Services Engineer Electrical Services Engineer Structural Engineer Main Contractor Mechanical Sub- contractor Pendant Manufacturer	Medical and Nursing Staff Trust Equipment Manager Medical Physics Estates Department Architect Mechanical Services Engineer Electrical Services Engineer Structural Engineer Main Contractor Mechanical Sub- contractor Pendant Manufacturer Examination Lamp Manufacturer

Table 55 above shows how a simple gas pendant has changed over 30 years and its specification is no longer the responsibility of one individual – the flexible pendant only had one model produced by one manufacturer. The flexible and rigid gas pendants are defined as Group 1 items of equipment- to be supplied and fixed by the contractor – cost included within the contract sum. The articulated pendants are also technically Group1 equipment items, but they now include small Group 3 items (Trust supply) which need to be attached to the pendants before they are installed. The cost of these items which is included within the Trust's budget has to be transferred to the contract sum – ideally at financial close which makes it important that all stakeholders are involved in the specification.

The stakeholders and the project stages of their involvement are listed in Table 56 relative to each of the pendants and reflects the additional components being added:

Table 56 Stages of Stakeholder Engagement

Item	**Description**	**Stages of Stakeholder Involvement**		
		Group	**Stakeholder**	**Stage**
Pendant 1.	**Flexible gas pendant** Supplies medical gases only in operating theatres – anaesthetist required to check the position of the pendant **Group 1 Supply – Contractor**	Design Team	Architect	Design Procurement Construction
			Mech. Engineer	Design Procurement Construction
		Trust Clinician	Anaesthetist	Design
Pendant 2.	**Rigid gas pendant** Supplies medical gases and electrical sockets – surgeon now involved along with an electrical engineer	Design Team	Architect	Design Procurement Construction
			Mech. Engineer	Design Procurement Construction
	Group 1 Supply- Contractor		Elect. Engineer	Design Procurement Construction
		Trust Clinicians	Anaesthetist	Design
			Surgeon	Design
Pendants 3 and 4.	Articulated single and twin arm pendants Supplies medical gases, electrical and data outlets, examination lamps and medical attachments – drip stands, infusion pumps, anaesthetic machines	Design Team	Architect	Design Procurement Construction
			Mech. Engineer	Design Procurement Construction
			Elect. Engineer	Design Procurement Construction
			Struct. Engineer	Design
		Contractor	Construction* * PFI	Design Procurement Construction
			Procurement	Procurement
			Manufacturer	Design

Combination of Group 1 (Contractor) and Group 3 (Trust) Supply			Procurement
			Construction
		Installer	Construction
	Trust Project Team	Project Manager	Design
			Procurement
			Construction
		Equipment Specialist	Design
			Procurement
	Trust Clinicians	Clinicians	Procurement
		Anaesthetist	Procurement
		Nursing Staff	Procurement
	Trust Estates	Estates	Procurement
		Medical Physics	Design
			Construction

What this table demonstrates is that as equipment becomes more sophisticated the number of direct stakeholders increase. In the case of Pendant 1 there are 3, in Pendant 2 it becomes 5 and by Pendant 4 there are 15 involved. The table also demonstrates that not all of the stakeholders are involved in all of the stages and as such there is no requirement to involve all of them at every stage, but it does demonstrate the need to integrate them and to maintain communication throughout the project. One of the most influencing factors which affects the requirements crunch point is procurement – who procures. In one PFI project the Trust decided to procure the pendants but did not share the specification early enough in the project, resulting in steelwork having to be altered in order to fix them. Conversely if the pendants are procured by the contractor, the exact specification has to be agreed at the RCP or the pendant chosen by the contractor may not satisfy the client's requirements.

3.2 Pharmaceuticals Management

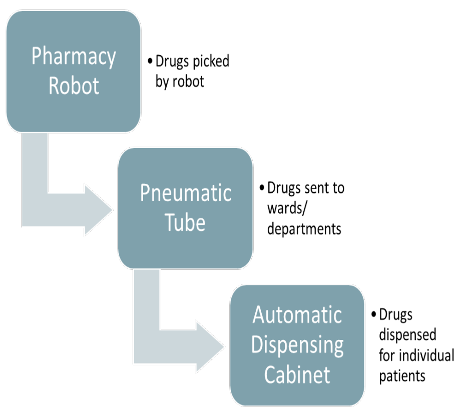

Figure 46 demonstrates the need to integrate different aspects of technology

Potential Stakeholders;

- Pharmacy staff
- *Pathology staff*
- Medical staff
- Nursing staff
- Estates staff
- Trust Management
- Trust Procurement
- Designers
- Installers
- Contractors

Figure 46 Stakeholder Engagement and Pharmaceuticals Management

This case study demonstrates the need for involving a wide range of stakeholders in the selection of equipment and that the equipment itself is interdependent on other technologies to maximise its potential. Excess spending on pharmaceuticals is a major problem worldwide and therefore there is a need to make use of new technologies. In this case the use of ADCs is only one part of the solution. There are already robots being used in pharmacies and pneumatic tubes distributing throughout hospitals which can then be linked to the ADCs. Figure 46 shows the three main elements in an integrated pharmacy distribution system. The pharmacy robot is situated within the main hospital pharmacy store. The robot picks the drugs requested by computer and the drugs can be distributed to point of need within the hospital department to be either given straight to a patient (pill-pick) or stored within an automatic dispensing cabinet which is also computer accessed.

To be cost effective the pneumatic tube system also has to transport samples from wards, clinics and treatment areas to pathology and as such decisions regarding system selection has to include pathology staff as well as pharmacy staff.

3.3 Automated Dispensing Cabinets

This case study demonstrates the combined effect of both built infrastructure and technology systems. It is an example of a combination of socio and technological stakeholders. It demonstrates how decisions made on equipment specification affect the working practices of the users.as in Table 57.

Table 57 Issues with Automatic Dispensing Cabinets

Provision of Automatic Dispensing Cabinets (ADCs) Stage: Construction and Client Fit-out	
Issues	Used for the dispensing of medicines and controlled drugs Introduced into the scheme after the contract had been let (Design & Build) Located in Clean Utilities – previously proposed in a storeroom External Equipment Procurer employed No consultation with medical and nursing staff
Requirements crunch point issues	Equipment was removed from the contract
Outcomes	Disliked by staff – changes to working practices Client dissatisfaction

Figure 47 Clean Utility with Automated Dispensing Cabinet

The first two photographs in Figure 47 above show an ADC in a Clean Utility, the left hand section of the cabinet contains various medicines. The right hand section contains the computer key pad which gives access to the cabinet and below this section are the drawers which contain controlled drugs. The problem for the staff is that only one person can access the unit at a time and only for one patient. The third photograph shows the laptop computers which are wheeled to the patient to administer the drugs. This means that for a ward of 24 patients nurses have to make 24 individual journeys to the Clean Utility unlike previously when the drugs trolley for all the patients was prepared and wheeled around the ward.

This system has been in use for many years but not in the UK and has proved to be very successful in terms of material management and cost savings – cuts down theft and wastage of drugs(use by dates) due to its accountability – every transaction is recorded on the computer and print outs can be obtained locally. The same system is being used in the Theatre Department at the hospital and is proofing extremely successful – possibly due to a different pattern of usage.

The problem with the ward system is that the nursing and medical staff were not involved in the discussions for its implementation. There are additional trolleys which can be purchased which would enable staff to carry out a 'drugs' ward round but these have not been investigated. In addition the pneumatic tube system which has been installed only caters for laboratory use due to its diameter and is also located out with the Clean Utilities.

3.4 Hybrid Operating Rooms

This case study demonstrates the poor stakeholder engagement and the effect of pressure groups on the decision making. It involved a very expensive item of equipment, Table 58 which had been paid for by charitable donations but the impact of installing the machine in its desired location (within an area where space was at a premium) produced pressure from other stakeholders resulting in the machine's relocation to another department. Better integration of stakeholders would have avoided considerable additional expenditure and disruption to a newly commissioned unit.

Table 58 Issues with Hybrid Operating Rooms

Hybrid Angio Theatre. Stage: Scheme design issues
• Angiography machine (Fixed 'C' arm) procured by charity donations • Theatre usage was not calculated • Assumption that the theatre could be used for other types of surgery if spare capacity
Outcomes
• Cardiac procedures only occupied one day per week • Theatre not suitable for general surgery due to the floor construction for the x-ray machine • X-ray machine was being relocated to the Imaging Department • Theatre was being reconfigured as a standard theatre

This example looks at the installation of an angiography machine in an operating theatre – the creation of a 'hybrid angio theatre 'which is used for heart surgery – Figure 48 Theatre designed as part of a Catheter Suite within an operating department consisting of cardiac and neurosurgery theatres

Operating table and angiography x-ray machine co-located in an operating theatre

View from the theatre looking into the x-ray control room

Figure 48 Hybrid Operating Theatres

As part of a literature review study into operating theatres (rooms) it was found within the last 10 years fixed radiology equipment has been introduced into operating rooms. The use of this type of installation can now be used for different types of surgery and the resulting benefits both in terms of patient outcomes and for the interdisciplinary working between surgeons and radiologists. There are three types as in Figure 49:

- Fixed ‘C’ Arm Angiography machines
- CT Scanners
- MRI Scanners

A. Radiology Room awaiting equipment installation

B.Standard Operating Room

C. Mobile ‘C’ Arm parked in a theatre corridor

D.Hybrid Operating Room with a Fixed ‘C’Arm

Figure 49 Integration of Radiology Equipment

The most common hybrid arrangement involves a fixed C arm. The images above demonstrate the technical problems faced trying to integrate a fixed C arm into an operating room.

Image A: at this stage the room is ready to receive the machine, pre-installation electrical supplies have been installed – galvanised steel cabinets on the wall and a steel trunking inserted in the floor.

Image B: standard operating room with ceiling mounted pendants, operating table and mobile equipment.

Image C: Mobile C Arm for use in a standard theatre

Image D: hybrid theatre with a fixed C arm

The photographs in Figure 49 highlight three major differences between a radiology room and an operating room summarised in Table 58:

Table 59 Infection Control issues highlighted by the differences in requirements between an Imaging Rooom and an Operating Room

Issue	**Room**	**Acceptable**	**Not Acceptable**
Surface mounted electrical trunking	Radiology	X	
	Operating Room		X
Floor channels	Radiology	X	
	Operating Room		X
Tiled Grid Ceiling	Radiology	X	
	Operating Room		X

The issue with all three items relates to infection control and the difference in procedures. the non-invasive radiology causes less of an infection risk than the invasive surgical procedures which run a risk of surgical site infections. Microbiologists advocate the use of smooth, seamless wall, ceiling and floor finishes which can be easily cleaned in operating rooms, something which is difficult to achieve in a radiology room.

Appendix B: Examples of Documentary Evidence Relating to Case Studies

1 Background Information

I have retained a number of documents from various projects over the years as my own personal “lessons learnt” for use on future projects. Some are diary notes, workbooks, other are schedules, draft proformas and prototypes. I also have a large collection of photographs and electronic records tracking the development of various templates. The following sections outline some of areas which I have used in relation to collecting data referred to in the case study ramblings.

<table>
<tr>
<td></td>
<td>Typical storage unit (1 of 8)
containing examples of:

Case study data
Project diaries
Project workbooks
File comparing room data sheets and equipment databases such as ADB with those used in different case studies
MARU file relating to briefing and post occupancy studies

</td>
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</table>

Figure 50 Typical Examples of File Storage

Figure 50 indicates examples of type of data stored in hard copy and Figure 51 shows examples of typical note taking.

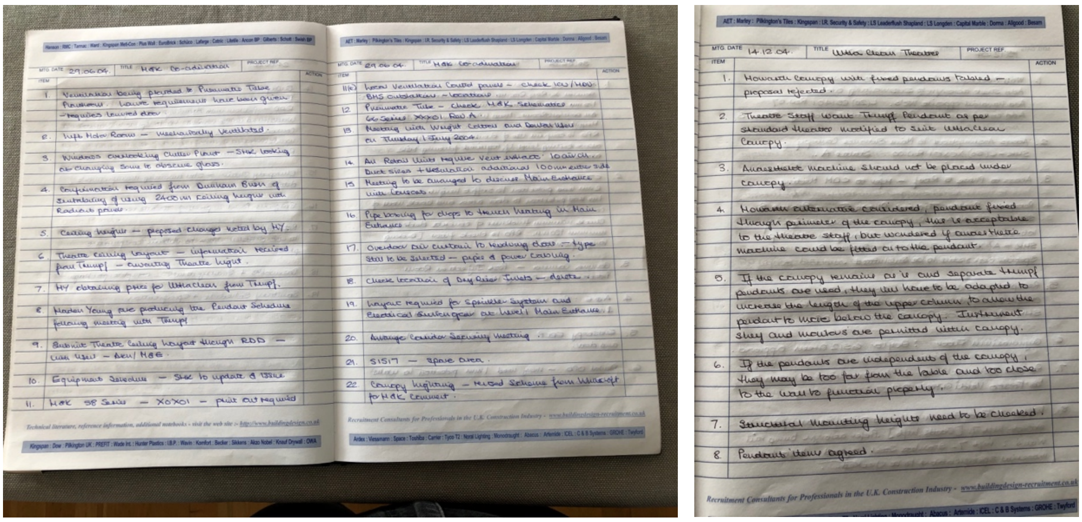


Figure 51 Typical Note Taking

2 Schedules of Accommodation

One of the important aspects in developing zoning is the methodology of setting out the Schedule of Accommodation. In Figure 52 below, the first image shows what the architects described as a schedule of accommodation, but this is purely an excel spreadsheet collated from the room areas taken from the Revit model. It shows what has been provided but not what is required. the departments are in alphabetical order and checking rooms against drawings takes considerable time and effort. The second image shows the schedule set out required departments grouped into functional units; inpatient accommodation, outpatient accommodation, treatment and diagnostic, clinical and non-clinical support. The bottom schedule shows a typical department which then also subdivided into patient areas, clinical support areas etc. Setting out the schedule in this manner enables a check to be made between what is required and what is being provided. This was the process used on Case Studies 3 and 4 to ensure compliance and in Case Study 5 to check due diligence.

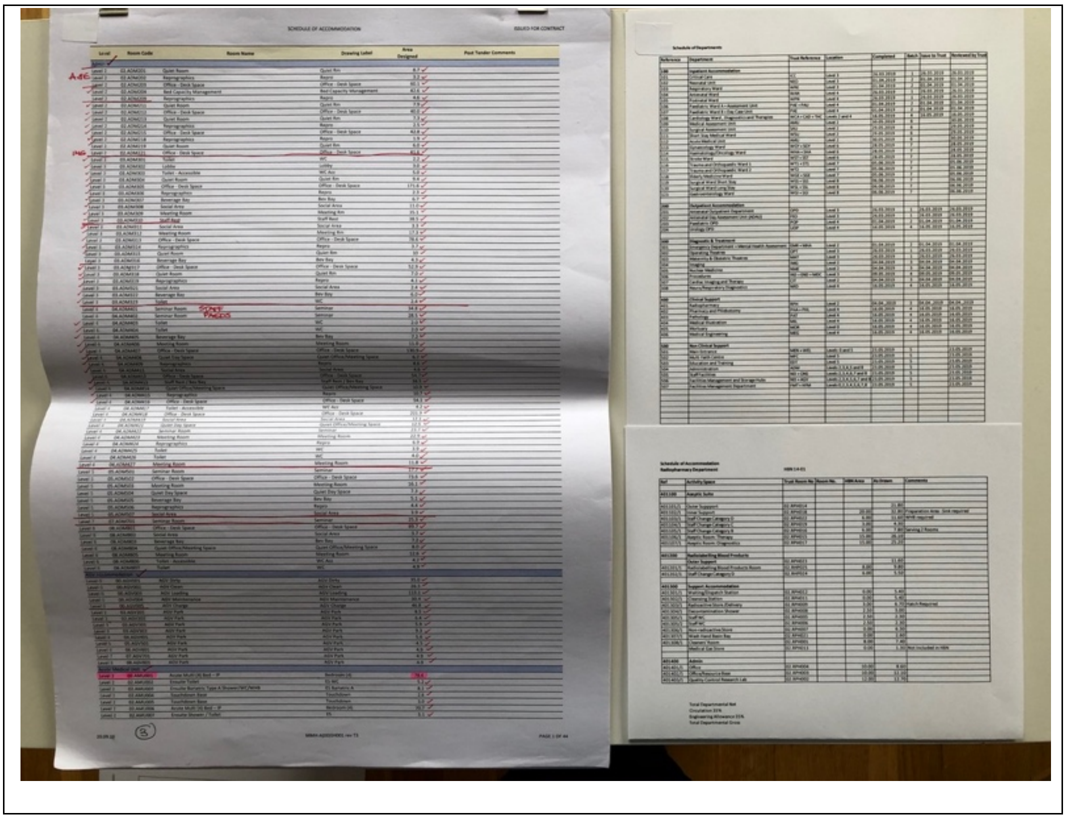
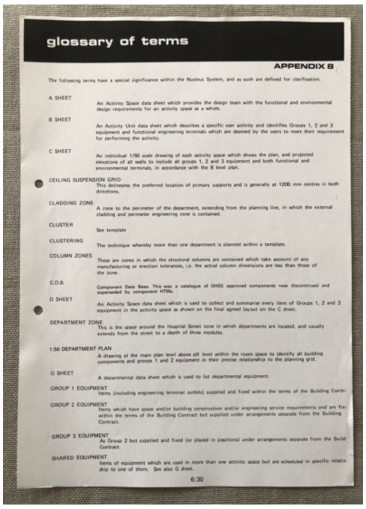


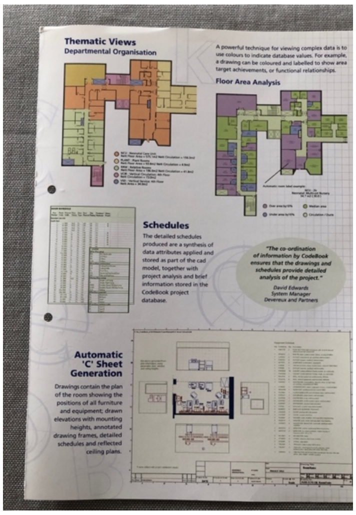
Figure 52 Schedules of Accommodation

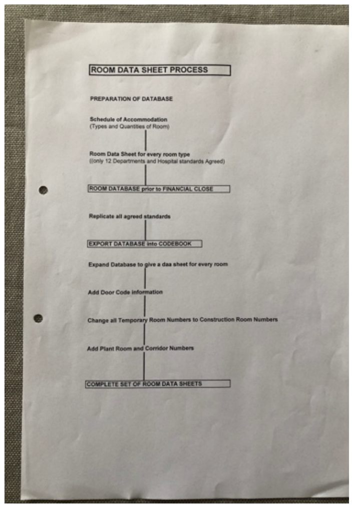
3 Databases and Room Data Sheets

The original Nucleus Data Pack described room requirements in terms of different ‘sheets’; one to indicate room activities, one to cover environmental requirements, one for equipment lists and one to show the room layout and wall elevations at a scale of 1:50. This latter sheet the ‘C’ continued to exist and the other developed into a Room Data Sheet (RDS).

The following illustrations in Figure 53 indicate the nucleus glossary of terms, a typical 'C' sheet which can be generated from Codebook and the process required to prepare a room sheet database. Codebook can utilise different databases although originally set up to accommodate ADB. It also provides a checking process to ensure that the items on the ADB equipment lists are included on the 'C' Sheet.





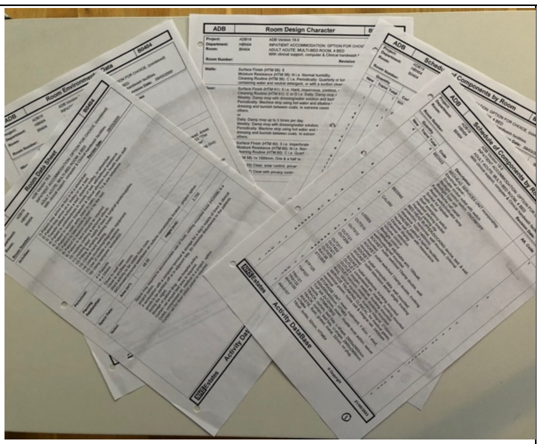


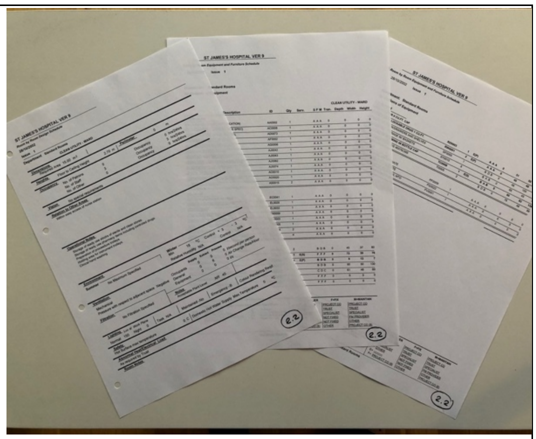
Nucleus | Code Book | Room Data Sheet Process

Figure 53 Nucleus definitions, Codebook outputs and The RDS Process

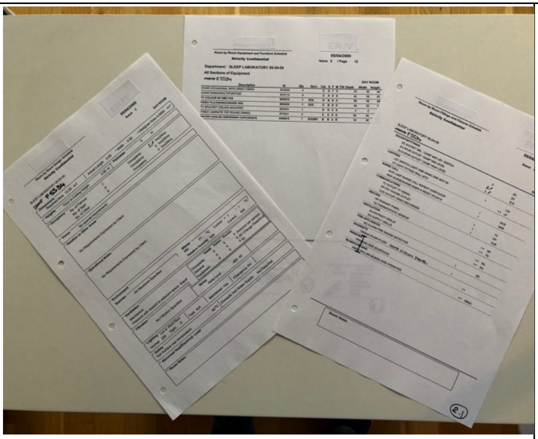
Figure 54 Compares three different room data sheets:

- The typical ADB sheet which utilises 4-5 A4 sheets
- The Hiltron data sheet which consists of three sheets – the middle equipment sheet causing issues in Case Study 2
- The data sheet designed for Case Study 3 and developed further in Case Study 4 which consists of a single A3 sheet which can be combined with a single A3 'C' sheet and proved much more user friendly for both stakeholder involvement and use on site

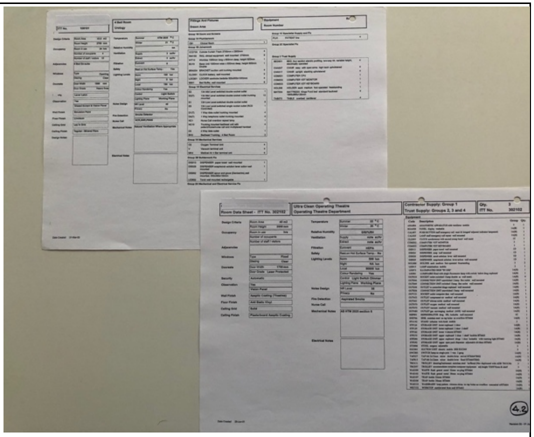




Typical ADB Room Data Sheet | Typical Hiltron Room Data Sheet



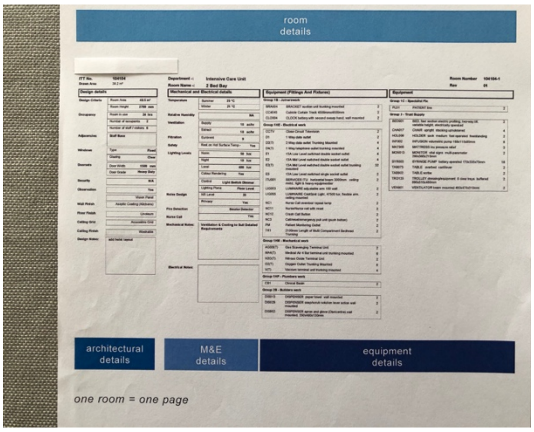
Case Study 2 Room Data Sheet

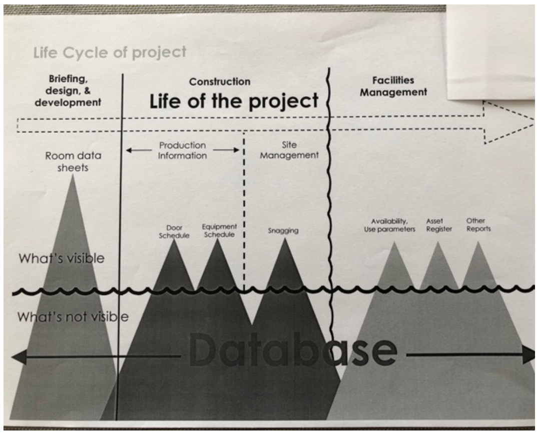


Case Study 3 Room Data Sheet

Figure 54 Comparison of Room Data Sheets

Figure 55 shows the development of single A3 data sheet and the importance of maintain a database throughout the project cycle.





Case Studies 3 and 4 Single Sheet Room Data Sheet

Figure 55 Development of A3 Room Data Sheet

4 Equipment Codes

Equipment codes are a fundamental element linking the room data sheets and the room layout sheets. The codes set out in ADB relate to four groups:

- Group 1 Equipment supplied and fitted by the contractor
- Group 2 Equipment supplied by the client and fitted by the contractor
- Group 3 Large items supplied and placed in position by the client
- Group 4 Small items supplied and placed in position by the client

With the inclusion of FM in the PFI contracts many Trusts reorganised the groups into different categories as illustrated in Figure 56. In Case Studies 3 and 4 the ADB codes for the contractor’s supplied equipment was translated into a more user-friendly format (based upon the original CDB documentation. The codes could also be related to the NBS Specifications. This allowed for codes to be created to represent assemblies rather than individual components particularly useful in relation to sanitary fittings and medical gas pendants. Examples of the ADB lists marked up to show outdated components being deleted and descriptions of new codes are also illustrated in Figure 56.

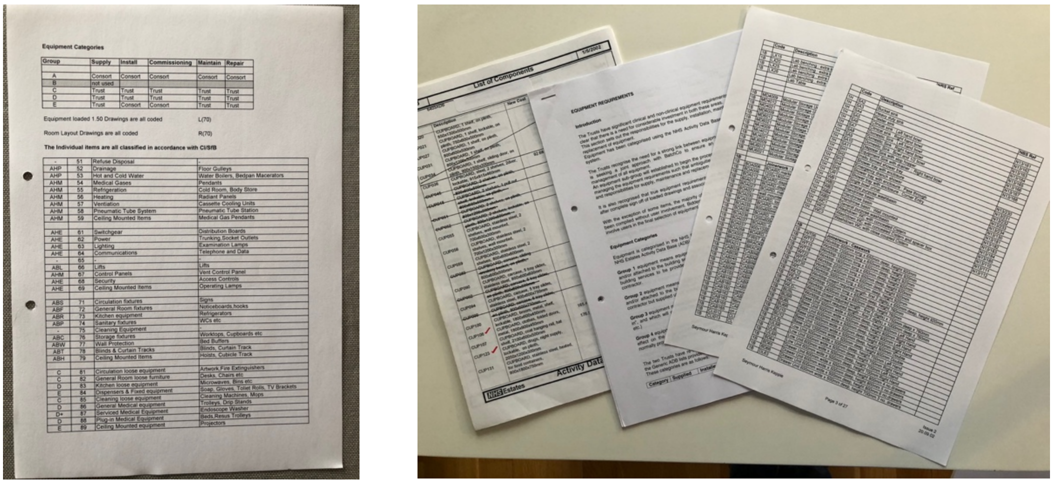
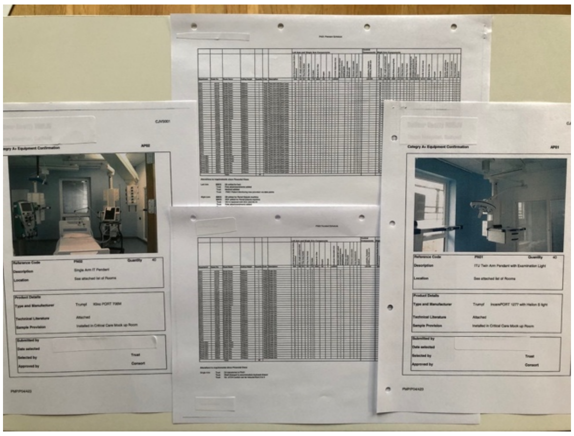


Figure 56 Equipment Schedules

Part of the process involves obtaining client approval as part of the Reviewable Design Process and Figure 57 below shows documentation relating to this process in relation to the procurement of medical gas pendants where there is input from both the client and the contractor,



Pendant Schedules showing both Group 1 and Group 3 items are illustrated – this avoids pendants being fitted, disassembled following client occupation in order to add the client components.

It also indicates a proforma submitted for approval by the contractor detailing the product for sign off by the client

Figure 57 Reviewable Design Data Approval

5 Work Package Information

The development of the works packages and in particular the achievement of producing integrated ceiling layouts incorporating both the mechanical and electrical components with the architectural ceiling grid layouts is set out in Figure 58. The photograph on the left shows the Work Package Scope Sheet, the NBS ceiling specification and a marked up copy of the HTM relating to ceilings highlighting out of date information with which the contractor does not intend to comply. This information is included as part of the contract derogations and in this case is a result of the Department of Health failing to update guidance to reflect industry practice. The photo on the right indicates the 1:50 reflected ceiling layouts from Case Study 4 where full integration was achieved and all the subcontractors worked to the consulting engineers' drawings. The photo also includes the compliance schedule which was signed off prior to handover.

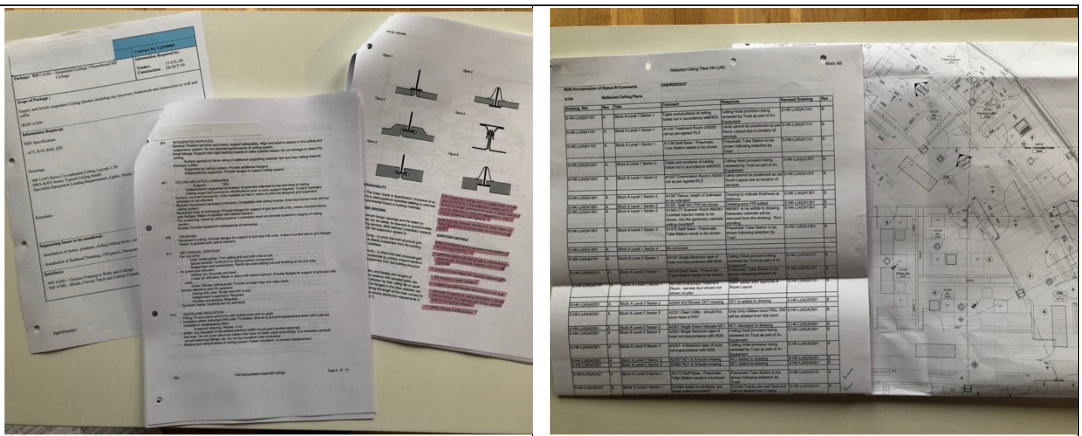


Figure 58 Work Package Information

Appendix C: Case Study Narrative

1 Case Study One

My involvement with this project started around 1980 when the redevelopment plan was first awarded to the architectural practice in which I was working. The practice was chosen by the Scottish Health Service, Common Services Agency, Building Division as a result of its healthcare expertise and previous involvement with the CSA and the hospital.

We were appointed as Architects and Project Leader, with structural engineer, mechanical and electrical services engineers and quantity surveyor with the local health board as client, the CSA acting as advisers to the client and the building contract being procured traditional JCT 80 Local Authorities Edition with Quantities.

The timing of this project proved interesting as it was the last major district general to be procured traditionally. The next project was design and build. It took place at a time in England where nucleus design was in use, healthcare design guidance in the form of UK (Department of Health) HBNs had been created in the "Scottish versions" to reflect departmental requirements without the use of nucleus templates which had not adopted in Scotland. Also unlike nucleus as architects we had to prepare room layout sheets for discussion with the users and began the process of understanding how they worked and what their requirements were. The meetings were attended by all members of the design team, the health board project director, clinicians, medical and nursing advisors from the CSA and the building and engineering advisors from the CSA to ensure that the users requirements and the proposed designs were in accordance with current HBN and HTM guidance.

The experience gained through this process was a valuable learning curve and advantageous as when the first PFI design and build projects were proposed, Scottish architectural practices were able to compete with the American architects who were starting to get work in the UK due to the fact that English architects had 'lost' the healthcare understanding caused by many years of reproducing layouts without the need for discussing them with users.

Traditional procurement also lost favour at this time, architects were seen as unable to control cost and time - skills which were perceived to be provided by the major building contractors. Ironically on this project the Scottish Health Service had introduced a strict Cost Control Procedure where each month the quantity surveyor prepared a report outlining all the changes due to the issue of Architect's Instructions, discharging if provisional sums and was signed off by the Architect. A meeting was then held with all members of the design, the health board and the CSA advisors to discuss and approve the report.

The project had to go through several approval stages:

- Pre-design Cost Limit – in theory no design required, based om departmental cost allowances
- Preliminary Cost Limit (PCL) – based on 1:200 layouts, elevations etc
- Final Cost Limit (FCL) – based on 1: room layouts, detailed design
- Pre-Tender Estimate – based on an outline Bill of Quantities

Delays in stage approvals meant that the it took until December 1987 to get approval to issue the tender documentation. The tender period was three months and with a 90 day tender acceptance period the contract was not awarded until June 1988 as a result of savings having to be made to the tender. One of the major problems was the diverting of major utility services – main power and water services serving the city trans versed the site. The Scottish Health Service decided to pay for the water diversion as enabling works and as a separate contract to a different contractor which complicated site works due to the enabling works not being completed before the new building started. The result was that the building contractor decided to change the sequence of site activities. The building was built over five levels – with four levels having ground level access.

Although the contractors were one of Britain's largest building companies, they had little hospital building experience in Scotland and their project manager and general foreman were both new to the company. The project manager came from a mineral mining and tunnelling background. The result was disastrous – heavy rain in August led to the newly cut topsoil being washed through several adjoining houses. By November 1988 the site was in a terrible state – it was being described as 'Passchendaele'. The project manager was having problems with constructing the reinforced concrete frame, columns were being out of tolerance, the retaining wall was 80mm of tolerance. The resident structural engineer was issuing site instructions to me to issue architect's instructions 'to remove from the permanent works'. The project manager pleaded that as some columns were only a 'few' millimetres out tolerance that as supervising officer I such not issue these instructions. I explained that I would be issuing the instructions as it work was incorrect and that if would be professionally suicidal to ignore the structural engineer's advice when it could easily be proved that he was correct. The project manager blamed all these problems on his site engineers who were hired and fired on a regular basis. Morale on site was terrible. By

February 1989 the regional director requested a meeting to inform myself and the design team that the project manager and general foreman had been sacked and that a new team would be taking over.

In May 1989 the site looked completely different – now being described as 'Beirut' dry and sunny with columns lying on their side in the process of being removed. The new project manager – an experienced builder, quietly set about putting the structure to rights and ensuring that the planning engineer was accurately recording events. In the interim period the returns to head office showed that more concrete was being taken from the site and to the site and falsework was being ordered to the original programme at great expense to the site. With the new team on board, relationships improved and we set up a regular 'lunch' meeting between the project manager, commercial manager, senior site agent, my two senior partners and myself. This proved to be very successful.

Once the frame was well under way and the brickwork had started the office decided that we would need a resident architect. We had employed an architect who lived in Dundee and it was thought that he would work from site – the only problem being that he had no hospital experience and was more interested in trying to use the site office as a base for winning work! This time the contractor complained and the result was that I moved to the site office for three days a week until then it had been a weekly visit as the senior partner did not see the need for my site presence! By comparison two other similar sized projects in the Borders and in the West of Scotland had senior architects based on site throughout the construction period. I worked for an Edinburgh based practice – one hour from the site, the architects for the Borders (also from Edinburgh) set up an office there (saw it as an opportunity to get work in the borders) and the Glasgow based firm who designed Ayr specified a complete suite of rooms on site as part of the site set up within the contract documents prelims!

Until this project, I had worked mainly on medium sized hospital projects (our previous major hospital had been cancelled just before the tenders were to be issued – financially advantageous! 75% of the fees, but as in most cases not all of the construction drawings had been completed), which only required a weekly site visit and a monthly site meeting. Working on site with drawings still to be produced proved a very different experience, especially when instead of dealing with a site agent and a visiting contracts manager there was a project manager and several site agents all requesting information.

The contract drawings were prepared at a time when computerised drafting was just coming into use. The drawings were all manually produced and there was some use of overlay drafting techniques such involving a base drawing and copy negatives used by the structural and services engineers. It was also a time when the RIBA introduced Co-ordinated Project Information (CPI) where the National Building Specification (NBS) was used to annotate drawings. Computers were used to schedules in A4 format. The room layout sheets were produced in A2 format to allow for the wall elevation and key to components to be laid out on one sheet. The written information could also be added by use of a 'long-carriage' typewriter. Drawings were all referenced using CI/SfB (Construction Indexing Manual) codes

The production of drawn information proved to be contentious in many ways:

1. The General Arrangement Drawings

   The main 'workhorse' drawings at 1:50 scale on A0 sheets: the senior partner wanted all the information to be provided on one set. I disagreed as they would be too cluttered and could not see the logic in giving plumbers details of fitments when all they wanted was the positions of 'pop up' drainage outlets through slabs. I was basically following the principle used by the services engineers by having different levels of drawings for different trades. The end result was that the following sets of drawings were produced.

   1. Brickwork and drainage: dimensioned drawings showing all drainage dimensioned from the structural grid and dimensioned external blockwork.
   2. Internal partitions showing all dimensions of partitions from the face of the internal skin (not grid) as this could be measured easily. The setting out of all door sets, coded to reflect the door schedule.
   3. Fitment layout- all fixed cabinets and sanitary fittings coded and dimensioned

2. The Room Layout Sheets

   The client had issued the room data sheets- by department and one for each room type. The sheets were prepared by the CSA and unfortunately somebody had 'tippexed' out Borders Health Board and replaced it with our Health Board as a result at initial room layout meetings users complained that the requirements were incorrect. The process should have been that the standard room data sheets based on HBNs and HTMs should have been reviewed at meetings with the Health Board, users and the CSA to agree requirements before issue to the design team. After the first review of the room layout drawings, amendments were made and layouts reissued for subsequent user group meetings. The final approval of the room layouts was made by the Health Board and any items which were deemed additional to the building cost were removed.

The room layouts were described as ‘Room Information Sheets’ and this proved to be very confrontational as they were not included in the contract drawings. The fixed equipment was all detailed on the 1:50 drawings. They were issued to the contractor for information and when the electrical services subcontractor (nominated under JCT80) started their installation they demanded issue of dimensioned room layout sheets. None of the electrical services drawings contained dimensions and they stated that normally they were issued dimensioned room layouts by the architect. This was supported by the consultant services engineers as ‘normal practice’. I stated that as the room information sheets only represented typical room type layouts that dimensions should be on the electrical 1:50s and should be approximate as the exact positions of the metal studs could not be pre-dimensioned. At this stage in the process dimensioning all the drawings would have taken a considerable length of time and the cost had not been included in our appointment. In discussion with the senior partners, who were asked to attend a meeting with the CSA and the consulting engineers I said that we should not dimension the drawings for the above reasons and also the fact that the consulting engineers were paid a fee for ‘services coordination’. They were afraid that we would have to dimension the drawings as the services engineers appeared to have the backing of the CSA. At the meeting the CSA produced a copy of the consulting engineers’ appointment (which we had not seen) confirming that the coordination fee was for ‘coordinating more than two services’ this meant that it did not apply to room layouts and it was for the architect to check that the electrical socket was not positioned behind the radiator! Coordination was for the schematics of the main services through the building – not drainage as this was a building function for the nominated subcontractors to prepare their installation drawings.

The CSA backed down when it was pointed out that the room layout drawings were ‘Room Information Sheets’ and not contract drawings and it was agreed that a solution should be agreed on site with the electrical subcontractor. I instigated a series of departmental reviews on site with all the services subcontractors, the services engineers and the site agent to review all the 1:50 drawings for the particular department and we marked up approximate positions of socket outlets, switches etc. and agreed that any problems would be raised to me on site and resolved. The outcome was that very few mistakes were made and I was told at the end of the project by one of the electrical engineers that the subcontractor’s claim for changes was much lower than normal and that one of the reasons for demanding dimensioned drawings was that they knew that changes would have to be made and they could use the drawings as a means of substantiating a claim!

3. Subcontractors' drawings

   The mechanical and electrical drawings were all produced as schematics to be issued for tender purposes with the successful subcontractor preparing the installation and subsequent 'as fitted' drawings. As a result, the services engineers did not update their drawings after the contract had been let and issued any design changes in sketch format which was difficult to manage in terms of drawing issue. All drawings issued were covered by an Architect's Instruction (AI) and drawing registers updated. Care had to be taken to ensure that these sketch changes had been covered by AIs. The services engineers' argument was that they were not paid to amend and update drawings.

   This highlighted a major difference between architects' and structural engineers' drawings and services engineers' drawings. It also indicated how a different degree of finalised design existed at tender stage. The architect's drawings were deemed to complete but would obviously subject to change if amendments were made to the services. At the same time a number of specialist subcontractors were emerging on the building side – cladding etc who also produced their own construction drawings. This also caused a problem of 'interface drawings' where the main contractor could choose the window supplier from a list in the Bills of Quantities. As architects we were expected to issue detail drawings of the windows fitting into the cladding but needed to know which windows the contractor was procuring. There was also a similar problem with fixing the cladding to the steel frame and the need for secondary steelwork. The contractor pointed out that had it been a management contract that these interfaces would have been managed by them. The programme was at risk through the need to be wind and watertight, so I issued an instruction for temporary cladding until the interfaces had been resolved. As good relationships had been established between us and the contractor, we worked together architect/structural engineer and contractor to co-ordinate the design of the external cladding.

The main contractor employed a services co-ordinator who was a mechanical engineer to manage the nominated mechanical and electrical subcontractors. An issue emerged early on concerning the setting out of the ventilation ducts and grilles. The consulting engineers had specified fixed connections from the ductwork to the grilles which meant that the exact grille positions had to be dimensioned. The mechanical subcontract documentation stated that the subcontractor was responsible for taking site dimensions in order to position the main runs. As architects we wanted the light fittings and grilles to be centred on ceiling tiles or aligned in solid plasterboard ceilings. These two situations caused problems.

1. The subcontractor was unable to take site dimensions – no partitions had been erected
2. Due to the fixed connections, positioning of the grilles had to be predetermined before the ceiling grid had been installed

The situation was resolved by sitting down with the contractor, subcontractor and services consultant and agreeing a different work sequence:

1. The contractor would fix the partition head channels to the slab soffit instead of the floor and this would allow the subcontractor to determine the position the major ventilation ducts
2. Dimensions would be added to the architect's ceiling layout drawings to indicate the setting out point from the gridlines along the centrelines of main corridors and setting the grilles at 600mm centres to correspond to the tile size, thus insuring that the grilles were located within the centre of the tiles.

From the start of the project design team meetings were held in our offices and once the detailed design and production drawing stages had been reached monthly meetings were held with inter-disciplinary meetings held in between with the services engineers, structural engineers and quantity surveyors. The meetings with the services engineers took place in their Glasgow offices as it gave the opportunity to meet the different engineering disciplines together rather than one of the partners representing the firm as at the design team meeting. This worked well and meant that problems could often be resolved before the main design team. Fewer meetings were held with the structural engineer as the once the grid had been fixed most issues could be dealt with at the monthly meeting.

Discussions with the quantity surveyor often proved more difficult. The appointed quantity surveyor unlike the other members of the team was not highly experienced in healthcare building. We had worked with them on their previous project which had been the Geriatric Unit at the same hospital. Savings had to be made due to additional engineering costs and these were made out of the building costs. The surveyors had downgraded some specifications (HTM doorsets) and at the end of the project the final account was considerably less than the contract sum. The QS thought that this was a great achievement giving back money to the client whereas our senior partner considered this as giving substandard quality. He told the QS at the start of the major project that there was no way that building savings would be made to cover services increases or reduce HTM building component specifications and that we would not be giving back money to the client!

The costing of the hospital was based on departmental cost allowances together with on-costs (circulation between departments and plant accommodation) and abnormals which dealt with site conditions. This reflected the nucleus programme documentation where hospital design and cost were based on two storey buildings on a flat site with a predetermined hospital street (circulation between departments). These costs allowed for HTM Building Components and Rooms and Equipment in accordance with SHBNs. (Scottish version of the Health Building Notes). As the cost is related to rate per square metre, ensuring that the gross internal area of the building equals the estimated area of the building is critical to achieving approval to proceed. I had learnt this information from a senior partner in the QS firm whilst working on a previous major project which had been cancelled due to the health board's attempt to save money by relocating services to another hospital. Working with him I learnt how to complete all the boxes on the PCL and FCL forms and thus understood the process and felt justified in specifying HTM compliant components.

The first area of disagreement with the project QS was that I wanted to contain the external structure within the external envelopment. (I did not know at this point that this was part of the nucleus integrated design solution). It meant that it was easier to layout furniture in the rooms and simplified the drylining installation. The QS considered this as increased cost. At that time all healthcare architects had two 'bibles', one the British Gypsum 'White Book' which set out plasterboard partition types and details and the other Armitage Shanks 'Blue Book' which contained the HTM Sanitary Fittings specifications. At a meeting with a representative of British Gypsum and the QS to discuss the benefits of using a standard partition type throughout the building the QS suggested that as the cupboard units were fixed to the partitions that there would be no need for plasterboard behind the units and this would save money! The BG rep had to inform him that this would cost more as they would fit the boards and then cut out the hole! As a result, we proceeded with standard partitions and plasterboard external linings which concealed the columns.

The second instance involved cost control procedures. The Scottish Health Service had set up a procedure whereby every month a cost report had to be submitted to the health board and the CSA and a meeting was held in the health board offices with the design team to review and approve it. The contract contained a contingency sum and items which were agreed to be category A – unforeseen could be allocated from this. All other items were classified as category B and the cost of these had to be met by achieving subsequent savings. The QS was averse to including provisional sums within the bills of quantities so achieving savings was difficult. He also had no control over the M&E figures as the services engineers prepared their own bills of quantities. Within the bills of quantities there was however one major provisional sum for reinforcement. The structural engineers had given the QS an estimate at the time of tender but bending schedules had not been completed at this stage. The QS proposed a 10% saving as part of the overall savings exercise for contract acceptance and despite the engineers' protests this was accepted by the client. The result was that when the reinforcement schedules were issued (they were all issued to the site timeously) and the costs submitted by the contractor and checked no savings had been made. The structural engineer and myself proposed this to be a category A cost but the QS considered it to be category B and wanted savings to be made. At the cost control meeting I declared that it was not possible to make such savings and that due to the circumstances it should be taken from contingencies. It remained unresolved until the end of the contract when much to the QS' disgust a 'commercial deal' was struck with the contractor. One of the anomalies of the cost control form was that the form was prepared by the QS but had to be signed by the architect. On more than one occasion I had to tell the QS that I would not sign the form if he persisted in overpricing proposed architect's instructions after budget costs had been obtained.

There were also contract administration issues with the QS, apart from a dislike of provisional sums, he also disliked prime cost sums which involved nominated subcontractors. Partly this was due to the fact that the QS is excluded from this procedure. On the advice of the mechanical engineer, we decided to procure the hydrotherapy pool from a specialist subcontractor who would not only construct and install the pool but would also provide and connect the filtration plant. The engineer suggested that by procuring this as a package any problems with interfaces would be the responsibility of the subcontractor. The QS was very unhappy as he wanted full details and specifications as he deemed it to be cheaper. Unfortunately, we did not produce the drawings in time, however we had obtained quotations from several subcontractors and the QS had to include a prime cost sum in the Bills of Quantities. This proved to be fortuitous as on another project involving the same services engineer and the same contractor as at Perth, but a different architect and QS, the QS persuaded the architect to detail a much larger hydrotherapy pool for a spinal injuries unit which resulted in the wrong specification causing algae to form in the pool before the building was handed over.

The final issue with the QS related to the contractor’s claim for loss and expense. I had granted extensions of time amounting to 48 weeks – all due to changes as a result of new legislation- installation of a water filtration plant, legionella prevention, delays in selecting radiodiagnostic equipment. Each delay was significant 12 weeks due to x-ray, 18 weeks due to water filtration plant and they were all sequential. The items were all critical engineering items which delayed the commissioning and occupation of the building. The QS rejected large sections of the delay and disruption claim as he said the contractor could not prove disruption and that it would take two years to finalise the account. The contractor offered a commercial settlement. As it is the architect’ s role to settle the final account, I prepared a document with three sets of figures: the contractor’s, the QS’s and a third set based on what I thought was reasonable if the case went to arbitration. The QS did not think that this should be presented to the client, but the client was being pressured from the Scottish Home and Health Board to settle the Final Account and the CSA liaison architect asked if there was any other solution. I told him about the contractor’s commercial settlement proposal and my estimations and asked for this to be sent to him. The result was that a commercial settlement was agreed based on my estimated figures.

During the course of the contract the client instructed two changes. The first was to cancel the HSDU (Hospital Sterilising and Disinfecting Unit) on the instructions of the CSA. The CSA Supplies Division were responsible for procuring all major equipment and had specialist departments dealing with Imaging, Sterilisation and Decontamination, Dental and Catering. In this case new legislation was coming which meant that the HSDU was subject to GMP (good manufacturing practice). The internal layout was redesigned whilst the concrete frame was being constructed and rather than continue and leave a ‘shell’ I suggested to the client that we should make provision for the openings in the slab to be cast to allow for future additional ventilation ducts. It was agreed to carry this out and as a result the when the decision came to delete the unit rather than upgrade it, the area was easily converted into a storage area for the adjoining theatre department. A larger area being required for sterile storage due to lack of sterilisation facilities which were now to be centralised in Dundee.

The second change involved the cancellation of the incinerator – again on the instructions of the CSA and this time it was the contractor who suggested that have built the chimney base and fixed the holding down bolts that rather than remove them, they would enclose them with protective concrete rings before burying them. The client agreed and the incinerator building was used as a store for the Estates Department.

The two items of equipment which caused the most problems were the selection of the radiodiagnostic equipment and the operating theatre tables. The selection of the radiodiagnostic equipment was managed by the CSA, they held meetings with the users and the health board and made suggestions, set up competitive tenders and arranged the installation. Although the dimensions of the x-ray rooms are set out in guidance the final layout drawings are prepared by the selected manufacturer and a set of pre-installation requirements is issued to the design team. At design stage the x-ray rooms which were on a ground level had the slabs cast 300mm within the rooms to allow for computer flooring (heavy duty – GIM floor – much to the horror of the QS who had allowed a provisional sum based on office type computer flooring – due to his ‘commercial’ background). This allowed the drainage to be installed and for wash hand basins to be positioned to suit the equipment layout. The Imaging department was in the heart of the building – deep plan – as this an area where daylight is not required (other than in staff areas, offices and waiting areas) and as such the main heating and hot water pipes ran through it. This meant that the services commissioning was delayed due the late completion of the department. The CSA/ user process was late in starting and was protracted due to the fact that the users did not want what the CSA proposed. They wanted a CT scanner in one of the rooms rather than a general x-ray room. Unknown to them the general machine had already been procured and was awaiting transportation in a crate at Berlin airport! As a result, an unnecessary delay was caused. As well as pre-installation works there was also post-installation works. This was not included in the contract and was not discovered until the suppliers’ contracts had been let. The general assumption was that the x-ray equipment was usually installed at the end of the building programme. The manufacturers however only install and connect the equipment but do not carry out any builderswork required to ‘finish’ off the installation such as framing around openings where pass-through processors were situated. They also said it was not the manufacturers’ responsibility to make good any damage caused by manoeuvring the equipment into the building. As there was still works to be carried out to some of the existing buildings on the site, the contractor agreed to carry out these post-installation works and to reschedule some of the works to allow the floor coverings to be fitted after the machines had been installed. An important issue related to this is that the new hospital could not be opened until the imaging department is fully functional. Interestingly the architect in charge of the Ayr Hospital was so frustrated by the CSA that he persuaded the health board to sack them from the project!

The other item of equipment involved the operating theatre tables. The tables are deemed to Group 3 items, procured and placed in position by the client. At the initial user group meetings there was discussion about the use of fixed based tables as opposed to mobile tables. It was agreed that the tables would be mobile, therefore this did not affect the design and construction of the theatres. The theatres are situated on the ground floor and hence a ground slab. Fixed based tables had quite recently been fitted at Stirling Royal Infirmary which had suspended concrete slabs. During the course of the contract the theatre staff went to look at various types of tables in order to make their selection and guess what they chose the same fixed base table as at Stirling Royal! By this time the slabs had all been poured and the partitions erected. The structural engineer had to recalculate the slabs and changes had to be made to area around the base as the levelness tolerances of the table were extremely tight. The result was holes 1500mm x 1500mm had be cut out of each of the theatre floors. Channels also had to cut to take electrical supply cables to the base plate. In order to lay the flooring the trust had order the tables earlier and hand over the bases to the contractor so that they could be installed and the supplies tested.

An interesting instance of buildability was the requirement within the mechanical engineering specification for the oxygen line to be protected during the alteration works to the existing boilerhouse. Part of the redevelopment plan was to provide a new boilerhouse and convert the existing one into workshops for the Estates Department. The oxygen compound was close to the existing boilerhouse and the oxygen main was ducted into the boilerhouse, then it was fixed up the wall, across the roof and down the other wall and back into a duct to connect to the main hospital. It's route being exposed through the building. As part of the alteration the chimney was to be demolished and the roof made good. As a result, when the contractor came to carry out these works, not having taken full notice of the mechanical specification requested that a new duct to take the oxygen line be taken from compound to the existing building be built. The consulting engineer stated that this would be at the contractors' expense as he was obliged to protect the oxygen line. This should never had been put in the prelims as it was effectively trying to get Shylock's 'pound of flesh'. Needless to say a new duct was built and this was part of the contractor's claim.

A couple of issues arose in conjunction with HTMs, firstly with partitions. The HTM specification had been deemed by British Gypsum (BG)to be outdated when the drawings had been prepared and as a result the 100mm nominal partitions had been changed from two layers of 9.5mm plasterboard either side of a 60mm metal stud to two layers of 12.5mm either side of a 50mm metal stud to cater for the greater loads, height and the bounce test. Due to the increase in services the floor to floor heights had increased from those in the nucleus hospitals (3900mm) on which the HTM was based. The result was that there was concern when the first partitions were erected in the theatre area which had a floor to floor height of 4200mm and BG were called in to check. The result was that 'I' studs were introduced in certain areas and BG prepared new details which ultimately were incorporated into the 'White Book' which superseded the HMT which had not been updated.

The second issue concerned the installation of medical gases. This is one of the few HTM's which is mandatory and not just for guidance. As a result of tests carried out by the CSA Authorised Person, deposits were found in the pipelines. As the installation had been carried out strictly in accordance with HTM this caused a serious issue at the highest level in the Scottish Office and in the Department of Health and a series of 'hush-hush' meetings to establish the cause. The cause was found to be the gas which was used for purging the pipes and I was instructed to issue an AI to the contractor to cleanse the pipework – cost to be borne by the client. Subsequently the HTM was re-issued stating that only nitrogen cold be used to purge pipelines, previously there had been a choice of nitrogen or carbon dioxide.

Early on in the project when decisions were being made regarding the preparation of working drawings, another lesson from the previous 'abandoned' major project was adopted. Namely the drawing numbering and room numbering protocols were adopted. The building was described in terms of Level 1, 2, 3, 4 and 5 – primarily due to the fact that apart from Level 5 all the others could be accessed at ground level. The building was split up into zones, each one on an A0 sheet and relating to departments as much as possible and the rooms were numbered as in hotels. This a typical room number would be 3129 – level 3 zone 1 room 29. This numbering was fixed following the approval of the 1:50 drawings and was utilised through to signage. A lesson was also learnt from a previous project where we had numbered beds 1-6 and the Medical Physics department had numbered from 6 – 1!

In the claim that architects were unable to control cost and sometimes they were judged on the number of Architect's Instructions which were issued. A large number indicating many changes. However, it depends on how the instructions are issued. Some people issue multiple items on one instruction each one involving several trades or subcontractors. I issued 1500 on this project but each one was headed according to its individual trade, instructions were issued for all drawing issues, site instructions and confirmation of verbal instructions. An index for the AIs was also produced cross referencing any site instructions etc. – the QS liked this!

During the course of the contract, we were contacted by the architects for the Ayr project which was being built at the same time when they had a problem with copper pipework. Table X copper was found to corrode over time and although this had been a known problem in the brewing industry it was not seen as problematic as they stripped out their pipework installations at regular intervals. The CSA investigated this and we were instructed to change to Table Y copper (medical gas grade) whilst a major study was being carried out to look at alternatives such as stainless steel and plastics. As a result, we visited Ayr and in turn the architects visited us at Perth. This exchange of dialogues and visits proved to be a very valuable exercise.

A measure of the relationship we had with the contractor was highlighted when the contractor for the West of Scotland Hospital's Project Manager asked the contractor if he could visit our project due to concerns, they had with partitions (knowing that BG had been consulted). The PM arranged to come one Thursday afternoon and unfortunately the contractor had forgotten that he had to attend a meeting at head office so would be unable to take him round the site. He asked me if I could take him as although the services manager was going to meet him, he would not be able to answer detailed questions on the building. The visit was very successful and at the end the PM asked me if it was a management contract as he thought that there was obvious a very good working relationship between the architect, design team and the contractor. He was surprised to learn that it was a standard JCT80 just the same as the West of Scotland project where the relationship between the architect and the contractor was not so good!

Prior to handover of the project all parties took the opportunity to take their clients round the building and the contractor held a seminar event in which I was asked to participate as was the hospital administrator. One of the clients we took round was from another Health Board with whom we had worked for many years and who were trying to finalise proposals for the redevelopment of another major hospital. They were very impressed with the design of the building, the quality of finish and the cost, considering to be good value for money.

I visited the hospital three times after it opened, firstly to carry out the making good defects inspection 12 months after, then for the official opening by the Princess Royal and again when I took some members of the team when I worked for a different firm of architects on Case Study 2 to see the operating theatres. The client and users were very satisfied with the building - apart from the overheating of the café in the Main Entrance where, as result of the glazed roof the Mars bars melted!

It was interesting to observe how the building was being used and how it was affected by working practices. In the Accident & Emergency department there were two single bedrooms for 24 hour observation for head injuries, but due to the lack of in-patient nursing staff they were not used for this purpose. In the Fracture Clinic there was a Plaster Room fully equipped with medical gases. Again this was not used as orthopaedic practice was to reduce all fracture in the operating theatres. One of the reasons given was that a new anaesthetic machine had not been purchased when the theatres had been equipped and that it was essential that any anaesthetist called to the fracture clinic was familiar with the machine hence they should all be the same.

In the last year of the project I started an MSc degree in Construction Management at Heriot-Watt University part time – one day a week, completing it in 1993. The subject of my dissertation was Procurement Methods for Hospital Projects in Scotland concluded that the traditional procurement probably gave the client best value for money if well managed but that involving the contractor earlier in the process could be advantageous. I even suggested that it might be possible to develop a new form of contract which would ensure that the client's architect was not compromised by the contractor.

This was the last of the traditionally procured hospitals in Scotland and probably the UK and at the end of it I felt that I had gained a considerable amount of knowledge which hoped that the lessons I had learnt could be put into practice on future projects. It was also a strange feeling when the building was handed over; for most of the project it felt like 'my building', towards the end I could sense the contractor feeling it was 'his building' and ultimately on handover it became the hospital administrator's building. The main lessons learnt was the need to work together, learn to understand one another, compromise when necessary but fight for something which you considered beneficial to the project outcome.

2 Case Study Two

This project was one of the first wave of Private Finance Initiative (PFI) projects in Scotland. A replacement for an existing city centre hospital was long overdue. The proposal had been to rebuild the hospital in phases on the original site and Phase One was completed in the 1970's when a boilerhouse capable of serving a completely new hospital together with outpatient departments etc was built. The next phase should have been the Maxillo-Facial, Plastic Surgery and Burns Unit which was the abandoned scheme which I had worked on prior to Case Study 1 The Health Board produced many briefs with varying numbers of beds. There was also the issue that the city had several other hospitals namely the in the west, east and north but none in the south. Funding was also an issue and meant that the new hospital would have to be built in phases. The PFI funding opportunity allowed the replacement of the hospital to be carried out as one project on a greenfield site on the south side of the city and with good access to the city bypass.

In 1997 I went to work for a different firm of architects and began to get involved with the project. The SPV and Joint Venture had just been selected as preferred bidder – by this stage they were the only bidder, two others having withdrawn. The contractor had previously worked with this firm of architects traditionally on a major hospital so now the tables were turned and the architects were employed by the contractor.

The project brief had been prepared by American Healthcare Architects who were establishing an office in Edinburgh. Instead of organising departments in a traditional manner, the were briefed according to 'aggregation'. The aggregation consisted for example CVTR – Cardio thoracic, vascular and respiratory; operating theatres, Intensive Therapy Unit. Wards and Outpatient Department. The form of the building reflected this; it is a three storey building with three linear (curved) zones: the ward arc, a parallel central spine building containing the Intensive therapy units, and a front building containing the operating theatres anchored a one end with the Department of Reproductive Medical and the other Accident and Emergency Department.

I started at a time when the outpatient accommodation had still to be planned – awaiting the brief from the client and the 10,000 square metres required was to be provided on the ground floor of the ward block. The HSDU also had to be planned. I was given the task of planning the HSDU having designed the one in Case Study 1. This firm of architects worked in a different way to how I had previously worked. The concept of the building and some of the internal planning was carried out by a couple of 'design architects' although the project was headed by the Project Director -a very experienced healthcare architect who had worked at Ayr. The result was that the shape allocated to the boilerhouse was completely unsuitable and the HSDU was located across the yard from it in the Estates Department compound. The designers were not interested in how the boilerhouse worked, so having also been involved with the boilerhouse in Case Study 1 and having worked with the consulting engineers many times before, I swapped the bolerhouse and HSDU buildings in order to achieve a functioning boilerhouse and set about designing the HSDU which could be accommodated in the more difficult shape.

Due to the scale of the project the building was subdivided into six sectors: the ward block, the central block, the theatre block, reproductive medicine, accident and emergency and the estates department. A team of architects was responsible for each area under supervision of the project director and a team co-ordinator. I became involved with the healthcare planning as other than the project director most of the team had little healthcare experience. The ERJV team had a senior design manager and a cost manager who we met regularly with and who had been responsible for putting the bid together. The senior design manager was a civil engineer by background and very organised. The structural engineers did the initial split of the building up into sectors, but this did not suit departments as a result I reorganised the sectors following the principles I had developed in Case Study 1 The senior design manager was very keen to use an electronic document management system - Documentum. At first this was hated by the architects in the office as everything had to be notated in a strict protocol to aid the filing and retrieval of documents. The cost manager took charge of the area schedule - key element in controlling the project cost, but the relationship between him and our teams was not very good - the parties didn't really understand each other! Due to my previous experience, and in particular the information I had gained on the abandoned project (the same Health Board and a well-known firm of QSs where not surprisingly a number of the contractor’s QSs had trained - being city based!) I found that I was able to work well with him. As a result, I became responsible for ensuring that the design reflected the brief. Having checked the 1:200 drawings I discovered that approximately 90 rooms were missing! Roughly one per sub-department and reflected mainly missing toilets and offices. I then marked up all the drawings to indicate how these could be accommodated. This did not prove popular with the architects who thought that I was siding with the contractor! Some of them could not see that it mattered if a toilet was missing and did not understand the necessity of being so exact. Needless to say the cost manager was very pleased and we built up a very good working relationship and we even had a cabinet on Documentum dedicated to the Area Schedule which only he and I could access so we could work on the schedule and not have others interfering until it had been fully checked.

The design of the outpatient department proved difficult as the footplate did not accommodate the recommended room layouts, in particular the consulting examination rooms which although the correct room areas were achieved, they were too narrow. As a result of some of these shapes, the cost manager developed a term 'useable area' which could be used on future projects to demonstrate the importance of understanding how the rooms functioned.

Although the architects were familiar with the use of the Activity Data Base (ADB) a briefing tool developed through the nucleus programme, the decision as to which briefing system would be used to develop the room data sheets was not theirs to make. The Trust as previously stated had used American architects to prepare the brief and the Trust’s Equipment Manager had started to use Hiltron which was an equipment procurement specialist based near London. The construction JV decided to adopt Hiltron to prepare the room data sheets (RDS). This proved to be a disaster. One of the contractor’s estimators, one of the consultant engineers and myself went down to Hilton’s offices for a couple of days to try to work out how we would use the system. The estimator had no idea about the use of room data sheets and was only interested in how schedules could be prepared electronically from them. We were trying to work out how the system could be used on line and how it could be managed if several parties were updating it.

ADB coding is not entirely intuitive, the six-digit code – three letters and three numbers gave an indication of what the item was: CHA017 being a type of chair. The ADB room sheets did give which category the item belonged to; Group 1: supplied and fixed by the contractor, Group 2: supplied by the client and fixed by the contractor, Group 3: large items of equipment supplied and placed in position by the client, and Group 4: small items of equipment supplied by the client. ADB codes suited group 3 and 4 item as these were procured by the trust and were familiar to them, but was not particularly useful on site as an OUT463 maybe a medical gas outlet and OUT375 an electrical socket outlet. The engineers preferred to use MA4 for 4 bar medical air and E2 for a twin socket electrical outlet – much easier for site operatives, designers and users. Similarly, at Perth Royal Infirmary I had developed a coding system for group 1 fixtures related to NBS specifications, based on examples such as CB1 Clinical Wash hand type 1 and WT30 which related to a worktop 3000mm long.

The Hilton team had initially prepared the RDS from the 1:200 drawings, as a result the room areas indicated were those measured from the drawings and not the required areas. Room perimeter dimensions were given – not required and sheet references given related to what they thought were the department names. The RDS were indicative of room types and as a result if there were missing rooms there were no sheets.

The Hilton Data Sheet consisted of three A4 sheets (ADB has four), Sheet1 was a general description of the room requirements, Sheet 2 was a list of equipment and fittings and Sheet 3 list of requirements to service the equipment. Sheets 2 and 3 confused the situation and it was agreed that items such as fitments such be on Sheet 3. Hilton Equipment Codes were all numeric – related to their core business which was procurement and supplying hospitals with equipment (many of them being overseas). These codes had no intuitive basis and as result we agreed at the meeting in their offices that sheet 2 would be the trust's equipment (retaining Hiltron codes) and that sheet 3 would be the ERJV 's equipment sheet using our own codes. This solution appeared to satisfy all parties.

However, the contractor and the trust both held Hiltron data bases and the trust's equipment manager would not agree to merge them. As a result, Sheets 1 and 3 were headed ERJV and hard copies printed on white paper and the Sheet 2 was titled with the Trust's logo and printed on pink paper to make identification easier for the people using them. Only the contractor's data manager was able to update sheets 1 and 3 as discussions of creating an interactive database with the design team proved too difficult. It was agreed that the trust would issue hard copies of their data sheets to the contractor.

The project was now in the stage of proceeding to Financial Close and the 1:50 drawings and room layout sheets needed to be prepared. I was given the task of checking and issuing room data sheets to each of the teams. This proved very difficult and timeous as the programme had been agreed rather optimistically by Architect's Project Director and the Contractor's Planning Manager – who checked it meticulously. The schedule of accommodation had to be agreed and then standard rooms identified. The proposal was to submit RDS and room layout sheets for three types of room – hospital standard rooms, aggregation standard room (LDRP room in Maternity for example) and unique rooms. The data sheets had to be cross referenced to the building numbering which was based on sector numbering -as at Perth and also on room type related to the schedule of accommodation. The engineering requirements for the equipment needed to be agreed in conjunction with the consulting engineer. At the same time the Trust sheets had to be incorporated – these needed to be cross referenced as they were identified using Hilton room references. In some instances, there was not an equipment sheet prepared for all the rooms which we had identified. The contractor set up a team on site to manage the RDS and also to lead the discussion meetings with the trust. I was transferred to site to work with them.

Within the JV roles were divided up between the three parties, the Project Director was from main contractor, the deputy Project Director from the M&E Services contractor and the Commercial Director from another building contractor. This division of roles was replicated throughout the project regardless of the individual's suitability or experience. The role of overseeing the RDS and room layout sheets was given to an experienced electrical engineer who would ultimately become the electrical construction manager on the site – this becoming a 'M&E Services role. A young graduate to manage the data base was appointed by main contractor to replace the estimator (who went back to head office) and a graduate trainee to process the RDS. Eventually an 'experienced medical equipment manager' from M&E Services contractor joined the team.

The electrical engineer was unfamiliar with the process and couldn't operate the data base, the data manager who also was although not familiar with the process or hospital equipment was extremely computer literate and it took some time to create a working relationship. Working in the same room helped to build a good working relationship. I also think that it helped that I had had site experience at Case Study 1 and was able to understand the engineer's point of view when he got upset with the quality of the drawings which were coming out of our office! [Towards the end of the room layout sheet approval process, the JV management decided that it was time for him to take up his 'real' role and replaced him with a 'commissioning engineer' who was new to the M&E Services contractor and had worked on the Jubilee Line in London. He was a complete disaster and as a result I went to see the deputy project director and ask him if the electrical engineer could return until the process had been completed. He agreed! Later when the electrical engineer was having problems from the subcontractors complaining about the lack of dimensions on our drawings he sent them all to me to mark them up!]

The room layout approval process was rather difficult. Monthly meetings were held in the SPVs site offices with representatives of the Trust, JV and the Design Team to discuss progress. The design team were not allowed to meet the client without the presence of the JV. There was no direct involvement with the users (medical and nursing staff) and the trust was represented by a project manager who I had known for many years having been one of the trust's capital planning managers and a nursing adviser– who unfortunately had not worked in a hospital for many years. The two of them took on the role of meeting the user groups and the nursing adviser marked up paper copies with their comments. Despite the fact that it had been included in the contract documents that all drawings had to be marked up electronically (all parties had a different mark-up colour) she was allowed to carry out a paper exercise as she could not operate the system and was not up to speed with HBNs. It was also too much for one individual to cope with and the design began to get the blame for lack of progress. Eventually another nursing adviser was brought into the team, but the two women held different views as the new adviser had until recently been in a sister in accident and emergency in the existing hospital and was more update with practice.

In the contract Room Layouts were required to be given one of three statuses: Status A: approved no changes required, Status B: approved subject to minor changes and Status C to be resubmitted. The hand written mark-ups were disastrous, the architects working in the office misinterpreted them and also misunderstood them not have met the users face to face – an example of this being that in Accident and Emergency the resuscitation bays were handed. This was not picked up by the trust, the drawings were approved and rooms built. However, after handover when this was discovered the staff were only able to use 50% of the as resuscitation bays cannot be handed, medical staff are trained to examine patients from the right hand side and not the left. If the architects had been allowed to meet the users this would have been discovered and corrected. Similarly, what was designed as an X-ray viewing area should have been a bereavement viewing room because it was listed as a 'Viewing Room' and located next to an X-Ray Room on the approved 1:200 layouts.

There was a flurry of activity approaching financial close (there was no question that project would proceed as the trust had underwritten the cost of procuring the steelwork so that work could start on site immediately after financial close) and in checking the drawings and documents hand written amendments which had been made to the RDS sheets proved controversial. On the ITU sheets mechanical ventilation had been scored out and air-conditioning added by the nursing adviser. Air-conditioning was not allowed for in the cost and not required- only operating theatres had this. This was an example of someone misusing a term and in this case was eventually overruled by deferring to the HTMs. The room layouts were not all signed off as Status A or B and before project handover all the drawings had be laboriously checked by a team consisting of a representative of the trust, consort, JV and the designers.

Another agreement took place at financial close of which we did not learn until late in the project, but the equipment provision did not follow traditional ADB groupings. Clinical wash hand basins are normally classified as group 1 – supplied and fitted by the contractor. In this case the JV proposed that they would only supply basins in areas where they thought you would expect to have them – ensuite facilities and toilets but not in consulting/examination rooms as these were deemed to be for medical use and as such constituted medical equipment! As a result, 50% were procured by the JV and the rest by the trust, although to an outsider this was not obvious as they were all supplied and fitted by the same subcontractor. The only problem came at the end of the project when they tried to work out the cost.

Equipment procurement and management proved to be another very difficult process. There were few discussions between the SPV (and JV) and the trust. The main items revolved around x-ray equipment, hi-lo baths and medical gas pendants, all of them being supplied by the trust. There was a lack of understanding on behalf of the JV on when information about them was required in order to design for their installation. The programme only indicated when they were to be installed. the M&E Services contractor had appointed an equipment specialist to manage this but his expertise was only in the medical equipment field and in the United States. Hence although he was knowledgeable about medical gas pendants he was not acquainted with general ADB equipment. As I was working in the same room as the JV team we often discussed various matters and one day they were discussing the ordering and delivering of the hi-lo baths (approximately 33 of them) which were coming from Sweden within the next few weeks with the quality manager. I asked them where they were going to store them as at that particular time the building although wind and watertight had not reached the fit out stage. They had not realised it and also were not aware that the baths were to be fitted after the floor coverings had been laid. As this was probably 12 months away and the baths were already in transit they had to rent a warehouse to store them. They also had not considered the fact that by the time they were fitted they would be out of warranty.

The second item involved the theatre pendants. The pendants were selected by the trust following consultation with the users, but this was carried out in house. The trust equipment manager ordered them but nobody thought to give the specification to the designers. The previous major hospital projects in Scotland all had concrete frames but this one had a steel frame. The primary steel of the frame had not been designed for fixing pendants due to information not being available and therefore secondary steelwork was required. It also meant that the pendant positions had to be accurately positioned. The secondary steelwork was erected in the Reproductive Medicine theatres, the pendant bases fixed, the ceilings were then completed and the pendant fixed. Unfortunately, the dimensions had been calculated from the primary steel grids rather than the finished dimensions of the room and the pendants were in the wrong place. The electrical consultants also complained that there were problems accommodating the perimeter lighting. This was an example of complete 'silo working' and the lack of understanding and experience by all parties. Having experienced the requirements to accurately position engineering services at Case Study 1 and having worked closely with engineers I ended up producing fully dimensioned sketches of all the theatres to allow the pendants, lights and ceilings to be completed.

Following architect's experience with the CSA (who were not involved in PFI projects) and my experience at Case Study 1regarding pre-installation works, the architect's project director made a point of highlighting the difficulties with the installation of x-ray equipment and the need for employing specialist 'unistrut' subcontractors.

What was not realised at this stage was that the RDS sheets that the trust had been signing off incorporating the 'Trust pink sheet' for equipment was not what the equipment manager was procuring. He had been updating the equipment list independently of the users on his data base and as result much of the equipment procured by the trust was incorrect.

The original design for the building by the architects was for a single completion date and was also based on a concrete frame. The contractor decided it was more economical to use steel than concrete despite having built the West of Scotland hosptal in concrete (this was specified by the design team). Probably on a cost comparison of the frame this was economical, but it did not cater for the fact that the height of the building was increased by a minimum of 300mm per floor to accommodate cross over beams, additional fire protection, boxing out for drainage pipes which could not penetrate steel beams unlike those which could have been cast in concrete. This meant that sanitary fittings had to be boxed out and often protruded into rooms. The situation was compounded by the 1:50 drawings being set up with partitions centred on grid lines and often boxed out in four corners which was rather unsightly and made cleaning more difficult. Part of the problem here was that the architectural team was inexperienced and the project director too busy to explain to it to them. He was also too eager to be ahead of programme to prove a point to the contractor. This approach backfired, the team did not understand the concept of major movement or expansion joints requiring double columns and some rooms had joints running through them. I had tried to persuade him to set out the partitions flush with column faces (as in nucleus and what I had done at Case Study 1) but he said that they had started so they would just continue.

Similarly, with ceiling plans, ceiling grid layout drawings were prepared so that cut tiles were of a minimum dimension. The only problem was that there were three possible set ups in achieving this and they were all dependent on the number and layout of light fittings and ventilation grilles! The result was that they had to be done at least twice following information received from the consulting engineers. The room layout sheets which were A2 size included a ceiling plan of the room – as the computer system at that time could not cope with updating the information a note was added to the drawing to refer to the ceiling layout drawings. In a discussion with the senior partner of the consulting engineer (I had worked with him previously) we agreed that on a future project we should consider the consulting engineers preparing the ceiling layouts since the majority of the components were engineering related.

Having worked on site, being pressured by the contractor to provide information and allowed to meet with their subcontractors I became aware of how they wanted the information to be provided. Also having set up the 1:50 drawings at Case Study 1 according to construction stages I saw the importance of achieving clarity. As most of the information was electronically prepared I suggested that we should ask the contractor how he wanted the information to be provided but was told that we would provide it as per our programme. The contractor decided to use a Swedish door manufacturer who our project director was keen on using (one of the major HTM door manufacturers which I had used he considered to be too difficult to work with – I had no problems, but had prepared a schedule adopting and HTM template) as they would schedule the doors. The cost manager and the commercial manager asked how we would provide the information. I wanted to schedule them using a code system based on HTM, but although this was favoured by the contractor, our project manager said that we had already started and it would mean amending drawings so we would let the door manufacturer take off the doors from the drawings. The doors were laminate finished in two colours – green and blue on alternate floors. Adjoining the hospital and part of the construction was the new University Medical School, also three floors, the difference being all the doors should have been blue as this was the university's colour. As this was not scheduled it was not picked up and a complete floor of green doors were ordered. The university would not accept this so they all had to be replaced. ERJV blamed us and kept them in storage – suggesting that they be used on a future project! The doors went into storage for use an Case Study 3, but eventually ended up being sent to the tip!

One of the problems of producing computer drawings was the failure by the architects to add setting out dimensions. As the architects could easily see the dimensions on screen and most of them had no site experience they did not realise the importance of providing dimensions to what would be the printed out version. The JV had agreed to pay for the services of a site architect (who had been the site architect on their previous project) and he spent a large amount of time phoning the office requesting dimensions or if required at the last minute working them out from the drawings uploaded to Documentum. Standard room layouts worked well for four bed wards, single rooms etc, but when it came to offices, although the rooms had the same requirements no two were the same layout. The result was that I ended up marking up the positions of electrical sockets for the subcontractors.

Despite the eagerness to be ahead of schedule the project director had a hard time every month at the progress meetings where they claimed that we were behind schedule and he claimed we were ahead! This was possibly due to working to two different programmes!

The new hospital was not only a replacement for the existing but incorporated the Maternity Hospital which had been on the same site and the Orthopaedic Hospital which was situated in a residential area overlooking rolling countryside. As described earlier the Department of Reproductive Medicine was at one end of the building whilst the accident and emergency was at the other. The building was bisected by a central entrance mall and the different aggregations were arranged from left to right as follows: general medicine, CVTR (cardio vascular, thoracic and respiratory medicine, GILR (Gastro, intestinal, liver and renal medicine) and Orthopaedic medicine. The operating theatres followed the same configuration with the Radiology Department being situated below the GILR and Orthopaedic theatres. Two events took place which affected the design and programme.

Firstly, although the Maternity Hospital had been built in the 1930s and was considered by many to be an example of Art Deco which should be protected, it was discovered that it was suffering from concrete sickness and as result there was pressure to complete Repromed ahead of programme. This did not seem to pose a problem for JV as they had decided to construct the hospital in two phases and this was in Phase 1. The only thing they had overlooked was that Radiology was in Phase 2 and they did not realise that without radiodiagnostic facilities the hospital could not open. The phasing line had to be relocated to incorporate part of the Radiology department to be included in Phase 1 and a temporary fire escape corridor had to constructed through the Phase 2 courtyard to comply with Building Control requirements. Had they discussed the matter with us before programming the works we could have designed the building to allow Phase 1 to be a ‘stand-alone’ facility.

Secondly the trust sold the Orthopaedic Hospital much earlier than envisaged as it was a prime site for an expensive housing development. The result was that temporary orthopaedic facilities needed to be provided in Phase 1. This happened before partitions had been erected so that General medicine was reconfigured to accommodate orthopaedic wards and two of the CVTR operating theatres were designed to accommodate orthopaedic surgery. This latter change was both drastic and costly. Orthopaedic theatres require ultra-clean ventilated canopies which are not suitable for other types of surgery, meaning that when the intended orthopaedic theatres had been completed the temporary ones had to be altered to cater for CVTR. It also involved additional phases in order to carry out the works. The removal of the canopies involved the complete removal of the ceilings, alterations to secondary steelwork and changing medical gas pendants. Although only about 18 months old the canopies had to be disposed of as they could not be transferred – the new theatres had to be completed and commissioned before the temporary ones had been decommissioned.

The contract change control procedure was very lengthy and onerous and relations with the trust strained, especially between JV and the trust. One of the SPVs team had formerly been a capital administrator with the health board so was more understanding. At one point, the SPV and the JV were not on speaking terms but as I knew the former health board administrators (including the trust project manager) from previous projects I was sometimes sent over to the SPV offices to visit them! One of these change order requests included additional data and electrical sockets. Again as part of the contract it had been agreed that the JV would provide a specific number which I recollect as being 10,000 – based on so many per square metre. JV were required to price this for the final account. This was part of the M&E Services'remit and as they were having difficulties establishing the number from room data sheets I was transferred by the architects to the M&E Services' team for a period of three months to resolve this for them. This was a very strange situation as the project director said to me not to answer any site queries during this period and on the other hand the JV staff thought it was a great idea and could ask me to resolve any of their problems as I was working for them!

The Pharmacy department included an Aseptic Suite. This is a highly sophisticated area which involves obtaining certification from the MHRA in relation to GMP. This was one of the few areas where the trust requested that the Chief Pharmacist should visit the site during the construction works. During the visit when I took him round the area he mentioned the necessity for obtaining the certification. I discussed this with the senior design manager and suggested that a specialist subcontractor should be employed in order to reduce risk. I had been involved with a similar situation at Case Study 1 and after considering all the options of producing details, organising the QA documentation we had decided to appointed a specialist subcontractor. It was decided however that aseptic facilities could be provided off site so this did not go ahead. It was however part of 'lessons learnt' and something which I might use in future. The senior project manager decided to propose this route to the commercial team and appointed a specialist subcontractor who successfully completed the installation.

In contrast when it came to fitting out the Laboratories, the senior project manager who had previously built laboratories took a great interest in procuring the equipment and laboratory fittings. Unfortunately, the architect involved with the laboratories was rather pedantic and specified the generic units in accordance with HTM (which did not reflect current cabinetry). Despite several manufacturers' offering the latest styles, the senior project manager insisted that we should be as nearly HTM compliant as possible. Visiting the building a few years later, this appeared to be a very foolish decision as the laboratory looked cluttered and outdated.

JV decided that due to the large number and very repetitive design the ensuite facilities to the 4 bed and single rooms should be prefabricated. These 'bathroom pods' were made from steel and procured and made in the UK. This was a 'first' for the contractor and involve a great many meetings which our site architect attended in order to agree the design and quality. The ensuite facilities in Repromed had to be built on site as the room sizes and layouts were not identical and the plans could not be altered to accommodate this. Prefabrication was deemed to be successful and was one of the innovations taken forward. However, it was different matter with the back panels for the sanitary ware. Armitage Shanks who supplied the most of the sanitary ware had a concealed panel system described as Armitage Venesta. This was deemed to be too expensive and the commercial manager secured a deal with a local fabricator to make laminate faced back panels. The problem came when the bidets for Repromed had to be ordered as due to HTM requirement for sensors Armitage Shanks only supplied them with Venesta back panels. JV had to order these units at a cost £1000.00 for each unit and then proceeded to dismantle them and refit the bidet, sensors and pipework to their 'cheaper' units – hardly cost saving!

The external envelope was designed as a white panelling system and the design information submitted to the contractor was based on Luxalon. All external materials had to be approved by the Planning Department. As such the contractor was unable to change the specification. As this was an expensive product the contractor looked for a cheaper alternative for the cladding to the internal courtyards. They also decided to tender the windows to get a more competitive price than the Luxalon windows. They thought that they had achieved the most economical solution. Unfortunately, however the Windows came with lugs which did not suit either of the cladding systems and they had to be modified on site. This was another lesson of attempting to save money by changing components within an integrated product.

The building was designed to have a pneumatic tube system. As this was a mechanical installation, we were not consulted other than agreeing locations, as a result the in the laboratories looked very basic due to the fact that no allowance had been made for the provision of enclosures for the end stations. The manufacturer could have provided this at an extra cost but this had not been deemed necessary by the M&E Services contractor. The consulting engineers had a very good relationship with M&E Services contractor they had worked with them many times and as in Case Study 1, in the traditional procurement route M&E design was schematic at tender stage with the successful tenderer preparing the installation drawings. Their relationship with JV was different from ours as they still worked closely together.

The separation of design approval into different areas such as reviewing the Nurse Call System caused problems. The trust's estates department met with Haden Young and the consulting engineers to approve the drawings but unfortunately they did not match with the positions shown on the room layout sheets and this caused problems when checking the requirements.

Another example where the integration of services became an 'architectural' design issue was with 'Bed head trunking'. This was a new concept introduced by Haden Young, whereby medical gas services, electrical socket outlets, data points, nurse call and integrated lights could all be incorporated into one unit which could be pre-fabricated and surface mounted. This not only gave uniformity and quality but allowed for future alterations. Until this project the means of delivery of medical gases in the wards was by use of the 'Scottish' wardrobe, a tall cupboard unit fixed to the wall to the right hand side of the patient's bed. (HTM 2022: Medical gas installations sets out the configuration of the gases.) The medical gas pipes were contained within the wardrobe with a services panel on the side of the wardrobe for the gas outlets and electrical sockets. There was a cut out at the bottom of the unit to take a suction bottle. These wardrobes were used in the single, 4 and 6 bed wards. By the time of this project the number of sockets required had increased as had the number of medical gas outlets thereby reducing the effective wardrobe space to accommodate them. Ward layout design had also changed and 6 bed wards had been replaced by 4 bed wards with an increase in the number of single rooms. Wardrobes were still provided but as there were only four patients, the wardrobes were situated on the corner of the rooms giving each patient their 'own corner'. (the two middle beds in the 6 bed wards were unpopular). The use of bedhead trunking between the wardrobes meant that the layout of the services could remain in the same relationship to the patients despite the wardrobes being 'handed'. It also allowed sockets to be position on either side of the bed. The service drops could be contained within the wardrobes.

I got involved with this installation as due to column/wall junction relationships site dimensions had to be taken by the subcontractor in order to prefabricate. This was compounded by the sequencing of installation due to the fixing of the wardrobes which were part of the builder's subcontract works. As there were over 600 beds we had to establish general principles for them to take site dimensions. The trunking was also used in theatre recovery areas and as there were no wardrobes, risers had to fitted to one end of the trunking. As these were all different I had to position each one with the subcontractor on site. This proved to be a very useful lesson for future projects and confirmed the need for integrated working.

This was one of the first major hospitals to be built following the loss of 'Crown Immunity' which meant that all the drawings had to be submitted to the Building Control Department. Normally in Scotland full approval has to sought before work starts on site, but in this case that would have taken a considerable period of time and did not suit the PFI design and build process. Equally Building Control were nervous as they had not been involved in either a project of this size or type. A very proactive view was taken and JV provided accommodation for two building control officers to work on site and have access to Documentum so that they could progress the approval and carry out inspections. This proved to be very successful as if in doubt the site team and ourselves could consult them at any time and we were also available to explain issues regarding compliance with HBNs and HTMs. The Council also agreed to receipt of the drawings electronically and it became the first example of its kind to extent that the two building control officers used to promote this to other authorities.

The use of Documentum enabled an accurate record of the issue and receipt of all information. It automatically displayed the las test version but it also held all the previous issues and such a version history could be easily obtained. On one occasion this proved to be unfortunate for the architects. I was covering for our site architect whilst he was on holiday when I was asked by a member of the site team to look at the external damp proof course levels (dpc). It had been pointed out by the subcontractor carrying out the hard landscaping that the dpc level was too low and did not comply with building regulations. Site queries were also raised and sent back to our office and the person responsible would answer them. The office replied with a drawing up loaded to Documentum. This however did not solve the problem as the dpc had already been installed. The first issue was to resolve the problem and then investigate how it had happened. The solution was to create soft landscaping around the perimeter of the building in order to lower the levels sufficiently to allow the dpc to be 150mm above ground level. When checking the version log of the drawings it was found that the dpc had not been dimensioned on the drawing prior to construction and had in fact only been added once the problem had been discovered. As the current drawing on the system did not reflect what had been built it had to be amended and re uploaded otherwise the as built situation would not have reflected what that architect had drawn. Although the situation was resolved the issued had to be raised to the project director as it could have constituted a potential professional indemnity claim by the contractor.

Trust Commissioning – the Trust set up a commissioning team to transfer the services from the existing hospital, the maternity hospital and the orthopaedic hospitals We did not get involved in this. There was however one interesting method of communication used and that was to advertise on the local buses the date and time of the transfer of Accident & Emergency Services. This large advert appeared on the back of many buses for months leading up to the transfer. All other services could be pre-planned with the exception of this department.

Local reaction to the new hospital focused not on the design but that the patients complained that the food was terrible! Although there was capacity in the basement to have provided a preparation kitchen, the method chosen was cook-chill (all the way from Wales!). The was because the SPV provided both ‘soft and hard’ FM services. The other compliant related to overheating, part of the problem resulted from an underestimation of the number of clerical staff being transferred. The clerical room occupancies were exceeded, also the numbers of computers printers. The situation as compounded due to the misalignment of the equipment information on which the engineering services were calculated.

Towards the end of the project the architects were asked to be part of the contractor’s team to bid for the PFI Team in Case Study 3. As the senior design manager and the cost manager were also involved discussions often took place on the site at Case Study 2. The JV had built up a data management team to organise and run Documentum. This proved to be very successful and the team (some of them graduate civil engineers) were keen to develop new ideas. The architect project director and myself who were working on the bid had discussed the idea of producing a single A3 Room data sheet and so saw an opportunity to develop this with the team. The contractor and the consulting engineers also saw the advantages of this and so we started to develop this with the team and use it for Case Study 3.

I think that the problem with this project was the steep learning curve encountered by the JV and the lack of integration within the JV as well as with the design team and the client. It was if any lessons learnt had been ignored and everything was being started from scratch learning as they went along. 'Silo working' was prevalent and roles were determined by which company the person worked for rather than their experience and abilities. Each sector had two project managers: one from the contractor and the other from the M&E contractor with both thinking they were in charge. Equally the architectural team also lacked experience.

3 Case Study Three

This was one of the second wave PFI projects. By this time more SPVs were interested and as a result, it proceeded through several stages of competition before reaching preferred bidder. The project involved building a major extension to a nucleus hospital, built on an exposed site a hill overlooking a large town. It was to accommodate the transfer of all the acute services from the existing town centre site which was a land locked with no room for expansion. The existing nucleus hospital which contained non - acute facilities had been built in a series of four phases each one designed using the nucleus system.

The same architects in Case Study 2 were asked by the same contractor to participate in the bid along with the same consulting engineers (who worked closely with the same M&E contractor - who were the other partners in the bid). Both the senior design manager and the cost manager from Case Study 2 were involved at this stage. This time it was a joint venture consisting Balfour Beatty and Haden Young (BHJV). It was the same SPV. This time the SVP had appointed a health planning consultant. Following notation of interest, we were selected as one of the 6 teams to proceed to PITN in August 2000. The trust in their PITN (preliminary invitation to tender) documentation had included Clinical Output specifications - written descriptions of the facilities required to carry out the services and which contained references to compliance with HBNs and HTMs. They also included ADB room data sheets and schedules of accommodation prepared from the PSC (private sector comparator) drawings. The trust also had a data room continuing additional information set up in the hospital which all bidders could visit.

The Project Director who was the same 'eager beaver' as in Case Study 2 being keen to get a head start proceeded to develop 'schemes' based on the PSC areas as the health planner was still preparing the schedule of accommodation. I started to check the rooms listed on the PSC with the clinical output specifications and discovered differences between them indicating that the PSC departmental areas were too small. The site was quite tight in area so this was problematic. The PSC scheme proposed extending the hospital by adding nucleus templates. As room sizes were dictated by the templates some of them were much smaller than those included in ADB. Eventually the health planner produced a schedule which confirmed the PSC as being under area. At this stage in the process it was the overall site layout and proposed elevations of the scheme together with the cost on which the bidders were selected proceed to the next round.

FITN (Final Invitation to Tender) was issued in October 2000 when the number of tenderers was reduced to three. FITN submission of December 2000 resulted in us becoming one of the final two tenderers to be asked to submit for BAFO (Best and Final Offer) in July 2001. A further submission in August 2001 LAFO (Last and Final Offer) led to our appointment as Preferred Bidder in October 2001.

During the BAFO stage we were invited to attend user group meetings at the trust. This was quite a difficult exercise for the Trust as they had to organise separate meetings for the two bidders and although we could present layouts and sketches we were not allowed to leave any drawings with the users even if they asked the Trust. The layouts were produced at 1:200 scale and approval was mainly sought for room relationships (departmental relationships having been agreed in principle in the earlier submission. It was also difficult in the sense that we were building up a relationship with the users and the thought of not being selected unthinkable. The meetings were attended by our project director, myself, the Senior Design Manager from the contractor and the healthcare planner representing the SPV. Strategic meetings were overseen by the contractor's Director of Design who worked within their Technical Services Department (the department responsible for the project until the site team were appointed).

The old road to the town bisected the site and beneath it ran the high voltage electricity cables. This road had now become part of the site development with the main hospital on the south side and the Mental Health Unit to the north. The new extension was therefore on the south side. The site was extremely exposed to the weather and the new main entrance was designed on the north side of the site with a tunnel under the road leading to the main hospital. The Trust liked this feature and the 's' curve ward block to the front elevation which faced the new main road away from the main hospital. During the final 'BAFO' submission presentation the Trust's Project Director apologised to us regarding the ward layout. The comment from the users was that the ward layout was unworkable. He explained that the matron in charge had not been at the last meeting with and had not raised the issue. We were able to demonstrate a different ward layout which would meet their criteria and were asked by the Trust to amend the layout and resubmit – LAFO (Last and Final Offer). I then spent two days with the contractor's Director of Design trying to redesign the concept which meant moving away from the 's' curve before integrating the ward layout. The scheme was resubmitted and led to us being appointed preferred bidder.

The trust held a feedback meeting giving user comments – the user groups had voted on which layout they preferred. It was quire amusing when we met them again; most of them had voted for our scheme and were very keen to tell us and looking forward to the next stage. One consultant however informed us that he did not like the scheme and that we were the team who had not gone to see him! The trust representative had to explain to him that they had not invited us to meet him as it was very difficult to arrange 100% duplicate user group meetings with both bidders. Ultimately when the final scheme was completed he was absolutely delighted and decided to postpone his retirement!

It was all change once the stage from preferred bidder to financial close started. BHJV appointed a site team led by the Project Director who had been in charge of another PFI hospital, a senior project manager and a commercial manager; the Senior Design Manager from Case Study 2 and the Director for Design went back to head office. The Trust provided accommodation on site in some existing buildings so that the team could set up a base. This stage was estimated to take 26 weeks in the Capital Investment Manual (Department of Health Guidance) and in fact lasted 84 weeks. 26 weeks was completely unrealistic as Planning consent was programmed to take 26 weeks and then 13 weeks had to be added in case there are any objections (which there were in this case as a local resident stated that lapwings were nesting in the hedgerow!) and due to size of the scheme it required Treasury Approval and the Full Business Case negotiations added another 34 weeks.

Before the 1:50 Room Layouts could be started, the 1:200 layouts had to be reviewed as the scheme had undergone a drastic redesign in order to reach preferred bidder. A series of departmental review meetings was set up with the Trust working with two teams. The contractor's Cost Manager who was still involved and I led two groups with another architect from the office supporting him and the commercial manager working with me. The first review meetings were completed by the 21 November 2001.The revised drawings were due to be issued by the end of November for a second round of reviews to start on the 3 December 2001. At the same time the first 1:50 Room Layout Sheets for standard rooms were due to be issued on the 17 December 2001.

This timetable proved to be too ambitious – too many things were happening at the same time. The JV had decided to adopt 'Build on Line' instead of Documentum as the electronic drawing management system and had just appointed a design-coordinator to manage it. I had arranged a meeting at the end of November with JV to demonstrate 'Codebook' which was a system which we were adopting which would link the room data sheet information and the room layout drawings and should ensure that the information matched on both. The advantage also of Codebook was that although it had been set up to run ADB (also Hiltron) we were also able to change the equipment codes to match those developed at NRIE and develop the A3 Room Data Sheet which we had been working during the bidding process and had included in the submission. This was a single A3 sheet containing all the room data sheet information required for review and directly linked to a corresponding room layout sheet.

The SPV had started the preparation of the contract documentation and at this point wanted the JV take over the appointment of the health planner. Having considered that he had hardly contributed to project so far it was decided that we would do without a healthcare planner and the cost planner and myself would monitor the Schedule of Accommodation with the architects managing the healthcare planning. Part of the contract core requirements documentation involved compliance with HTMs and HBNs. The SVP's lawyers were the same firm who had been involved at Case Study 2 and were keen to take the same approach whereby the majority of them are guidance only with the exceptions being related to medical gases, ventilation and fire precautions. The Trust had employed a health planning consultant during the bidding process and had decided to continue throughout the 1:50 review period. It was a different person who took over, someone who was more focused on equipment and the layout of the individual rooms rather than the room and departmental relationships. He came from an engineering background and was very pernickety and devoted to ADB! Our first meeting was rather fraught, he saw no reason why we were altering ADB, using A3 data sheets and reducing the sizes of some of the rooms. He did not get on with cost manager who pointed out that we were using room sizes used at Case Study 2 which although less than ADB were greater than those in the PSC and that currently the scheme was unaffordable! The result was that the cost manager did not attend future meetings with him, we did not however change the room data sheets or our coding system!

In early January 2002 the contractor introduced another Project Director (who had been Scotland Director) so there were two Project Directors on site. Not only were they completely different in approach but they also disliked each other. With the second Project Director, the divisional commercial manager arrived to help the contract negotiations with the SPV and the Trust. This Project Director quickly started to interrogate the area schedule with the cost manager and as a result I began to work with them. It was a confusing situation having two project directors and caused tensions with some of the office working with one and the rest the other.

At the beginning of February 2002, the Trust's Project Director wrote to the SPV to record concern about the design development programme and its impact on the project timescale. The review of the second pass 1:200 drawings had demonstrated that amendments had not been incorporated and so the remaining meetings were cancelled as the Trust could not agree to continue with 1:50 reviews without adequate resolution of the 1:200 drawings. The

Trust in order to mitigate delay agreed to review the drawings without the users and feedback comments. At the beginning of January 2002 the Trust requested that two rounds of 1:50 reviews should take place and agreed to move financial close from the 28 March to 31 May 2002. The drawings were due to be issued on the 4 February, this date was missed and the result was that the Trust cancelled the proposed meetings. At the same time, the Trust became aware that the area of the building on the current 1:200 drawings was now 3,600 square metres greater than the area in the BaFO submission. Their concern was what had caused this as the only additional area added by them for the Cardio Catheter Lab and had been assured that the revised ward layout could be accommodated within the BaFO cost.

I set about looking at the 1:200 drawings to see where we could make such drastic cuts, to be effective the same area had to be cut from each floor with the exceptions of Level 0 and Level 3. As a result of incorporating the BaFO requirements, we had created additional space at Level 3 to accommodate the Haematology Clinic to suit the consultant who had complained! Having listened to him and discussed with the Trust it was agreed that his requirements were unreasonable, he wanted a waiting room for 80 people one day a week! Although he had liked his new department and was pleased that we were listening to him, he wanted it to be closer to the main out-patient department (OPD). We proposed therefore to combine it with the OPD and delete it from Level 3. He was delighted and the new Project Director was very pleased saying that we should do more of this! He had already marked all the departments up as ‘good and bad departments’ – the bad being over area. We had suggested to change the mix of 4 bed and single rooms to reduce area but this was not acceptable to the Trust. By carrying out some amalgamations and relocations we manged to reduce the overall area to within 300 square metres of the target. The redesign met with some opposition within the architect’s office from some of the ’designers’ who were more concerned with appearance than functionality and found it difficult to understand that if could not achieve functionality there would be no project!

Immediately after the letter from the Trust to Consort expressing concern was received by JV a meeting was held with the new Project Director and the Senior Commercial Manager, our Project Director and myself to address the Trust’s concerns. This involved drawing up a new programme, agreeing the area schedule with them and reviewing the main entrance. Fees were also discussed, and it was concluded that the contractor’s current order value was sufficient to cover the architects’ commitment. One of the major design changes was to the main entrance where the entrance to the building was incorporated into the main building on the south side of the site. It was at this point that JV confessed that they had had no intention of building it on the north side and tunnelling under the HV cables as this would have been too great a risk. The programme included a series of 1:200 Departmental Reviews starting at the end of February whereby meetings were held involving ourselves, the consulting engineers, representatives of the Trust, the SPV and the JV reviewed the drawings and recorded the number of rooms, area, their relationships and types in order that the room layouts and loaded 1:50 drawings could be drawn and submitted. A Departmental Review Sheet was then signed by all parties. (this format was developed from one which had been instigated at Case Study 2 when there were problems with checking compliance prior to financial close). This process worked well and the trust prepared the status report by the end of March indicating that only 8 of the 42 departments still had problems, four of which were already being addressed and one – anaesthetic administration which had serious area problems due to the 22 consultants wanting individual rooms. The Trust Project Manager took the initiative and managed to persuade them than by agreeing to one large open plan room with a separate library/meeting room they would have a much better working environment with natural lighting. This proved successful and by the end of April 2002 all the Departmental reviews had been signed off.

By this stage the SPV had appointed their team consisting of a Project Manager and a Construction Manager (both of whom had worked on the Cumberland Infirmary which was the first PFI project) and an architect as Design Manager. Not long after the JV original Project Director moved of the project and the second one took on overall charge. The cost manager also returned to Edinburgh. Gradually the JV team structure was taking shape.

Also in late February 2002, I took part in the initial JV Risk Workshop. Five high risks were identified and after mitigation these were reduced to four medium and one low risks. The risk which was mitigated to low related to Services and a 'Failure to commission on time'. The actions related to mitigating risk involved planning and programming sufficient time for commissioning, efficient construction and commissioning management and appointing and independent tester. Two of the other high risks involved design, 'Non-compliance with agreed design brief/accommodation schedule'. Mitigation reduced the risk by understanding difference and obtaining agreement, concluding final documents and incorporating them into the project agreement and re-designing where appropriate eg. room relationships. The residual risk was to fail to fully understand all the differences. The other design risk involved 'Insufficient design resource/management' due to insufficient funding, lack of understanding of the design management process, shortage of available design resource. The mitigation actions involved were to consider additional funding, develop better integration, ie. one team, prepare process/resource chart and recruit as appropriate. The residual risk was that there was no additional funding approved. Groundworks relating to disturbing existing services (particularly the HV cables). Mitigation involved Pre- Health and Safety plan, method statements, inductions and training, modifying design where possible, check robustness of existing contingency plans. In this case the residual risk was human error. The final high risk related to Late Changes, caused by trust requirements, control of users demands, design development and changing legislation. Actions considered to mitigate included clear, defined, workable, practical change process, clear responsibilities for action, decisions within appropriate time parameters and no changes until post practical completion. The residual risk is that changes are still required.

Looking at the risk register there are several items which were considered to be low risk which had the potential to cause problems. Three of them are related to design, the first being the clarity of the Trust's requirements – presumably because the building area discrepancies had been resolved at this stage. The second relating to changing government legislation may cause re-design and re-work but will be at the Trust's expense and the third relating to the impact of design on FM is reduced due to the fact that only hard FM facilities are being provided by the SPV. Under the heading of' Envelope' relates to the lack of co-ordination of design elements; the interfaces between cladding windows etc; the problem which occurred at Case Study 2! Refurbishment of the existing buildings, the risk here was related to the Scope of Work and though estimated as low, it ultimately cost much more than anticipated. Services and 'Re-work on site' due to lack, or insufficient co-ordination with architectural, structural or other services was also considered low risk but was difficult to control as although a 'joint venture' they behaved as two entities.

This was a particularly difficult period in architectural practice. There were teething problems with using code book and even though there was a synchronising check which could be run to ensure that all the equipment indicated on the RDS was transferred onto the drawings, manual checks proved that there were discrepancies. Many of the team were not experienced and the we were heavily criticised to the extent that the JV employed another firm of architects to visit our offices to check the drawings against the RDS. Interestingly the JV were able to pay another consultant to carry out QA but stated on the risk register that there was a residual risk to the design as there was no money for additional resources! Eventually we were able to convince JV that this was unnecessary and in fact becoming detrimental to the process as the firm checking the drawings were misunderstanding issues.

The JV also sent their design co-ordinator to work in our office to monitor progress. Having made their point about quality and acknowledging that we had put in place a more rigorous system (including the Departmental Reviews) this 'overseeing' of activities stopped.

The architectural team started to grow and luckily a senior architect returned (she was part-time but extremely able, more effective than most of the full-time team members) and she got involved in the 1:50 process and the user group meetings. During the bidding process we had built up a good relationship with the user groups and this continued throughout the 1:50 process. The Trust's health planner who had at first opposed our A3 RDS Sheet with simplified codes (which the Trust liked) warmed to the idea and when we produced code lists and demonstrated our understanding of the ADB codes we built up a good relationship with him. He was extremely good in explaining to the users what they should be looking for on the room layouts and protecting the Trust's interest. Having demonstrated to the JV Project Director that we could be trusted to promote the JV's interests and not 'overspend', he decided that I or our senior architect could represent the JV without having a 'minder'. He did not see the sense in paying a member of his staff purely to watch us doing our job! The SPV was initially represented by their Design Manager but he left and the Construction Manger took over. The Trust's Project Manager organised all the meetings and we made an agreement with her to give proposed dates well in advance – the contract had a two week review period from the issue of drawings, but in order to get the right people at the meeting the programme she told us that the meetings needed to be arranged six weeks in advance. We set up a system whereby the construction manager took the meeting notes, the project manager marked up the RDS and I marked up the drawings. This worked very well and when the JV sent their quality managers to our offices to carry out an audit the result was successful.

The User Group Meeting programme was much more involved than anticipated, I produced a timescale to complete a department and it involved 23 stages over a period of 10 weeks. On the basis of two user groups for the first 6 weeks, followed by four user groups for the next 12 weeks and then two groups for a further 6 weeks the overall time required is 24 weeks.

The Project Director kept a close eye on the area schedule being acutely aware of the link between area and cost (this reflects the situation at Case Study 1 and traditional principles of 'How to cost a Hospital') and in November 2002 expressed concern that the net departmental areas had increased from April 2002 when the major area reduction had taken place. The overall building area had been reduced but this was due to a reduction in the calculation of plant space in the roof area. The major costs are in the net departmental areas particularly highly serviced areas and although in department cost allowances this reflected by department, the costs in the JV were split between the contractor and the M&E services contractor. We had adopted the same format of accommodation schedule as at Case Study 2 with the schedule being broken down firstly into Departmental Groups:

- In Patient Accommodation
- Out Patient Accommodation
- Treatment & Diagnostic Facilities
- Clinical Support
- Non-Clinical Support

And secondly within departs as:

- Patient Areas
- Clinical Working Areas
- Admin Working Areas
- Support Facilities (FM)
- Staff Facilities
- Public Facilities

In order, to reduce the engineering costs the Project Director created a separate schedule for the M&E services contractor to define high and low cost areas. For example, offices within Wards and Theatre Departments he deemed to be low.

By the end of 2002 all the 1:200 drawings had been reviewed and the accommodation schedule updated and the Trust had issued all their comments. Clinical Sign- Off by the Trust is a major element to achieve FBC and the Department of Health had introduced 'NHS Plan Uplift' during the process which affected the design. Also at this stage the preferred bidder is working at risk financially and as such is keen to keep costs down which includes design fees. The architects had a payment agreement during this phase; the consulting engineers had a different arrangement with Haden Young and were not being paid until financial close. This caused a few problems regarding the amount of input that the engineers needed to make to the RDS and room layout process. The trust had protracted discussions with the Department of Health and altogether this led to a lengthy timescale to reach financial close.

Works to the existing building proved difficult as there were no base room data sheets prepared by the Trust and we tried to set up a system whereby the Trust could access our data base. This proved difficult for technical reasons and sheets had to be hand marked. The alterations to the existing building were underestimated. A joint survey with BHJV and the consulting engineers reviewed all the rooms and an estimation of the level of refurbishment was made on which to base the cost. Some of these proved illogical; where two rooms were being created in one and they had different floor finishes, because the commercial team thought that the conditions of the floor finishes were good, then they did not have to be replaced! Needless, to say this did not happened and a single new floor covering was installed – at the JV's expense.

The Trust had compiled an equipment list from the ADB Room Data Sheets which had been part of the initial information provided. As this information, can be exported into Excel format it is very easy to create schedules from it. Our codebook data base was also in Excel format so the Trust's list could be compared with the items being loaded into the 1:50 drawings. Equipment was grouped traditionally into Group 1, Group 2 and Group 3. All of the radiodiagnostic equipment was been procured by Siemens as 'Managed Equipment' provide by the SPV. Many of the machines are on a leasing agreement rather than purchase and have a replacement period of 7-10 years, so this works well being include within the SPV payment mechanism. Although Siemens was the provider they were only allowed to provide a maximum of 70% of their own machines in order, to allow the users choice and not create a monopoly. The contractor and the M&E contractor wanted to split the items between them, so as a result I created three codes for Group1 – 1B, 1H and 1C to differentiate on the schedule. This allowed them to work out their respective costs. All of the traditional Group 1 codes had been transcribed into our coding system, but the Trust wanted some traditional Group 2 items (eg. leaflet racks) to be provided as Group 1. These we left as ADB codes. I spent a lot of time with the commercial manager explaining and advising on equipment due to the ADB information reflecting the PSC submission and not the Trust's requirements. The Trust had also provided outline specifications for large items such as medical gas pendants (correctly defined as Group1, but which the JV had decided would be procured by the M&E contractor as they had deemed it to be a 'services' item) and their Project Manager (not her official title, as she had been involved in supplies and procurement) who was responsible for the User Group Meetings was very knowledgeable which was beneficial to the project.

In 2003 before financial close the commercial manager team moved to another company and a new commercial manager arrived. Luckily, the equipment schedule had been resolved by then so there was a smooth handover.

By June 2003 all the sign-off comments from the Trust had been scheduled and agreed and 14 out of 42 Departments had been signed off at 1:50. However it still took until 9 October 2003 to finally achieve Financial Close with the 'Sod Cutting' ceremony taking place on 10 October 2003. After the enabling roadworks had been completed the site compound was set up at the far end of the site where the new entrance road had been created. The team was quickly expanded, it was however quite a tight team. There was no one with the title of 'Design Manager', this role was effectively carried out by the Senior Project Manager with the Design Co-ordinator managing 'Build on Line'. The architects were allocated a small office which we could use when on site, I spent 2-3 days most weeks based there whilst attending User Group and JV Meetings.

In September 2003 I also started the MARU MSc course 'Planning Buildings for Health' part time at LSBU.

The remaining 28 departments still had to be signed off, but by this time we had an effective system in place and sign off was obtained. Within the architectural practice I also started weekly meetings with the consulting engineers taking members of our staff to their offices as we could meet all the services engineers in one office – similar to the practice that I had set up at Case Study 1. The senior partner at the consulting engineers and I had discussed the idea of them preparing the ceiling layout drawings as the majority of the information was theirs, but unfortunately our 'eager beaver' had decided to get our 'students' to set them up as there was a lull in the programme. Again this proved to be a disaster, changes kept having to be made and when the ceiling erector started there were all sorts of problems with the grid and which direction was 'main tee'. There were also problems with the fire breaks above the ceilings and light fittings which had to be moved. I ended up solving these problems after I joined JV in August 2005!

Again, despite the irregular grid and that fact that the existing hospital being nucleus had a reinforced concrete frame with fixed 3900mm floor to floor heights, the contractor was determined to use a steel frame with floor to floor heights of 4200mm. At one point the use of 'slimdeck' had been suggested by the Senior Design Manager from Case Study 2 which would have meant that the floor levels of the existing buildings would have lined through. This solution was uneconomical due to the irregular grid and it was too late to redesign to suit a new grid. [this system was subsequently banned by the contractor due to Health &Safety!]. The result was that ramps had to be incorporated at Levels 1 and 3. I was however able to influence the column/partition junctions and ensured that the external columns were contained within the external envelope and out with the corridors. This helped to avoid drainage being positioned through steel beams! Partitions were also set out to contain movement joints (one exception!). The biggest problem with the steel frame was wind bracing. The contractor had priced for the cheapest solution which was basic cross bracing and finding locations on the external walls was difficult due to random window patterns, the solution to this was to use portal bracing in some of the bays. There was also a requirement for wind bracing within the building which could be either accommodated between rooms or on the link corridors. This highlighted a problem within the architectural team where the technical team were agreeing to locate the bracing between the rooms and I had to tell them that they could not position them there due to services within the walls. In the end we agreed to position them in the glazed link corridors and expose them as a feature!

The Project Director was very keen on innovation and prefabrication and had seen GRP Bathroom Pods. He was aware of the steel pods used at Case Study 2 but wanted to use GRP and set up negotiations with an Italian company who made pods for student housing and cruise ships. We were asked to design a pod which could be used in the ward ensuites. As they were constructed from a mould and this was a costly item there was a minimum number of pods required to make it cost effective. We ended up with 5 types: Left and right single rooms, left and right 4 bed rooms and an orthopaedic pod. Adjustments had to be made to drawings to accommodate this – it had not been a requirement during the design stage. The Project Director liked the sanitary fittings which he had seen in the pods which were all good quality German products but as they did not conform to HTM the proposal was that all the sanitary ware would be shipped to Italy together with all the Trust's Group 2 items- paper towel holders, soap dispensers to be factory fitted so that the final product could be shipped back and installed without disturbing the units until such times as the doors required to be fitted. This was to prevent them being used on site and reduce remedial work on site. A small team led by the Senior Project Manager, the mechanical and electrical engineers, a representative of the FM provider and myself – representing the design team visited the factory in Italy in March 2004 to inspect the prototype and discuss how the units would be delivered and installed on site. All the services connections had to be out with the pod. The engineers had prepared a very detailed check list and it proved to be a valuable exercise in team working.

A number of the major items of equipment were pre-selected by the Trust, to be procured by JV and as said earlier the equipment list was cross referenced to indicated who was responsible for procurement. As a number of the items were not 'stand-alone' I suggested to JV that an equipment meeting should be set up comprising representing the contractor, the M&E services contractor, the consulting engineers and myself. This proved to be very successful and resulted in the procurement of specialist packages such as the Aseptic Suite and the Containment Level 3 due to the success at Case Study 2. Another instance of using a specialist subcontractor involved the Audiology Booth. Due to the integrated working a couple of potential clashes were eliminated. The Trust's preferred medical gas pendant supplier was Trumpf. They were particularly keen to use them in ITU and as there was also a requirement for an examination lamp – which had a separate code and which the M&E services contractor had already provisionally procured. Trumpf could provide this as part of the pendant assembly, which meant that only one fixing point was required and any clash avoided. The Trust agreed and this led to the development of pendant schedules on future projects. The Ultra Clean Theatres also had Trumpf pendants specified and this time there was a clash between the canopy and the pendants. The solution in this case was to specify pendants provided by the canopy manufacturer. Cableflow again provided the bedhead trunking and following lessons learnt at Case Study 2 we avoided some of the problems. The ward installations were easier as there were no fixed wardrobes. I did have however to prepare a trunking schedule as seemed to be a task which no one thought was their responsibility and the engineers' both consulting and the M&E services contractor looked to the architect to provide as it would have been traditionally. Due to the process of providing construction/installation information being different in engineering services to building the change from architectural project management to design and build made little difference. the M&E services contractor staff tended to treat the architect in the same way as they would have had it been a traditional contract.

Just as in Case Studies 1 and 2 when it came to installing the electrical components the electrical engineers demanded setting out dimensions for all sockets etc. and a full set of wall elevations or 'C' sheets (termed used in ADB). They were well experienced in hospital building – mainly Nucleus hospitals which due to their nature were easy to replicate. As architects, we resisted the request for producing every room on the grounds that the 1:50 Drawings were fully loaded, although by this time computer aided drafting (CAD) made this much easier. A standard sheet giving the mounting heights for all items was produced and the wall elevations had a 200mm x 200mm planning grid (not 300mm as in ADB as this does not suit plasterboard or the setting out of studs which affects socket positions). This did not satisfy them – firstly they wanted sockets set out to centrelines, whereas we wanted them set to the top to line through – this was solved by asking for the dimensions of the socket boxes and working out the centrelines so that the tops all lined up! After many debates we gave in and produced all the Room Layout Sheets showing wall elevations (there were already RDS for every room). Although at the time it appeared a rather laborious task it was ultimately beneficial; an A3 RDS and Room Layout were pinned up in every room and it made compliance checking much easier. The result was that the JV team declared that on the next project this requirement would be included as a mandatory obligation from the outset. It avoided any debate as to how many should be done and 'what was a generic room' and reduced continual site requests for information. The other reason for wanting this information was that Haden Young were intending to use 'modular wiring' which greatly reduced the number of electricians on site by prefabricating the electrical connections to the socket outlets and plugging them in to junction boxes in the ceiling instead of using conduit.

One of the more difficult items of equipment to install were the ventilated post mortem tables. The Trust wanted Thermoshandon and unfortunately this was an American company whose equipment was manufactured to imperial sizes and connections. At this time there were rapid technological developments with laboratory equipment, in particular automated haematology analysers. The laboratory user group were very proactive and the Trust highlighted early on that they would be unable to provide equipment information until nearer the end of the project when this equipment was due to be selected. As it was an expensive element the Trust had to go out to tender but they would update us throughout the process. Early in the financial close preparations the contractor had asked us for drainage information, at that time most analysers required drainage, so to progress the design I had suggested that the slab in the laboratory be lowered and computer flooring (as in Case Study 1) be installed. This would allow for future options. The then commercial manager said that it would be too expensive and so it was not included. When work started on site, the senior project manager requested setting out dimensions for the drainage. I explained the problem and he was prepared to look at proposition again. This time he agreed and the lowered slab cast. Later in the project when it came to providing the fixed laboratory equipment which was JV supply, members of the laboratory staff came on a visit to Case Study 1 and the subcontractor's factory in Edinburgh. There they could see the latest options which had been developed since Case Study 2, the use of spine wall around the perimeter of the laboratories allowed the services to be provided and the layout of benches to be flexible. This solution allowed the floor to be completed and await the final equipment selection. This turned out extremely well and the end result was a 'state of the art' laboratory.

Towards the end of 2004 I was approached by a 'head hunter' for a major London Architectural Practice. This made me think about what I wanted to do next as on the design and build projects, the architects' role ends earlier than in traditional contracts. Also in early 2005 the Project Leadership module in the MARU course often led to participants thinking about their futures and changing direction. I had thought about working for a contractor and when the commercial manager suggested that I should 'change side' I said that I would be interested. The result was that in June 2005 I accepted a post at Balfour Beatty. The interviews were conducted at Head Office and although I knew the job would involve healthcare I was not sure where it would be. The JV Project Director knew exactly where it would be – at Case Study 3 to complete the project and then at Case Study 4. He was in the process of building his team. From my point of view I was pleased to complete Case Study 3 as I felt that I could help to ensure that the design could be executed as it was envisaged.

My role hardly changed on moving to the contractor and it did allow me to persuade the JV on several occasions to take a more proactive approach to design issues. I did discover some bizarre situations, one involving the ironmongery. Having spent time with the door set manufacturer (this time we had adopted the door coding which I had proposed for Case Study 2) and their ironmonger who had allocated a code to each type of ironmongery set to the individual door set, I noticed joiners fitting the wrong ironmongery to the doors. When questioned they knew nothing about 'ironmongery sets'. It turned out that although the suppliers had prepared the schedule with sets, they had sent the individual items in boxes of handles, closers etc. they did not even have the sense to pick out sets and label them. The result was that doors were damaged and had to be replaced. By comparison the M&E services contractor had a storeroom on site with a storekeeper for the issue of small fittings etc. a similar system could easily have been set up for the ironmongery.

One of the problems of the joint venture was that it was not fully integrated. The two companies divided up responsibilities. The contractor operated a 'work package' system for which we had to provide information. The consulting engineers were at the same time working closely with the M&E services contractor on their packages. The contract contained a list of Reviewable Design Data (RDD) which had to be approved by the Trust. This was separated into Architectural RDD and Services RDD. An attempt was made not long after work started on site to use 'ADePT which is software for use in the design process. It was too late in the process and unfortunately only the services consultant was enthusiastic. The architect selected by the architects was not interested and the design-coordinator from the contractor was too busy. Having seen a demonstration later I think it would have been useful but it needs to start much earlier in the programme. Initially, I was involved all the meetings related to departmental information including ceilings etc, and eventually ended up attending the building fabric meetings when staff did not want to come down from Glasgow. It was not until the electrical engineers raised a query over video entry systems did I get involved with the services RDD meetings. Up until then these meetings had taken place between the Trust's Estate Department, Haden Young and the Consulting Engineers. When I looked at their security drawings I realised that they did not understand how the departments worked and contacted the Trust Project Manager (who was excluded from the services meetings because the Trust deemed this to be the remit of the Estates Department). We both then attended the meeting and had to explain the overall building strategy to them. I tried to make the point to the Trust that even if separate streams were taking place and not wanting to waste valuable staff time (including the design and construction team) at least the Trust's Project Manager and the Project Architect should attend all meetings to ensure integration of both streams. This problem had arisen at Case Study 2 with resulting difficulties for the Nurse Call and Pneumatic Tube Systems.

As a result of this I worked much closer with the M&E services contractor and built up trust with the individuals, it was more difficult for the Trust's Project Manager (not her official title) and the Estates Director as he had prepared the original PSC and felt excluded from the Project Team. The increasing complexity of the security systems necessitated the involvement of several subcontractors in one item. This was demonstrated with problems in connection with external doors. In one instance 5 parties were involved: the subcontractor installing the door, the door manufacturer, the door closer supplier, the security system installer and the electrical subcontractor. People were also agreeing to provisions which could not be met – automatic double swing doors! Due to the principles of horizontal fire evacuation (Firecode) double swing doors between departments were deemed necessary, but this caused problems with the use of electro-magnetic looks for swipe card access. The use of double swing doors in long corridors as the doors could be held open by magnetic devices which could be released in the event of fire. The problem concerned the locks. It was something to note and avoid on future schemes.

In the reconfiguration design we had located the departments having considered how the decanting process could take place. Unfortunately, the JV Project Director and the Planning Engineer set about producing a programme including splitting the new build into three handover phases without consulting us. The JV had worked on the assumption that some services could be move into the new building to allow work to commence in the existing phases. In the end they had to revert to the sequence discussed during the design phase and although certain parts of the new build were handed over earlier they could not be occupied by the Trust due to access problems and need to create ‘buffer’ zones in the fire strategy between the hospital working areas and the construction site. As with Case Study 2 this situation could have been avoided if phasing had been included as a design issue.

During the package procurement stages the contractor had started a series of ‘Joint Procurement Initiative’ (JPIs) looking mainly at the components related to HTMs: doors, ceilings, floors for three forthcoming projects. This involved suppliers and subcontractors and by the end of the project we had established these agreements with ceiling and flooring suppliers.

Although Case Study 3 was a small hospital and in a smaller town than Case Study 2 they were similar operationally and both involved the transfer of Accident and Emergency. When the staff at Case Study 3 were setting up their transfer team I introduced the Project Manager to the Head of Commissioning for the Trust at Case Study 2. They toured the new hospital together and she was able to give her advice and a breakdown of the ‘The Transition Process’ into

- Structures, Processes and Risk – being prepared to re-invent every few months to meet the needs of the project at that time, having a dedicated team, managing a risk register – not collecting it
- Key Tools – Risk register, master programme and visual aids to help people understand what is happening
- Key Steps – Operational Policies, patient and staff flows and communication, orientation and training (this she considered to be HUGE!), FM policies and ambulance service training
- Key Challenges – planning theory versus the reality of the day – flexible thinking, building culture meets NHS**,** significant accommodation issues, building readiness, lack of enthusiasm (services) good working relationships – Service Co and FM provider, procurement and materials management, sophisticated security systems and keys (avoid at your peril!), waiting lists, winter planning, interface with primary care, communication strategy and decommissioning of existing facility

I also found this meeting very enlightening and how it emphasises the need to integrate the construction team with the Trust team particularly in the transfer of knowledge of the operation of systems and equipment to the users – both the FM staff and the clinical users. Once the internal partitions had been erected the construction team used to take different user groups around the site on a Friday afternoon and this continued until handover. Closer to handover I arranged compliance checking visits with representatives from the SPV and the Trust to ensure that the departments were ready for handover.

Not long after financial close the Trust's Project Director left to take on the role of Project Director at the Trust for Case Study 4, a larger trust with an ambitious project leading a Batch Hospitals Proposal. The project was in stages of redesign leading to preferred bidder. Towards the end of Case Study 3 the project manager also left to go to Case Study 4 closely followed by the Facilities Manager. The senior project manager left the contractor a few months before I joined and a 'Fit-out' Project Manager arrived so I effectively took over from the senior project manager, but still continued to work closely with the M&E services contractor and the contractor's commercial team on equipment. The JV were close to achieving preferred bidder status for the Batch scheme when I joined so as most of the team who were working at Case Study 3 were destined to move to it we started to look at some of the problems encountered and how we could avoid them. They included:

The Trust

- Output specification requirements greater than PSC (affordability difficult to achieve)
- No agreed accommodation schedule
- Output specification highly prescriptive (reference to HBN/HTM)
- Introduction of NHS Plan Up Lift during bidding stages
- NHS Estates – Planning issues, problems with their advisors

SPV/JV

- Lack of professional Health Planning advice
- Insufficient funding for design process
- Lack of knowledge and interference in the Design Process (Consort)

Architects

- Failure to fully carry out analysis at the start of the project
- Lack of holistic approach to design (split team responsibilities: internal and external)

Many of the positive aspects from Case Studies 1 and 2 had been adopted and developed on this project:

- Dividing the building into sectors and use of room numbering system
- Development of the Schedule of Accommodation format

- Creation of the A3 Room data sheet
- Use of an electronic data management system
- Inter disciplinary meetings with Services Engineers
- Setting up of integrated Equipment Package Meetings
- User Group meeting protocols
- Presence of Building Control on Site
- Partition setting out to reduce protruding columns
- Development of Door Schedules etc

Some problems still occurred:

- Failure to understand the need for considering phasing as a constraint to the design
- 'Silo' working – RDD process

4 Case Study Four

Case Study 4 was part of a 'Batch Hospitals' project consisting of three schemes. The idea was to price one of the hospitals and then use the rates to cost the other two. The project chosen on which to base the cost was Case Study 4. Just before preferred bidder status one of the other hospitals decided not to proceed and as a result the Batch involved only Case Study 4 and one other Hospital.

I became involved with the project in 2006 following preferred bidder. It was a long process to agree the commercial deal as the scheme at Case Study 4 had to be reduced in scope and redesigned. The contractor had employed an architect with healthcare experience (working in private practice and in a trust estates department) as a design manager in Technical Services to work on this project along with a Bid Director (outside QS consultant) and they continued on the scheme until preferred bidder was formally announced. At this point the project was transferred to the JV the contractor and the M&E Services contractor (sister companies). The Batch Core Team consisted of a Project Director, Deputy Project Director (M&E), Commercial Director and myself. There were then separate teams for the two projects. The core team had all transferred from Case Study 3 and at the handover meeting with the Trust their Project Director who was sat next to their Project Manager (both of them having moved from Case Study 3) said 'Well we know the two people at the other end of the table!' referring to the Project Director and myself. The discussion then continued between the top and bottom ends of the table with the others observing! This proved to be an important situation as both parties were experienced and understood each other and our Project Director was keen to 'exceed Client expectations'. He also did not recognise 'problems' instead they were 'challenges' which required solutions.

The contractor operated a system which separated stages of the project to different teams and therefor a handover procedure needed to take place, in this case from Technical Services (Bidding team) to the construction team. I started to get involved just before the costs for preferred bidder were agreed and attended a risk review meeting in April 2006. The project director, myself and the M&E services director had seen some of the proposals and they were horrified. The main acute building was circular and the single rooms around the perimeter had 17 facets each! I was asked to try to persuade them to change this as it would cause severe construction difficulties and extra cost. Politically this was not the time to attempt any changes but what was more concerning was that the site of the building encroached onto the main switchboard building. Rather than add cost to the project to relocate the telephone switchboard and operators' room the proposal was to remove the roof of the building, relocate the operators' room and building on top of it! This I considered the completed opposite of providing 'buildability'! The bid director said that this had been approved on the drawings and that it was something to discuss after preferred bidder had been achieved. The client wanted a 'signature' building and it was our job to deliver it.

The project consisted of several phases: the building of a multi-storey car park, an education centre (which also included high tech areas – mortuary and post mortem, decontamination and an aseptic pharmacy), the main acute building, link buildings including an underground link – to connect to the existing buildings on the site. The multi storey car park and education buildings were constructed first which gave time to develop the detail design for the acute building, although detailed costs had to be achieved for financial close. The new education facilities had to be completed first as the existing were in the two tower blocks which had to be demolished as it was the site of the new acute building.

Not only did the acute building have problems with buildability relating to the telephone switchboard, the circular shape and the facetted rooms, there were rooms missing and under area resulting in the net areas falling short of target, the gross area of the building was greater than target, the structure did not line through, services risers were missing and there was no possibility of using standard bathroom pods!

A new project director from the SPV joined the project at this stage. He has shadowed the previous director but he had no construction or healthcare experience as his background was in process engineering related to manufacturing and retail. During the bidding process, the SPV director and the technical services design manager had set up regular visits to the architects' London offices. The architects were an Anglo-American company and relied on their American healthcare expertise which did not always align with UK practice. (The fact that architects' offices were in London – a real annoyance to the M&E contractor who wanted the whole design team to be on site!) I went with the new SPV project director and the previous design manager to their London offices to review progress, but he could not understand why the architects did not have a 'process' which could deliver the solutions to be the problems and why there were delays. I tried to explain to him that designing a hospital was like designing a prototype, each one is different. As part of our design control process, we were required to carry out a quality audit on the designers, so I asked our Quality Manager who also at the time did not have much experience with auditing design (later she became extremely good and I worked closely with her to review our whole procedure) to audit the architects with the SPV project director. This proved to be successful as both of them had an understanding of process engineering, but she had construction knowledge and the understanding of the uniqueness of the project. Once the SPV director became more relaxed with the design process, he introduced new techniques such as setting up different work streams with the trust to tackle different issues. He was also very proficient with new computer programmes and introduced mind mapping, ‘go to meeting’ and particularly the use of interactive white boards. Even although the SPV and the contractor were both part of the same group, the two had very different budgets! The SPV had the latest of technology, better working facilities even travelling first class to London whereas construction travelled standard class!

The use of the interactive whiteboard was particularly useful for marking up drawings which could be downloaded and marked up on the board, images saved and then sent back to the architects. Using video conferencing discussions could also take place. I requested one of these interactive whiteboards for the site at Case Study 4 but it was deemed too expensive! Also another of the contractor’s hospital projects had bought two of them but they remained unused as nobody knew how to use them! The SPV director had a graduate trainee working with him and before we commenced the user group meetings he gave him the task of producing a document explaining to the participants what to expect at the meeting. The trainee was a law graduate who had to spend time looking at different aspects of the SPVs work before continuing in the legal department. As he knew nothing about design or construction the SPV director asked me to look at what he had done. It was a great idea, but unfortunately his lack of knowledge meant that it could not be issued. However having proposed the idea and seeing its merit I prepared a document entitled ‘A Guide to the User the ‘Group Process in the Design of Healthcare Facilities’ together with one for the ‘Departmental Co-ordination Meeting’. These two documents were issued to the Trust who sent them to all the participants of the user group prior to the meetings. This proved to be very successful and was adopted on future projects.

Originally my role was to oversee both Case Study 4 and the other batch project with design managers allocated to each project. The design manager who had worked on the Case Study 3 project was assigned to the other hospital as it involved the same architects. Two new design managers were engaged to work on Case Study 4 – one an architect who had worked for another contractor, considered himself to be very knowledgeable but proved to be disorganised – had little healthcare experience and not good at following procedures. The other one was an internal transfer from a retail project with a background in steel design! Neither the project director nor myself thought that he would be suitable but were overruled by head office. He also proved incompetent when it came to following procedures. The

Batch Core Team was also established on site at Case Study 4 being the major project and as a result I in order to ensure that Trust's expectations were met (the other Trust had lower expectations!) the majority of my time was involved with the Case Study 4 project. The project director who at Case Study 3 had allowed my colleague and I as architects to attend meetings with trust without a 'minder' realised that this could not be the case at Case Study 4 as the architects had failed to comply with the brief and the resulting cost.

Before the detailed user group meetings could take place, the departmental layouts had to be reconciled and the serious discrepancies between gross and net area resolved. The architects were tasked with this together with rationalising the 17 faceted single room! Having successfully achieved the area reduction exercise at Case Study 3 and set up the departmental review process – initially at Case Study 2, then at Case Study 3 I proceeded to carry out the same procedure at Case Study 4. The same procedure was also carried out on the other batch project where the trust had an affordability problem. Some of the initial alterations were rather brutal and it was difficult to stand aside and not interfere with the design. This was something I had to repeat to the architect design manager who tried to issue sketches to the site, explaining that we were managing the design not designing! I did however make suggestions about ensuring that the structural frame should line through, coordinate with the services engineers to ensure that all riser provision had been met. I also instructed them to design a standard ensuite bathroom which could be prefabricated which meant that dimensions for its enclosure had to be fixed. Layouts had to be revised due to the fact that 'drainage does not go through steel beams' and this gave me the opportunity to suggest alterations. After a lot of effort, awkward room shapes were eliminated, wasted spaces utilised and the target net areas were achieved within the gross target. The circular effect was achieved with minimal faceting to avoid the need for expensive curved beams.

At the same time we also reviewed the site plan and decided to move the acute building further north to avoid the telephone switchboard. The original idea was completely insane as it was not possible to locate the operators remotely from the equipment. Even if it had been possible, the building would have been too close to the building site in relation to health and safety which was a major feature of the 'Zero Harm' campaign. The services contractor could not believe anyone could be so stupid as to make this suggestion but did not want to pay for a new installation. The part where the new building which was to' cantilever' over the existing switchboard was redesign to accommodate a new switchboard and telephone operators room with cable ducts built in to allow the existing switchboard building to be demolished after the new building was completed. The other aspect which made this unbelievable was that this was situated at the main entrance! It was not on the front elevation to the main road, but as the site was being redeveloped with 'a green heart' removing the original buildings in the centre of the site and creating a green space in the main new entrance faced onto this green space.

One of the problems of the original Case Study 4 scheme was the communication routes. Incorporating a number of large new buildings into redevelopment and retaining the newer existing buildings meant constructing communication routes across and around the site. Existing access across the site was through the basement of the building being demolished. This link needed to be re-provided as the kitchens were located on one side and had to serve both. Also the Radiology department had different types of imaging facilities in three different locations which meant moving patients across the site. A link corridor which was partially subterranean and then turned into a covered walkway was landscaped into the 'green heart'. This link corridor also had to link into the new acute building. Due to site levels the link through the existing building turned into a connecting bridge parallel to the main theatre building at ground level. The theatre building also had to link to the new acute building at high level to connect the new intensive care unit to the existing operating theatre department. The proposal was to build a new link between the existing bridge and the theatre building together with a high-level bridge to the theatres. This was another example of poor 'buildability'. The project director had great faith in the Planning Engineer who had worked at Case Study3 and insisted in appointing him on the project- he was an outside consultant and as such a greater cost to the project than using an 'in house' planner. The architectural team was large and as such different individuals worked on the various departments without thinking about the scheme as a whole and did not take cognisance of the effect of the new facilities on the existing departments. As a result these links were not only 'unbuildable' but the communication routes did not work.

I began to work with the planning engineer to look at the phasing and how these links could be achieved and between us we were able to propose a solution which could achieve the required circulation and could be built. It involved creating a new façade to the theatre building which created an external corridor at all levels. It did mean some isolated expensive construction due to working in restricted zones but the end result was that by continuing the cladding used on the new acute building across the façade of the theatre building the new building blended in with the existing. It also avoided the construction of a 'cheap' freestanding link and allowed one of the levels to be used as a services zone. As an architect working with the planning engineer enabled an aesthetically pleasing solution to be achieved.

The moving of the building also required attention to be paid to the location of the existing external medical gas services compound at the theatre building. The relocation of the building allowed a courtyard to be created to accommodate this as if left in its original position it would have caused a problem. The lesson learnt here is that before designing any new facilities cognisance of existing buildings and services needs to be fully investigated and understood.

Much of the early planning was carried out by American healthcare architects and although they used HBN and HTM guidance problems arose due to lack of knowledge about building regulations in relation to circulation and fire escape. They also focused more on the use of lifts than stairs. This resulted in last minute alterations having to be made to the main stair in the education building as it started at the Main Entrance Level but did not go down to the floor below. On entering the building the main focus was the lifts with the stair wrapped behind them. In order to access the lower floor where the clinical support areas were situated you had to go back out of the building and re-enter it through a different door. The layout was re-arranged to ensure this did not happen.

Both the project director and the project manager were very impressed and had great faith in the design director from the architectural practice. He was an experienced UK architect but not an expert in healthcare design. Although he headed the team, it was spilt between healthcare designers who focused on the internal layouts and technical architects who developed the detailing and external envelope. The two groups were coordinated by a project manager who allocated resources and produced internal programmes. The architects on case studies 2 and 3 also tended to work in this manner, although the project director was a healthcare architect with good technical skills who oversaw the whole project. I have always worked as a project architect taking full control and although my expertise may lie in certain areas, know when to delegate certain tasks to others who are more capable in a particular field. However, I think that you should not separate healthcare design from technology and in particular mechanical and electrical installations, structural frame and most importantly internal drainage -which is usually the responsibility of the architect. The architect is also responsible for co-ordinating all other disciplines and mechanical and electrical services alone accounts for around 40% of the building cost. Although the external façade and roof etc can be designed by different members of the team it is important that elements such as windows suit the internal layouts as well as the external elevations.

At the same time as I became involved in the scheme, a new UK architect joined the architects who had healthcare experience and was used to a more integrated approach to architectural design. Gradually as some of the American architects returned to the US she took over a greater role in the project and became involved in the user group meetings. The original UK architectural practice which had joined with them split from them. Although the principals working on the project were now mainly from the UK, all costs etc were monitored from the US. The commercial manager had agreed the fee payment schedule with them– which was front end loaded (prepared separately with head office and based on design and build principles where they deem the architects' services not be required in the latter stages!). The architects spent the money – including staying in the most expensive hotel in the city and as a result when it came towards the end of the project and their input was required they were very reluctant to attend site – head office in the US would not sanction the expenditure. They did have site representatives but they were contract staff and were not able to make decisions.

It was an unfortunate situation as both the project director and myself had good relations with them, but some members of the construction team became very irritated by them. During the room layout process I brought a young engineer with a construction management degree on our graduate scheme on the team as a design co-ordinator and introduced him to them in their London office so that he could see how and where they worked. Not having seen an architect's office or being involved with architects, this worked extremely well and he built up a good working relationship with them getting involved with the user group process which involved meeting clinicians and the trust project manager. The result was that he became a very good design manager having gained experience relating the stakeholder engagement, working with the designers and then overseeing subcontract work packages on site.

The trust's brief was again prepared using ADB room data sheets and a series of clinical output specifications. Equipment was categorised into A, B, C and D reducing to A, B and D where A represented Group 1, B Group 2 and D Group 3. The JV wanted to use the same A3 format which had been used on Case Study 3 and this was welcomed by the trust. The architects however were using the standard 4/5 A4 sheets which result from ADB and were at first resistant to using the coding method used at Case Study 3. After much discussion they agreed to adopt the different codes and format and their data manger became a very valuable member of the team. They also agreed to produce RDS and layout sheets for every room – although they wanted to use typical and unique rooms, the JV having had a complete set at Case Study 3 were not for backing down. The arguments against the complete set were becoming weaker due to the advances in computer programmes and having fought the same battle and lost at Case Study 3 I had to advise them that the benefits of providing the complete set out- weighed any perceived gains in producing the information.

This time the trust had categorised certain equipment items within the A category as A+ to define the items in which they had a choice of manufacturer. For each item we had to propose three options if possible and had to agree a timescale for selection. This list with attached costings became part of the contract documents. Most of the other category A items were part of the general Reviewable Design Data (RDD) process. Category B were items which the trust had to provide and we indicated against each item when it was required. Category D items were mainly large items of medical equipment and furniture including beds but it did include radiodiagnostic equipment which interfaced with the design and construction. I suggested that we should note these items should be categorised as D+ and a timescale provided by the trust relating to the model selection. This was agreed and proved to be advantageous to the mechanical and electrical engineers as they were able to ensure that the correct services were being designed – unlike the problems with equipment at Case Study 2. Following the success of setting up equipment meetings at Case Study 3 the equipment list was itemised and grouped into packages indicating which subcontractor within the JV was responsible.

The team set up at Case Study 4 was slightly unconventional in the sense of roles and responsibilities. The project director and myself were more heavily involved with Case Study 4 even though separate project directors had been appointed for both batch projects. The other batch project operated as a more autonomous project, only reporting to the core team at monthly review meetings. The project director at Case Study 4 unlike the other senior construction staff was unqualified having worked his way up from being a bricklayer and although he had been a project director on a large P21 hospital project for another company was not computer literate, old fashioned in his practices and considered that as it was a design and build contract he could over rule the designers. He did not like management duties and would have preferred to be the construction manager. As a result he was generally ignored and the management team and staff looked to the core team project director for leadership. The team had great faith in him, the majority having worked with him at Case Study 3. The senior project manager and construction manager oversaw the site.

Generally, the title design manager only related to building element as the JV M&E partner also employed their own design manager. The M&E design manager's role was however rather different and was more of a 'design checker' of the consultant's design which did not involve the detailed design input from the subcontractors. On many of the other hospital PFIs an equipment manager was employed by the M&E partner to look after the medical equipment. This had been the case at Case Study 2 and had proved unsuccessful and at Case Study 3 where no appointment was made (the Project Director did not see the need) the outcome was more successful as a result of my role acting in the more traditional architect's role of coordinating the design. As a result I set up the integrated equipment work packages and managed the information for specialist packages relating to medical gas pendants etc on behalf of the M&E services contractor.

We set up regular meetings between our project director and the trust's project director and myself and their project manager to discuss items informally with the sole aim ensuring that 'client expectations' were met. This arrangement was set up during the financial close negotiations and continued throughout the construction phase, it started on May 2006 when I met up with the Project Manager when we carried out a check of the rooms as drawn against the brief prior to the User Group meetings starting in June 2006. A regular meeting with the construction team and the trust estates department was also set up so that day to day issues regarding deliveries, service shut- offs could be addressed without either disrupting the running of the hospital or the construction works. These were additional to the regular meetings which took place with the SPV.

The trust's motto was 'safe-clean-personal' and they were very proud of their infection control record. At all the user meetings there was a representative from infection control. This is an issue which is very emotive and subjective in opinion, unlike the building standards regulations, the HBN document is for guidance and can be interpreted in different ways. Some advisors advocate use of hand gel in certain areas others require wash hand basins (gel is effective for MRSA but soap and water is required for c-difficile). The position of wash hand basins within a room is also debateable and it was the position of the wash hand basin in the single room which nearly caused a crisis at financial close. A lot of work had gone into rationalising the shape of the single room and a full size mock-up together with the ensuite had been constructed within the existing hospital for staff to comment on. The position of the WBH was close to bed but backed onto the ensuite to optimise the drainage. The room had been approved and signed off by the trust when a member of the infection control team suddenly drew to the attention of microbiologist who had attended all the meetings that the basin should be closer to the door. Despite the fact that it had been approved the infection control team pressed the trust to have this altered and apologised for having missed it. The problem was that due to the radial plan and the steel frame the basin was projecting too far into the room at its narrowest point and would restrict access. To widened this dimension would have meant increasing the radius of the building which would have resulted in increased area and cost. Due to a similar isolated problem at Case Study 3 where a basin was close to steelwork, the services contractor had utilised a different type of drainage system which was of a much smaller diameter. This was investigated and by using this, the concealed plumbing box outs were sufficiently reduced in size to allow the basin to be repositioned without restricting the room access. This was a lesson in how something which was not mandatory could influence outcomes by suggesting that patients would be put at risk and the trust would not take the risk even although contractually they had agreed to it.

Another example of statutory versus guidance related to the building regulations and DDA. In accordance with the regulations the electrical subcontractors were proposing to supply and fit grey sockets and switches in order to comply with regulations regarding visual impairment and DDA requiring a contrasting colour to the background. The trust did not want this – they wanted white sockets on a white background. In order to satisfy the building authority, I prepared a paper outlining the clinical reasons for using white on white in-patient areas, allowing for grey sockets and switches for patients, public and staff elsewhere and this was successfully submitted by the trust.

The SPV had used an external healthcare consultancy prior to preferred bidder and in the next stage to Financial close they employed a healthcare planner as part of their team. Her background was a radiographer. She became involved in all the user group meetings and took on the role of signing off for the SPV along with the Trust project manager and myself adopting the same process as in Case Study 4. The trust also decided to appoint the same healthcare planner that the team had worked with at Case Study 3 to review all the RDS and 1:50 drawings. As a result with an established core team and the ‘new’ members – the project architect, the SPV healthcare planner and our design co-ordinator we successfully built up a strong user group work stream. The process did not go quite so well on the other batch project as the trust decided not to appoint a healthcare planner to carry out a check for them as they considered that they could save money and do it themselves. The problem was that they had a very experienced equipment manager, but her assistant had no healthcare experience having come from shoe retailing! Some of the clinical and nursing staff had rather old-fashioned ideas and in no circumstances could you suggest that they adopt 'Case Study 4' ideas!

As well as using the 'User Group Guide' the trust project manager kept a folder of photographs from Case Study 3 to show staff what certain items of equipment looked like. The contract programme indicated a two week process for issuing drawings and immediately after preferred bidder this timescale had been set out by the SPV and previous construction bid team. After a couple of disastrous meetings when everyone was ill prepared and drawings issued late, the project director and myself met with the trust and agreed to adopt the same principle as on Case Study 3. The User group meetings would be arranged 6 weeks in advance to ensure that the right people could attend and the programme adjusted to reflect this. The drawings would still be issued on a two weeks basis to reflect the programme but meetings arranged in advanced. The trust's project manager also arranged meetings with the users before the meetings to explain the process to them and help review the information. This process worked extremely well and the meetings were generally attended by the senior consultants, senior nurses as well as junior staff and secretarial staff. On one occasion a particular consultant who had agreed to the 6 week appointment (time needed to ensure he had no clinics or surgical commitments) told the project manager a few days before that he did not think he could come. She told him that he had agreed to this meeting and it would be going ahead regardless and it was in his interests to attend. He attended the meeting, was extremely helpful and the end result proved to be very successful. It was an important department to review as it was a 'one stop shop' meaning that the outpatient clinic, treatment rooms and ward were all interconnected.

The importance of having the right people involved proved critical in the accident and emergency department. This department was design as part of an 'emergency village' as it interconnected with a 55 bed emergency admissions unit. It was designed at ground level and part of it was single storey with the curve of the ward block cutting across it. The resuscitation room was originally designed to be in the single storey section. The trust had briefed an 8 bay room – larger than in the HBN. The room was wedged shape and undersized. Unfortunately, one of the consultants who attended the meetings was unable to visualise from layout drawings – she also wanted a staff base from which all the cubicles (over 40) could be viewed and the layout remained in this configuration until just before financial close. The main discussions on the resus room centred on the provision of medical gas pendants to each bay and requirement for an overhead X-ray gantry. Because of the 8 beds this would require two sets - one over each four bays. This was not included in the costs and had the additional problem that they could not be accommodated if twin-arm pendants were to be installed. The HBN recommendations did not reflect modern technology or current medical practice. As a CT scanner was going to be installed within the department the radiographer agreed that this would provide better diagnostic facilities than overhead gantries. A new consultant became involved in the project and immediately pointed out that resus room was in the wrong location. Because of the good relationship with the trust, together with the architects we met him with the project manager and produced a revised layout. The biggest problem with the layout was that it meant a major change to the grid layout in the area as the resus room was now sited below the radial block and in order to remove columns from this large space transverse beams had to be designed into the structure. At this point the primary structural steel design had been completed. The project director realising the importance of this change agreed to this late change to the design. From then on we dealt with this consultant and the end result was very successful – it is now considered to be an exemplar department.

The project director was very keen to build ‘mock-ups’. He considered that it was better to spend money building a room when it was going to be replicated many times. We had built a single room and ensuite prior to financial close and so as there were 36 intensive therapy beds he decided we would build one in a warehouse which the trust had rented. This room was built full size with all the components, sanitary fittings etc being supplied by the proposed subcontractors including the medical gas pendants. The trust supplied the bed, trolleys, infusion pumps etc. this then allowed all the members of the trust staff to come and view the room, try working in it and then give feedback before work started on site. At this stage the room dimensions could not change (they were in accordance with HBN) but the position of the clinical wash hand basins and the pendants could be established. It also allowed staff to see the extent of the glazed walls. This had been an issue early in the design when the architects had produced 3D visualisations which did not reflect what could be built – artistic licence! (On subsequent similar situations we had to stop the architects issuing such drawings directly to the trust without prior approval in order to prevent unachievable - buildability or cost causing upset to the trust.)

Later in the project we made another ‘mock-up’ this time it was for a renal dialysis station. Roughly 30% of the acute building was related to renal medicine – outpatients, dialysis and 56 in patient beds. As there were 27 dialysis stations in one room with 6 adjoining single rooms the trust wanted this to be a light open area. Again, the architects had shown low level walls and glazed screens. This time however each bay required its own wash hand basin, services trunking and a built in renal services' panel to provide RO (reverse osmosis) water. Having used a 'spine wall' system in the laboratories at Blackburn where services could be provided in a prefabricated system which could connect to benches etc. I suggested that this manufacturer could possibly design a system to cater for the renal dialysis panels. They made a mock-up in the site cabins. At this stage nothing had been proposed to the trust and as a result of its cost I was forbidden to let the trust see it! The surveyors backed by the site project director wanted to build the low walls in plasterboard and surface mount bedhead trunking, decided to build a mock-up in the warehouse where the ICU room was located. This mock-up looked terrible – bulky and easily damaged. The trust was not asked to approve it! The wash hand basin was being installed in a concealed services panel as per all the sanitary fittings. A system of slim resin panels (better performing than laminate).

The solution needed agreement from all parties within the JV before it could be proposed to the trust. The architects who did not participate fully in the discussions (partly due to their internal cost problems and deferring to the site) did not object strongly about retaining the ethos of their original 3D designs. I was therefore at that point out on a limb trying to create a solution which resembled as closely as possible the original intention, was buildable and acceptable to infection control – avoiding too many junctions making cleaning difficult. Each month the site held a PRM (Project Review Meeting – or progress – performance P standing for different things to different people!). this was normally attended by the Core Team Project Director, Deputy Director (Services), Commercial Manager, myself, the site Project Director, Project (Construction) Manager, Commercial Director, the Electrical Services Manager and the Mechanical Services Manager. The site design manager was not included – on most sites design was not included. I attended as part of the core team and also recorded the action notes – this task had previously been carried out by the core team commercial manager but after he moved off site his replacement was so useless at producing notes that I produced them (an easy task having been used to chairing and minuting site meetings!). I also chaired the meetings if the Project Director was absent. I thought that it was essential that design was represented at these meetings as invariably the design was criticised for causing delay. I therefore raised the matter at one of the PRMs and put the case forward for attempting to provide something better than the proposed 'site mock-up' on the grounds that renal medicine was of the upmost importance for the trust who had to compete for its service and that it had to be state of the art and better than its competitors. According to the site project director I favoured the prefabricated solution as it was produced by my 'Edinburgh cousins' and could see no reason for not building it in plasterboard.

It was suggested that perhaps we could ask the subcontractor who was providing the concealed back panels to come up with an alternative. I had a good working relationship with this subcontractor who had also worked at Blackburn and so we set about making a third mock-up. As part of this proposal it would be possible to integrate the bedhead trunking and incorporate the services risers within the wash hand basin back panels. It did however mean that the services had to be installed in two stages with the riser being integrated and not surface fixed. Despite costing more than the plasterboard solution, it was agreed that this proposal would be submitted to the trust. After the meeting the electrical services manager (who I got on very well with and had also worked on Case Study 3) told me that I had only achieved the result because I was more passionate about achieving what the trust wanted and had done my homework! The services managers used to describe me as 'their architect' because I ended up scheduling information for them and plugging the gaps which the architects said was not within their 'scope of works'. They expected the same service from the architects that they would have had had it been a traditional contract. The architect's scope of service was a problem with agreements set up by the commercial team trying to reduce fees but not fully understanding what was required and the architect's carefully reviewing it to see what they could omit!

Managing the design was quite difficult on this project with the site project director thinking he knew best because it was design and build and the architects not defending their design strongly enough. I tried to tell them that if they strong feelings about something they should express them and they would be listened to. The trust project director and manager were very keen on design and they certainly made their thoughts known if things were not to their liking. There were another couple of examples in this category. The first concerned the roof supports. As the building was in a very prominent location the planning department were heavily involved in the process. Following planning approval all material samples had to be submitted and approved. The roof was a curved butterfly design supported by angled struts from the tile clad circular drum. During the course of the structural design these struts became structurally redundant. In order to comply with design concept struts were required and it was not until the roof had nearly been completed that the trust noticed that the spacing of the struts did not match the elevational drawings. The trust project director mentioned this to our project director in one of their weekly meetings. Our project director told him that some of the struts had still to be fitted. He then asked me to find out what was happening. When I asked the site team I discovered that the design manager and the site project director had agreed with the site architect that the struts should only be located on the grid lines. This resulted in only half the number of struts being fitted. I had to tell them that additional intermediate struts would have to be fitted in order to comply with the approved planning drawings. Despite protests from them the additional struts had to be ordered and installed.

The second issue also concerned planning issues. This time it was related to the main entrance signage. As a company we had JPI (joint project initiative) arrangement set up with a preferred supplier/subcontractor. The signage was also subject to RDD Approval (reviewable procurement was a simple process. When the signage package manager asked me to look at the prefabrication drawing, I noticed that it had not been prepared by our preferred subcontractor. I asked him who had approved this order and was told that the site project director had agreed it with the design manager and commercial manager. As the drawing did not reflect the wording, type face or colour of approved RDD I raised this with team and due to its nonconformity the commercial manager rescinded the order and appointed the JV preferred subcontractor. Although it caused displeasure with the site project director, it had been caught in time and the trust were unaware of something which would have made them extremely angry.

Another JPI (there three majors PFI hospital projects being carried out by the company at the same time) involved the steelwork subcontractor. The company preferred to build in steel for safety reasons despite the fact that the design of the building was circular and did not lend itself to steelwork. The project director being a civil engineer took a great interest in the frame and quite often meetings were held in the structural engineers' offices with the subcontractor and himself. As I had been used to working closely with both structural and services engineers I tried to ensure that the architects were involved as much as possible. I was also concerned that decisions were being made on a cost basis particularly in relation to cross bracing. The window arrangements were very regular so bracing should not have been a problem. Again, as on Case Study 3 the steelwork subcontractor wanted to introduce internal bracing which did not suit the layout. I therefore arranged a meeting in the structural engineers' office with the architect and the subcontractor to resolve the internal bracing issues and some external window issues which had arisen on the render section and could be resolved using portal bracing. Apart from a couple of minor problems which were later resolved on site the structural frame integrated well into the building. By contrast the cross bracing on the other batch project resulted in a four bed ward having a 'hotch potch' of windows which looked dreadful both externally and internally. In this case the Tameside project director and commercial manager had led all the discussions with the subcontractor without consulting the architect and presented them with a 'fait accompli'. The cost to use portal bracing would not have broken the bank!

One of the advantages of using preferred subcontractors was supposed to be that they could give advice to the designers. Both hospitals had large areas of render. These rendered areas required joints. The other batch project was ahead of the Case Study 4 acute building programme wise and as a result the render was completed first. Unfortunately, the joint line was set to the bottom of the perimeter steelwork, this resulted in an uneven line across the elevation and at the returns as the depths of the beams varied. I knew that if this was repeated at Case Study 4 there would be severe repercussions as the trust would not accept it. I discussed this with the subcontractor and there was a simple solution – to line the joint to the top of the beam thus resulting in render joints which lined through. This was the design adopted at Case Study 4. The lesson here was that although the subcontractors may be experts in construction, the detailing needs to be discussed with the designers to ensure that what they design is executed.

One of the most important aspects of healthcare building is the incorporation of medical equipment and technology. If the cost of equipment is added to the cost of the mechanical and electrical services installation the percentage cost will be more like 50% than the 40% estimated for the services. Analysing the equipment list which is derived from the room data sheets may only show a few items which could be defined as medical equipment. ADB does not differentiate between the classification of a cupboard and a medical gas pendant. The cost of equipment list does not include the cost of the Trust's equipment which can run into millions of pounds if scanners et are included. The trust on this project tried to ensure that where an item of equipment was composed of a mixture of groupings eg. modular storage units where the cabinetry is supplied by the contractor and the baskets are provided by the trust that these the trust items should be included within the contractor's cost. It might seem a small issue but although there are several suppliers to the NHS there are differences in specification which can result in incompatibility and most trusts have an agreement with a particular basket supplier. This did not cause a problem at Case Study 4 but it did on the other batch project as the trust assumed that the baskets would be provided with the cabinets and the commercial team had not included it as the description on the room data sheets was standard ADB.

With the major medical equipment items issues are more complicated and this was the case with the medical gas pendants. The trust had tried to specify the pendant as fully as possible but not all of the attachments were included and remained as trust supply on the RDS. At the start of the procurement process the medical gas pendants were within the M&E services contractor's scope of work. They had to obtain prices to insert in the contract as A+ items which the trust could select. The trust knew which manufacturer they wanted and although alternative prices had to be obtained it did mean that process was simpler. The JV had not employed an 'equipment specialist' as the project director saw no advantage and by the end of the Case Study 3 project we had in place a system which worked well. The packages were divided between construction and engineering services but the ones which involved both were fully coordinated and I carried out the role which the architect would have done on a traditional contract. for each item we prepared an approval document showing a picture of the item, detailing the description and a schedule of the items being supplied with their locations. In addition the manufacturer's information and any preliminary drawings were included. For most of the items this worked very well and was quite a simple process. The medical gas pendants were however more complicated and when the full schedule was prepared including all the trust items such as infusion stands included the cost of the pendants had exceeded the budget. The trust was angry, the M&E services contractor wanted savings and suggested that the trust pay for 'their items'. This did not make sense as yes the trust items could be fitted separately but this would be dismantling the pendants after they had been fitted to attach the additional items whereas they could all be attached before final installation. I re-examined the equipment list and noted that each bed had two sets of equipment rail each three metres long. Having built the mock-up it would obvious that this was not required and as it was an expensive item reducing its length to 600mm would save a considerable amount of money. As a project architect on a traditional contract I would simply have proposed this to the client and then issued an instruction changing the medirail and accepting the medical gas pendant quotation. I put this proposal to the M&E services contractor but they were afraid that construction would not transfer the money! I spoke to our project director who agreed with me and then told the M&E services contractor and our commercial department that it was all one pot of money and to go ahead and discuss it with the trust. The trust accepted this solution and I set up a combined group with the trust clinicians and the M&E services contractor to agree the final pendant specifications. This was an example of the need for flexible and integrated thinking, most of the design and build companies are led by engineers or quantity surveyors who have been trained within their disciplines and not to oversee all the other disciplines within the construction industry. The sudden transfer from traditional to design and build has resulted in a steep learning curve which even after 20 years is still not fully understood by some.

A similar situation arose with the pneumatic tube installation. This was another mechanical services package. The engineers tended to discuss this with the trust estates department and such items were the subject of M&E RDD. Having had experiences at Case Studies 2 and 3 where these meetings were not attended by the trust project manager or a construction representative, I agreed with the project manager that we would prepare and issue a tracker of all RDD meetings and that I would update then to ensure that no items slipped under the radar which affected clinical matters. I also suggested that she needed to be present at all the meetings, a suggestion which she welcomed. The problem with the pneumatic tube installation was that all the trade literature from the manufacturers showed the stations fully enclosed – very clean and neat – acceptable to infection control, it was a fully integrated system, but the cabinetry cost extra. Needless to say the M&E services contractor was not intending to purchase the cabinets, but because of the previous experiences the trust had written it into the contract and it was provided. This was not the case on the other batch project and the end result suffered.

HTM on sanitary fittings and back panels has for a long time promoted the use of concealed plumbing systems often through a supplier such as Armitage Shanks Venesta who supply the sanitary fittings pre-plumbed on back panels. Many other subcontractors supply and fit Armitage Shanks sanitary fittings onto their own custom designed back panels and it provides a very clean surface to comply with infection control requirements. The HTM however does not include bed pan macerators or sterilisers – items which require electrical, water supplies and drainage. These are situated in a dirty utility an area of great concern to infection control who do not want exposed pipes and trailing leads. The machines are difficult to site – they cannot be built-in the same way as domestic washing machines or dishwashers as maintenance access is required to the sides of the machine. Again having spent time on site working with M&E services contractor's engineers and plumbers, I assembled a small group including the panelling subcontractor to try to achieve as neat a solution as possible. Before the sample was built we visited the existing hospital along with a member of the estates department and a representative of the infection control team to look at some of their existing installations. Having looked at this, we then set up a sample within one of the dirty utilities under construction and invited the trust to inspect it and the different stages in its installation. This proved to be very successful and having completed one the rest were then installed. Using an integrated approach worked very well and I was very pleased when faced with a problem of providing an emergency connection for RO water within the wash hand basin assemblies one of the young graduate construction engineers worked with the plumber who had worked on the macerator assembly and between them they came up with an excellent solution.

The accident and emergency department included a small self-contained radio-diagnostic sub- department with a general x-ray room and a CT scanner. In the project agreement the equipment had been designated as D+ trust supply but with a stipulated timescale for the supply of information to the construction team. The trust utilised the services of the NHS North West supplies division in procuring the equipment in accordance with the programme which allowed the pre-installation services to be carried out while construction works were ongoing in the department. A&E was scheduled to be the last department to be completed. Again, an integrated team was set up and the design co-ordinator who had returned to the site team by this time was involved in the process. Having been involved in the user groups and the design approval process proved to be advantageous, as he had also built up a good relationship with the trust. There was pressure towards the end of the acute building to handover on time as due to earlier problems with the over-all site redevelopment plans, the demolition phasing was tricky and decanting to the new building needed to be escalated. The project manager having gained experience at Case Study 3 regarding the transfer of A&E was well aware of the difficulties even although in this case patient transfer was easier as the new A&E adjoined the old A&E (this was being turned into a paediatric A&E). Because of the radio diagnostic works starting during the completion of the acute block, the trust was able to transfer the first patients into the new building three weeks after handover which was quite an achievement – this normally takes three months.

Having had a rather acrimonious 'change control procedure' at Case Study 2 and late NHS briefing changes at Case Study 3 we were aware of potential changes and as such tried to make the process as reasonable as possible. The PFI contract documents included standard change control procedures, generally designed to discourage trusts from making changes. Timescales to make changes were laboured, especially the initial request from the trust to make a change without giving a well defined proposal. Just before financial close the trust's project manager approached me with saying that in order to get Treasury approval the trust had to increase the number of acute beds. This they proposed doing by replacing the dermatology ward and outpatient department with two acute wards. She wanted to know if they had to wait until after financial close and then submit a change order. I discussed this with the project director and he agreed that if we could revise the layout before FC the this would not constitute a Trust Variation Enquiry. This we managed to achieve without full consultation. I prepared a Design Manager's Evaluation which listed the level of redesign and the actions required related to contract issues and design brief requirements to be carried out by the architects, structural engineer and services engineer. After FC the trust wanted to make alterations their offices within a shelled area. The Design Manager's Evaluation had been incorporated within our project management plan, so we used this together with a sketch plan which I prepared on behalf of the trust as part of the Trust Variation Enquiry in order to speed up the process. In the first example work had not started and in the post FC situation the walls had been shelled so making changes did not affect programme. This system of providing a sketch and an evaluation at the same time as the request enabled the site to assess what effect it would have on programme, made the additional cost more palatable to the trust and created a situation where there was a willingness to accommodate the trust's requests which would result in a higher level of client satisfaction with the completed project.

During this course of this project, the company appointed a new Director of Design as head of the technical services department. He was an architect who had worked for another major construction company in charge of their design and build department. That company however did a lot of the design work in house – mainly commercial and industrial. He was very keen to promote design management and persuaded the managing director to hold a design management conference for all the design managers. He also set up a steering group with representatives from each division and technical services. These sounded like good ideas promoting design within the company but it did not improve the way design management was viewed on site mainly because his focus was on technical services and the site design managers reported to their respective site project directors/ managers. I became involved in the steering groups after a while my project director who did not rate the individual decided that I was too busy to attend. However after the Director for Design rewrote the design section in the company quality manual – changing what the Project Director had originally set up as the design procedures relating to site activities he changed his mind and I represented the West Division at the steering group meetings. Along with the quality manager we split the quality manual to reflect pre-construction design and activities on site. The Director for design was not particularly focused on site procedures – he never even visited either of the Batch hospitals even though they were within 30 minutes drive from head office. His role in technical services was in winning work and selecting design consultants as unlike his previous company we did not actually design any projects.

The design procedures needed considerable reworking and I set about this with the quality manager using procedures which I had set up at Case Study 4 – RDD, approvals processes, compliance checking and most importantly the works package and project management trackers. Whilst at Case Study 3 the commercial department had set up a system of 10 'Golden Rules' which laid out how work packages had to be procured. The aim was stop 'scope creep' and ensure that costs were contained within budget. The adoption of these rules – which was supported by the divisional director (formerly commercial director) particularly annoyed the project managers as the subcontract documentation which was prepared by the site commercial team had to be signed off by the commercial director before it could be let. All site instructions (the meaning of site instruction in this case being an instruction to the subcontractor to carry out additional works) had to be issued by the commercial team not the project manager. The result was that the whole process took longer. As design managers we also issued tender and construction verification sheets for works packages to the designers for them to complete, listing the relevant drawings, schedules and specifications stating that the information was ready for issue. We had to monitor the receipt of this information and record progress against the overall programme. I got so fed up with the design information being continually criticised for being late that I set tackling the works package set up. At the time I did not realise that I had opened up a can of worms! The designers were being asked to keep within cost, but had not been given a cost plan – not that it would have helped as the cost plan was elemental and did not reflect the work packages! The programme was set out with the design activities reflecting the construction sequence not the design sequence which in a hospital project needs a long lead in time as the underground drainage layout cannot be fully established until all the room layouts have been completed. The integration of mechanical and electrical services also affects layouts and this tends to be developed after the contract is let. The scope of the works packages changed according to who the commercial team were intending let it to eg external envelope.

All of the drawings were coded using CISfB and all the specifications used NBS coding which is also used in SMM7. The company had a standard list of work package number but they did not mean anything. I therefore set out the works package list using CISfB codes and included all the mechanical and electrical packages as well. This list was agreed with the commercial team together with a proposal that the works package should reflect the sub contract order and that the initial works package list should be based on broadest scope eg external envelope – walls and roofs on the grounds that it was easier to split a large package than combine two packages. This is as a result of my experiences at Case Study 1 where problems can arise with the interfaces between packages. If it is scoped as a larger package then the interface team then es are more likely to be included than if two smaller ones are combined where there is the likelihood that they may be missed. Scope sheets were then prepared including NBS specification references. Once the designers had completed the sheets and issued the information I reintroduced a procedure which had been in the original design procedures – the squad check.

The squad check was a meeting which was chaired and minuted by the design manager responsible for the package, attended by the quantity surveyor responsible for the package, the works package manager, and the design team. All the drawings were reviewed together with schedules and specifications and the package amendments recorded. The design team then carried out the amendments and signed off the tender verification sheet. This process was repeated when the proposed subcontractor had been selected but before the contract had been signed. The subcontractor was part of this squad check and again any alterations could be made at this point to ensure that what the design team had signed was reflected in the subcontract order. It also reduced the amount of information being inserted into the subcontract order document, as previously the surveyors had been including irrelevant information, adding addendums using different revisions of the drawings to the ones signed off without consulting other members of the construction team or the designer. This process was effectively a mini version of what happened in traditional contracting when variations could be valued against the set of drawings used to tender. The senior commercial managers were in agreement as they could see the potential to reduce ‘scope creep’ and accurately measure changes and claims from the subcontractors.

This was just one of many new procedures which was instigated based on my experiences as a traditional architect – taking the principles of architectural contract management and converting them into a set of principles which could be used by contractors.

The most useful tracker I created was the ‘Project Management Tracker’ for review at the monthly PRM meetings. This was created as a result of the criticisms of design causing delay. The original tracker set out the dates when the information had to be provided by the designers and when it was received and approved and as it was prepared by the planning engineer in discussion with the site it often failed to recognise the design sequence and resulted in information being requested too early or too late. It also only included the construction packages and not the M&E. I therefore set a spreadsheet incorporating the work package list (including M&E), the approval dates and then added columns for when the surveyors required the information to prepare the tender, the squad check date, the signed off package, the time to get the order approved, the time for the subcontractor to mobilise, the proposed start on site date and the actual start on site date. The status was highlighted using the ‘traffic light’ system which meant that at each meeting the package progress could be monitored. It was really a project management tool but as this role was largely missing I used to update the sheet each month after consulting the construction manager, the commercial manager and M&E managers before issuing at the meeting. It proved to be very popular as blame was not directed at one party and in fact what it often indicated was that the original dates given by the surveyors were inaccurate and it gave evidence to the construction manager when delays to commencement on site were proved to be the failure of the commercial team to get the orders signed on time. It took very little time to update and by asking each one individually meant that potential delays could be averted in advance. It reduced the time in which the tender documents sat on the commercial director’s desk!

As a result of the success of the design management at Case Study 4 these principles formed the basis of d the new procedures in the company quality manual. I was asked by the divisional director to carry out a series of workshops outlining the procedures to all our sites. There was some dissent from other sites within the division as the procedures were deemed to be too onerous and I was told that ‘hospitals’ were different, and they did not have time to carry them out. Fundamently however what works on a large project will work on a small project. The difficulty I think was accepting that on traditional contracting where the architect had administered the contract this rile of contract administration had not been transferred to the construction team. The project managers continued to work in the same way as on a traditional contract and the commercial teams sought to take over the role but lacked the architectural skills associated with coordination and decision making – in France where they do not have quantity surveyors, the architects employ ‘valuers and measurers’ much in the same way as mechanical and electrical engineers. Just having completed the roll out of the new procedures the company started a re-engineering process, due to excessive losses and the failure to win new work. The result was that the role of divisional design manager was no longer required, design could generally be managed by project managers and in any case there were few contracts to manage and no healthcare projects.

There were many lessons to be learnt from Case Study 4, many of them positive. It was a successful project for both the trust and the construction company, delivered on time, within cost (highest profit margin in the company) and to the high standard expected of the trust. There was a great team spirit and a good relationship with the trust. One regret at the end of the project was that due to the team starting to break up, only a few left to complete the remaining alteration works, the new building going into operation very quickly, and the project manager being off ill at handover the proposal to submit the project for a design award was never carried out. It was seen as not only a hospital in the city but as part of the city's overall development and the local artist Harold Riley (a student of L.S. Lowry), who was the official artist to the Royal & Ancient Golf Club and had painted many famous sportsmen, , donated a collection of his sketches worth over £1million pounds to the trust. He had originally let them select 250 drawings and sketches for them to have copied and framed as part of their Art in Health Project (1% of the contract value is supposed to allocated for art in health) but decided as his was his home town that after copying them (they were displayed all over the hospital, in single bedrooms, waiting areas etc) that they could keep the originals.

At the end of the first phase -The Education Building we held a Lessons Learnt workshop involving everyone on the project. We also held a Design Dilemmas workshop to highlight the problems involving statutory requirements (DDA) and guidance issues (Infection Control) and how to interpret and resolve issues.

The project highlighted the value of continuity and that for members of both the trust and the construction team it was the second time that they had delivered a major PFI project. As a construction team we aimed to tackle a third but it was not to be. We reached the final stage competing with one other company to become preferred bidder. The director for design decided to invite a different firm of architects, another London based American company and allocated a technical services design manager who although an experienced architect had no healthcare knowledge to the bidding team. The M&E services contractor had appointed the same engineers as Case Study 4 and all their previous schemes, and the structural engineers had also worked on Case Studies 3 and 4. The design elements were the weak link and although the project director and myself were asked to help out before the final submission it was too late. I had a great time managing the building of a mock-up of a single room, trying to recreate the architect's 'artist's impression'! rather unrealistic but after much effort resulted in a great space which could be built. The problem was that the bid team lead by the same SPV director at Case Study 4 were not listening to the client. The client had not asked for a mock-up at this stage an as our competitors had not built one they would not allow the trust staff or patients to see it! The layout had some departmental relationships which did not work but it was too late to change. We also constructed a section of the proposed external wall within the site compound at Case Study 4. The brickwork coursing designed by the architects was so bad that the construction team made comment and when the SPV saw it they thought that it was the fault of the bricklayers! After several attempts this together with an inset window with very expensive glass which changed colour was shown to the trust when they visited Case Study 4 to see the newly completed facility. I felt very sad for the construction team when we lost the bid as many of them were hoping to move on to the project. the SPV had invested a considerable amount of money in the bid, but as with technical services they were bidding teams so just started out on a new project! This highlights the need for feedback and ensuring that the right people are engaged on the project at the right time.

5 Case Study Five

It is a new acute general hospital being built on a 16 acres (6.5 hectares) brownfield site. In August 2015 Preferred Bidder stage was achieved with a design team led by a concept design architectural practice supported by two other architectural teams, one taking the clinical planning lead and the other a major UK/US healthcare architectural team

The new hospital, with over 60,000 m2 floor area, plus support facilities and car parking, comprises 669 beds (50% of which provide single bed accommodation), 13 operating theatre suites, plus an innovative fifth floor Winter Garden that will be the main space within which visitors can wait, eat and drink, and obtain information. This spacious facility, accessible from all levels, will be the heart of the new site.

The PFI contractor had employed healthcare planning consultants to work closely with the Design Team to achieve a number of strategic goals including separation of key clinical, public and FM flows to support privacy, dignity and efficiency; maximised repeatable design; developed innovative room designs that are more space efficient and therefore more cost effective than comparable contemporary standards. The overarching project objective was to deliver a solution within budget and achieve financial close 3 months ahead of programme, with the consequent earlier start on site for construction. Due to the degree of innovation and the need to demonstrate evidentially the healthcare planning viability of the proposed repeatable rooms, the contractor constructed a series of full scale, finished and equipment mock-up rooms in order for the Trust to undertake scenario testing and risk assessments. This validation process was successful according to the Trust - and essential - given the inherent challenges to accepted design guidance

The total capital cost was forecast to be £297 million of which £100 million would be provided by HM Treasury with the remainder privately financed. Work on site started in January 2016 and construction was due to be completed in October 2018, but the project became delayed, with completion initially rescheduled for 2019.

Construction came to a halt in January 2018, and in March 2018, it was reported that the project had been costing over £17m more than the contractor had officially reported by which time another PFI contractor were negotiating to take over the hospital's construction, with the project 18 months late and likely to cost an additional £125 million. In May 2018, Trust had yet to confirm the new PFI to complete the project, and with the unfinished site deteriorating, completion was likely to be pushed back an additional two years, to 2022. In

June 2018, a consortium of banks financing the project withdrew their support, and HM Treasury cancelled the PFI contract for construction of the hospital, leaving it with a lengthy search for new investment and pushing the completion date back to at least 2022, Table 60.

In the meantime, the NHS trust started tendering for an interim contractor to deliver a £13m programme of works to protect the site until a replacement construction contractor could be appointed. In October 2018 this work was awarded to a new contractor.

In August 2018, market testing with contractors showed there was little appetite to bid under a private finance model, and that a PF2 bid would be over £100m more expensive and take six months longer. As a result, the NHS trust sought direct government funding to complete the project, and on 16 August 2018, the government announced it would provide funding to complete the hospital. In November 2018, it was reported that the NHS Trust was struggling to find a contractor to complete the hospital, with the possibility that the hospital might be delayed beyond 2022. In January 2019, firms - some previously involved with the project - were formally invited to apply for shortlisting to complete the half-finished hospital; the successful bidder was expected to start in October 2019 and complete the project in 2021.

Table 60 Significant Dates

July 2014	Original OJEU Notice
August 2015	Original PFI contractor selected as Preferred Bidder
September 2015	Planning Permission Approved
End 2015	Anticipated Financial Close
December 2015	Financial Close Agreed – Contract signed
22 January 2016	Start on site
May 2017	Announcement of delay due to the installation of M&E services
July 2017	Topping-out Ceremony
July 2018	Anticipated Completion
End 2018	Revised Completion
January 2018	Construction stopped
April 2018	NHS Trust receive government support to aim for opening the hospital in 2020. The hospital is considered to be two-thirds built
August 2018	NHS receive government approval to proceed with a design and build project (reversing the previous PF2)
August 2018	Trust launched a competition for an enabling works contract to prevent further deterioration to the building
September 2018	Enabling works contractor appointed
October 2018	Anticipated Hospital Opening

November 2018	Start of Enabling works contract
Early 2019	Revised Hospital Opening
January 2019	Invitation to tender issued
October 2019	Anticipated site start (half-built hospital)
2021	Anticipated revised completion
2022	Anticipated revised Hospital opening

An initial visit to site with members of staff who previously worked for the Mechanical and Electrical Managing Contractor and who now work for new contractor's Mechanical and Electrical Partner highlighted issues with the design and installation of the Mechanical and Electrical Installations and conflict with the original contractor's M&E design consultants. This raises concerns regarding design integration and the roles and relationships of the project participants. The situation of having three architects involved in the project is also of concern as is the decision by the contractor to commence works on site with an RIBA Stage 3 Design and not following the completion of Stage 4. This presumably was a decision resulting from the two and a-half year projected construction period.

The bidding process started with a three-day Competitive Dialogue Outline presentation and introduction by the trust. The Trust's Project Director is also the Estates Director and led the team during the PF2 phase. Several members of the original construction team have been employed by the Trust to prepare the project for the new procurement route and such the Trust Dialogue Sessions were led by the former Project Director. The team also included the former Commercial Director, Planning Engineer and the Construction Manager.

The Trust has prepared a cost to complete the works which is also being cross checked. This together with the preparation of a revised programme and design and clinical reviews creates a requirement crunch point establishing whether a compliant project can be completed on time and within the anticipated cost.

The project started on site in January 2016, at which time it would have been reasonable to have expected that the design should have been completed given that it was due to deliver BIM Level 2. Traditionally Mechanical and Electrical Services Design is only at schematic design by the consultants with specific areas detailed to demonstrate coordination and confirm that sufficient spaces within the services zones have been provided in the overall design by the architects and structural engineers. The full detailed design is then normally carried out by the specialist subcontractors. The use of BIM changes the way services are designed, transferring the coordination into the building model at an earlier stage. In May

2017 a project delay was announced due to the design and installation of the Mechanical and Electrical Services which suggests that the design followed that of the structure and spatial planning and was not integrated. The lack of integration can also be demonstrated in the following photographs as in Figure 59 taken following the collapse of Carillion and before recommencement of the works.

Figure 59 Problems with Ceiling Mounted Services

These photographs indicate ceiling mounted services and the potential problems for the ceiling subcontractor when it comes to installing the suspended ceiling. Even at this stage not all the services are installed, and it is evident that there is little room for installing the ceiling hangers. The result will probably necessitate additional bracketing at additional cost.

Part of this problem has been caused by agreed derogations. The Trust have agreed to derogate the corridor width in some areas where the corridor widens out in open spaces following the confirmation that beds can move effectively into rooms. This does provide for a more open and less rigid environment but unfortunately the width available for the services is determined by the narrowest section of the corridor. A similar situation also occurs in the operating theatres, where in the operating room the actual usable space around the table has been reduced. Whilst agreeing reductions in floor areas, this should not be done in isolation and not without regard for what happens in the ceilings.

Currently the services design has not been signed off at Stage 4A although work to Stage 4B has commenced. The original Mechanical and Electrical Services Consultants do not want to be novated to the successful bidder and before work installed can be accepted their Stage 4A design needs to be signed off in order to transfer design liability and warranties.

From the above examples it is evident that the design has not been fully integrated and that there has been a lack of design leadership and management. The lack of integration has been compounded by the involvement of three firms of architects and two civil/structural engineers, one of the engineering consultants being a subsidiary of the contractor and therefore not being novated. The imposition of the 7.8 metre grid and the difficult movement joint detail have also caused problems with standardisation. On many new major hospital developments prefabricated bathroom pods are used, but in this instance due to differences in size and shape it is not possible to use them as the quantities would be uneconomic. Prefabrication requires ‘absolute’ standardisation. There are also potential problems in utilising modular wiring due to the congestion of services in the ceilings.

The lack of integration of the services and structure is also demonstrated by the fact that some of the main risers do not line through and that the building ‘concept’ form has resulted in poor distribution from the plantrooms due to their location. Figure 60 below sets out how the original team was constructed. Unlike many healthcare design and build teams where the percentage cost of the mechanical and electrical services accounts for over 40% of the total cost and a joint venture is created between the main contractor and the M&E contractor, the main contractor engaged all the subcontractors directly and appointed a separate M&E subcontractor as ‘Managing’ services contractors.

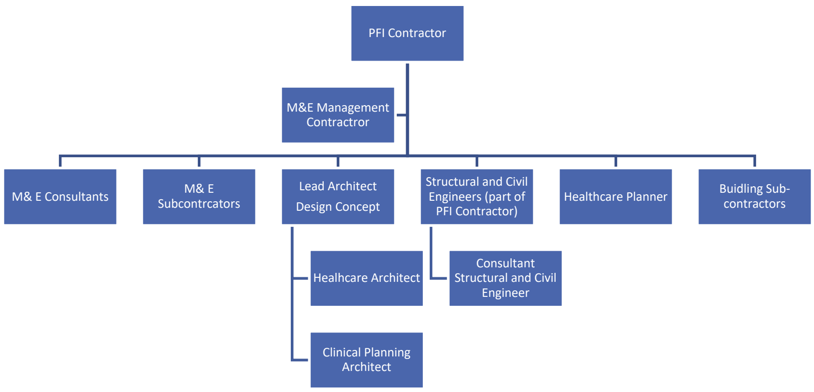


Figure 60 Team Structure

The relationship between the design concept architects and the mechanical and electrical engineering consultants appears to have been strained and the ensuing difficulties with the services design and installation is likely to have resulted from this. The concept design makes a bold statement including a feature design for the ventilation ducts, unfortunately this design does not take full cognisance of efficient healthcare services design and as such has probably caused conflict with mechanic al and electrical services consultants.

Trust Requirements and Evidence of a Requirements Crunch Point

The Trust want ‘tried and tested’ and robust resilience for services, not ‘state of the art’ and no innovation. They are happy with the clinical design and future proofing is in the form of a few shelled spaces in Imaging and Theatres together with a shelled ward floor at Level 9.

Achieving affordability at Financial Close is highly dependent upon the cost per square metre and the area of the building. The aim is to maximise the net clinical departmental areas, minimise circulation within departments and communications between departments. The ultimate contract sum was 20% less than the amount included in the Business Case submitted to the Department of Health. Trust statement “We compiled a thoroughly researched “Design Standards Review” report which challenged previous NHS Guidance and assisted in the scheme gaining the support of the Trust Development Authority – ultimately reaching Financial Close in December 2015.” The Trust considered that they had achieved a compact design, achieving clinical functionality whilst keeping the footprint as small as possible.

One of the reductions in area was achieved by the ‘innovative’ design of the single rooms which reduced the room area by 3.5 square metres – achieving a saving of approximately 1000 square metres in total. Considering the Trust want ‘tried and tested’ with no innovation this is a bold move for the Trust. The other areas which have been consolidated concern staff facilities, administration and storage. The concept of shared ‘hub areas’ is outlined in the Health Planning Document. One of the difficulties in checking compliance with HBN requirements is that the Schedules of Accommodation contain these facilities. An additional consolidation has been to site Waiting Areas between Departments, some of which may cause problems with departmental security.

The architects’ schedule of accommodation has been set out by clinical departments and a series of ‘consolidated’ departments such as Neighbourhood Facilities, Visitors Facilities and Administration. However, in order to check against HBN these need to be allocated. The trust has admitted that they have not allocated administration areas to specific departments. This should have been done before Financial Close as part of the requirements crunch point as a similar failure in Case Study 2 resulted in under provision. The findings from ‘restructuring’ the Schedule of Accommodation indicate that there is a potential problem with the consolidated facilities.

Table 61 demonstrates how the Trust's aspirations have in many cases not been achieved.

Table 61 Client Daylight Requirements

Functional Space	**Essential or Desirable**	**Achieved**
In-patient Beds	Essential	Yes
Level 2/3 Beds	Essential	Yes
Recovery Beds – Theatres	Desirable	No
Admission/Recovery	Desirable	Some
Delivery Room	Desirable	Yes
Consulting/Exam Rooms	Desirable	Yes in OPD, otherwise no
Treatment	Desirable	No
Interview/Counselling	Desirable	No
Reception/Staff Base	Desirable	No
Main Waiting	Essential	Limited
Sub Waiting (>6 people)	Desirable	No
Offices	Desirable	Some
Operating Theatres	Desirable	No
Day Rooms	Essential	No
Overnight Stay (Visitors & Staff)	Essential	No
Primary Circulation	Desirable	Only adjoining courtyards
Seminar/Training	Desirable	Some
Main Entrance	Essential	Yes

Phase 1 Findings

Before the construction had stopped two warning signs had appeared:

1. 18 months into the contract a delay announcement was made due to engineering services
2. Cost estimate of an additional £17 million

Indicating a potential failure to deliver 'on time and on cost' two fundamentals of design and build projects and why clients benefit from contractor led projects.

There did not appear to be a requirements' crunch point, as if there had been the issues regarding incomplete design and an impossible programme would not have occurred.

An example of 'disintegration" I wanted to check if the electrical small power drawings to ensure that some items had been picked up (the architectural drawings have incorporated some electrical elements into "unions" which do not display the items on the architectural layouts - only one icon for the union. This are items which should not gave been created as unions in the first place. There are 18 A0 architectural sized drawings for each level of the podium titled Sheet 1 of 18 etc. there are also 18 sheets for each level of the services dealings - the only difference is that the two sets do not match and it took an unnecessarily long time to find the information. At first I thought that the services drawings had been incorrectly titled but when I spoke to the planning engineer who had also worked for the previous contractor and told me that the two sets of drawings were set up differently, nobody had set out a drawing system and all the consultants and subcontractors did what they liked. Some subcontractors only had four sheets covering the podium levels. He had produced a "conversion chart" to make life easier for himself and said he would look for a copy for me. I was horrified as never in my 40 year career had I ever come across a less integrated design. This is symptomatic of a project where the design is not integrated, the construction is not integrated and the client has no regard for complying with healthcare HBNs and HTMs albeit that some of them are out of date. It demonstrates the total lack of integration, no evidence of a systems integrator, incompetence and lack of capabilities on behalf of the design team and the contractor and a client who is both naive and "uninformed".

Phase 2 Findings

As stated earlier when the Trust began the process of picking up the pieces from the previous contractor a number of key senior managers were engaged to help the T[2]rust prepare and administer the selection of a preferred bidder to complete the project. This was on the grounds that the Trust were 'happy' with the design, they had built up good relationships with the contractor and that these former members of staff were very knowledgeable about the design, state of construction, and potential subcontractors and suppliers who would be willingly to work with another term. The architects with overall responsibility had also been engaged by the Trust and were being novated as were the sub-consultant structural and civil engineers. The Mechanical and Electrical Services Engineers declined to proceed to the next stage causing a problem with validating the services design and the installation to date.

This appeared to be a strange relationship and one which emphasised that the project failure was due to financial mis-management at ‘group level’ and was not associated with what had happened to date on the project. However, during the due diligence process and Trust dialogue sessions it became apparent that this project would have failed in ‘its own right’ regardless of the company’s failure. There were indications that the construction company’s ability to deliver projects, including this one attributed directly to its downfall questioning why former members of staff are now advising the Trust. The cost plan and programme has been prepared by a team who were in the process of failing to deliver on these elements and setting difficult targets for a new team.

The major issue revolves around the design and integration of the engineering services and the actions taken in Stage 1:

- Commencement of Stage 5: Construction, before the completion of Stage 4 Design Approval of Engineering Services Design; evidenced by the inclusion of MEP in the TCRs RDD (Reviewable Design Data) List
- Engagement of an Engineering Services Construction Management Team which had the capability to act as a major Subcontract Partner as in the majority of the PFI projects.
- Absence of an integrated 3D BIM Model

As can be seen from the previous case studies and from literature integrating engineering services has caused problems in the past due to the different levels of design between the architectural disciplines and engineering. Architects and Structural Engineers preparing detailed designs on a 1:1 scale basis whereas mechanical and electrical design consultants prepare schematic layouts for the services subcontractors to prepare manufacturing and installation drawings. In this latter case it often led to strong relationship between M&E design consultants and the subcontractors. The adoption of BIM should have led to improved integration at design level as it requires all designers to work on a 1:1 scale basis. Engineers have to draw pipework to scale and not schematics.

The Bid Team have appointed M&E consultants to carry out a due diligence exercise on the current design and the state of the currently installed services. These consultants have previously work closely with the bidder's services partner and as a result there is an existing level of trust between them. Having reviewed the previous consultant's design and with the absence of approved RDD they consider that the Trust's envisaged recommencement date of October 2019 is not achievable and is more likely to be January 2020 as it will take several months to approve the RDD.

The Trust's requirements or brief is poorly presented; a set of drawings and what the architects describe as a Schedule of Accommodation but is in effect a list of rooms. The TCRs state that the design and clinical functionality should comply with the Health Building Notes and Health Technical `Memoranda produced by the Department of Health except for the list of derogations included in the TCRs. Following the due diligence check further derogations are required – mainly due to changes in Models of Care. In preparing a schedule of derogations it is apparent that the trust has paid little attention to the application of the HBNs, although they have developed new models of care they have not issued Clinical Output Specifications and have not complied with selected ADB Room requirements. There is however at in this re-tender period the opportunity to create a requirements' crunch point to ensure that ultimately the Trust's requirements are met.

Appendix D: Supplementary Literature

1. Requirements Management and the Opportunities it Presents for Integration

1.1 Requirements Management in Design and Construction

The term requirements in this thesis is used to describe not only the client's brief but compliance with statutory building regulations, which sometimes cause conflict with each other as a result of a healthcare client's requirements being highly specialised and the building regulations being generic to all types of building. In the hierarchy of compliance statutory requirements will always take precedence, although this does not mean the client's needs are overruled and in specific cases derogations can be agreed. The architect traditionally was the broker between the two parties, understanding both the client's needs and being able to interpret the building regulations. The introduction of design and build contracts adds another layer of requirements, those of the contractor who is now the architect's client and who often wants to influence the design to what he perceives as his needs in order to deliver the project on time, within cost and quality. It is important the contractor declares his preferences at the start of the design process as a building designed to be built with a concrete frame can be fraught with difficulties, particularly regarding the integration of engineering services if the frame is changed to steel.

Green et al (2004) believe requirements management has no equivalent in construction, but similar practices are applied such as programming, value management and change control. Green et al (2004) discuss knowledge sharing between the aerospace and construction industries and in relation to requirements management considers construction lacks the disciplined integrated approach of the aerospace industry. It is a process which requires an investment of time and resources and many clients are unwilling to provide these. This is certainly the case in design and build projects where teams are competing with each other and difficult to meet user/stakeholders.

An empirical study of the complexity of requirements management in construction projects by Jallow et al (2014) state over the past decade RM has become an important focus in major product development industries such as: software engineering, manufacturing and aerospace and goes on to outline CRPM (client requirements processing method)– Kamara, et al (1999, 2000 and 2002). Kamara and Anumba (2001) state objectives, needs, wishes and expectations of the client are described as client requirements. Requirements may also be regarded as measurable statements of the client's needs which are transformed into an architectural design and subsequently into a finished facility. They can be used to assess the completed facility. This definition implies the architect is the 'conduit' for failure or success and is further skewed by Design and Build and PFI where the building contractor is the 'conduit' and the architect's client.

Yu and Shen (2013) also note recent research by Yu, Shen and Chan (2009) relating to requirements in construction only relates to traditional procurement and the current focus is on integrated delivery. It is naïve to suggest the client knows exactly what the problem is as often the ‘wrong’ experts are engaged. Construction may not use the term ‘requirements management’ but ‘good architectural practice’ would manage the brief during the design and construction phases. Terms such as programming, value management and change control are used but they are not similar to requirements managements. Programming is a term used establish the project timescale and the sequencing of operations required to deliver the project. Value Management is a tool used in briefing the project and change control is a process for assessing/approving project changes.

Pegoraro and Paula (2017) refer to requirements processing in building design in the same terms as used in the software engineering (SE) industry or as descried by Young (2006) the IT industry and differentiate it from the traditional briefing process as it covers the whole design and construction process. Using this approach to construction opens up a greater opportunity for dynamic briefing, with a level of continuity which is likely to provide greater client satisfaction.

1.2 Requirements Management

Literature relating to requirements management was investigated as an alternative approach to design and construction management Few papers have been written relating requirements management to the construction industry. A major element of requirements engineering is the briefing process, and this will be reviewed together with briefing systems used in construction. It is also very much focused on continuity and single point expertise, elements which are currently disappearing in construction where a very linear ‘silo’ process is emerging, and individual ‘specialists’ are employed who have difficulty communicating with each other.

Gotel and Finkelstein (1993) identify requirements traceability as a problem within requirements engineering and have identified the pre-requirements stage needs to be addressed. This is in relation to the IT industry but could also apply to requirements management in the construction industry.

Fernie et al (2003) look at the duality of requirements: technical complexity versus social complexity and how the defence and aerospace industries have also adopted requirements management as a distinct discipline. These industries have complex technical requirements and whilst systems engineering has an established track record of addressing complex technical problems, its extension to socially complex problems has been challenged. Unsure whether requirements management could be successfully applied to construction they do consider the administrative functions offered by RM software could be used on PFI and prime contracting construction projects to aid traceability. Davis and Zweig, (2000) and Fernie et al., (2003) cite a reoccurring theme of project conflict and dispute as being poor management of brief/programme of requirements management.

The main adoption of the term ‘requirements management’ is in the information technology (IT) industry. This is well outlined by Young (2006) where a good example of dynamic briefing is demonstrated of changes being incorporated throughout the process until the project is handed over. One of the key features is the role of the requirements manager who is involved from the beginning until the end. Although the IT industry is very different from construction, it does have similarities and has adopted language from construction, for example ‘systems architect’ and ‘technical architect’. The development of software is fluid like the design process, but it does not have a physical form which makes continual change possible unlike building. If static briefing and lack of continuity appear to be problems associated with poor client satisfaction, then there is a need to look at dynamic briefing and agile thinking. The project design changes and adapts throughout the project lifecycle to meet requirements until the product is ready to be launched. Although there are obvious differences between the IT and construction industries in relation to the timescale required to produce the end product, it does not mean every construction product or item of equipment needs to be selected before construction can commence.

In reviewing Young (2006), unless you are aware this is written about the IT industry, you can easily relate the process to the design of buildings. In the ‘Encouragement from a Fellow PM’, Kathryn Altizer, PM. Northrop Grunman Corporation, McLean, Virginia states “In a long-term program, revising requirements periodically is advisable. One thing managers of long term program's sometimes forget is that requirements change!” This could easily be applied to a major hospital project. The term requirements analysis, as opposed to project briefing, is it implies continuous assessment, and the role of a requirements analyst is someone who is involved with client from the start of the project to occupation. The RIBA Plan of Work separates out briefing and POE and groups them as stages 0, 1 and 7, suggesting this can be carried out by a different party, whilst at the same time advocating the architect/client relationship should be single point contact and continuous. In hospital building this briefing role is often undertaken by a healthcare planner who often does not understand design and construction and as such is only fulfilling part of the requirements analysis. Again, in the preface, Young states Requirements analysts must build their skills, enabling them to do their job effectively, not just push ahead without the needed qualifications for their work. Project Managers must demand and facilitate good requirements analysis, not just tolerate whatever they get.

Lack of integration is cited by Jallows et al (2014) relating to failures in project delivery systems (Bouchlaghhem et al, 2004; Latham, 1994; Egan, 1998) describing a typical project lifecycle as having different phases incorporating various stakeholders amongst them being the client who states the purpose of the project and the needs and expectations to be delivered or achieved at the end of the project which the paper refers to as the client requirements of the project.

1.3 Communication and Information Management

The UK Office of Government Commerce (2009) recognises the process of elicitation, documentation, organisation and tracking requirements information and communicating across the various stakeholders and project teams as Requirements Management (RM). This can lead to confusion as requirements management manages the project requirements and Requirements Information Management (RIM) manages the information relating to the project requirements and should be considered as a data management system.

Fernie et al (2003) indicate few documented methods exist that provide traceability and ability to analyse change throughout the life of projects and Connelly and Gallagher (2004) with reference to projects in the United States, states a large number of contractors and subcontractors are often involved in large construction projects all sharing information and designs and that huge delays can be caused in finding documents. Although written at a similar period of time on what appears to be the same subject there is a subtle difference between them. One describes recording for future use whilst the other describes document management during the construction process.

Jallows et al (2008) also looks at traceability and define requirements traceability as the ability to describe and follow the life of a requirement in both forwards and backwards directions. They propose an Enterprise Requirements Information Management Framework where a Requirements Management System is linked to a Change Management System between the design and user operation stages of a construction project. They consider integrating the change management system with requirements repository will help satisfy user demands for interoperability. Jallows et al, (2014) is an interesting paper and one which provokes thought as it links requirements management with the need to take an integrated approach to client briefing. It does however need to be read in conjunction with A K Jallow's PhD (2011) and the earlier Jallows et al (2008), as all three documents discuss the same subject and contained duplicated text. The exception is the 2014 paper where the word 'information' is dropped from the title. There is no clear definition between Requirements Management and Requirements Information Management. As a result, the paper appears confused. The paper outlines the methodology clearly, but the sample set is small and contained with a sector of construction which does not reflect the use of electronic document management systems which were in use at the time on large projects and had been since the late 1990s. The data is 'old' at the time of publication as are many of the references. It is written by individuals who are unlikely to have been involved in helping to prepare a brief as they come from backgrounds in information technology, civil and structural engineering.

The emphasis in Jallows et al (2014) has moved distinctly towards 1. 'Requirements Documentation, Storage and Distribution' – otherwise known as document management. This task is normally carried out by somebody with an administration background. 2. 'Requirements Traceability, Dependency Checking and Impact Analysis' relates to both requests for change and compliance checking – both of which require procedures to be in place; processes which existed in major PFI projects. 3. 'Requirements Change Process Management' describes the process for changes by all parties in great detail and 4. 'Communication and Distribution of Requirements Change Information' describes the 'physical process' in this case e-mail or hard copy. Reference is made to the lack of a common language which hinders communication of requirements information between stakeholders (Austin et al, 2002) and to the brief not being carried throughout the project phases and not being updated to reflect changing needs (Kiviniemi et al., 2004) and (Sun and Howard, 2004) who refer to the large quantity of paper generated by construction projects. This paper highlights how the same situation has developed in design management and how by the addition of the word 'information' different roles are created. In terms of communication it demonstrates the need for careful use of language in order to avoid misconceptions. There is a lack of clarity between managing the requirements as in understanding them and ensuring the documentation is kept up to date and accessible by all parties.

There is no reference to Young (2006), which includes requirements management as part of project management, which suggests but fails to realise the importance of continuity which Young advocates by describing the role of Requirements' Analyst. The Requirements Analyst in Young's model is a highly experienced and qualified individual unlike the Requirements Manager in the eRIM (electronic Requirements Information Management) framework who is likely to be a document controller dealing with Information Management.

The concept of encapsulating the requirements in the BIM model also indicates a misunderstanding of how the briefing, design and construction processes. The BIM model is accessed through a document management system and can track when and who alters it but it cannot track changes to a brief before a model has been created. The briefing document can be uploaded to a document management system and changes tracked.

Den Otter and Emmitt (2008) concluded the use of a project website found the website was not used as prescribed and users experienced fewer benefits than was expected. The users worked in their own internal networks and only uploaded to the project website as a means of storing information for archiving purposes.

2. Value Management Interventions and Limited Integration

Thomson et al (2003) look at DQI (Design Quality Indicators) to ensure stakeholder value during the design stage. The need for a common understanding of quality and value and in terms of cost design represents a very small proportion of the overall project – although the percentage design fees could be considered low being represented as 10% of the construction cost. It also looks at DQIs in terms of the Vitruvian principles of functionality (commodity), build quality (firmness) and impact (delight). It includes Miles (1972) definitions of different types of value:

- Exchange value – open market price of a building;
- Use value - building performance in relation to performing required activities; and,
- Esteem value – attractiveness or desirability of a building – subjective value.

There is a relationship here with Zeisal (2006) and the concept of paying client (exchange value in terms of PFI), user stakeholders (use value) and designers (esteem value). This paper concludes DQI (example being AEDET) could have an important role in delivering value. Macmillan (2004) also reflects upon the DQI- design quality indicator and its use on differing types of building – two chapters on healthcare and notes the Egan Report has little to say on design – the focus is on time and within budget. Mills (2013) focuses on the 'soft' value management surrounding stakeholder values attitudes, behaviours and qualities during the design process and makes the link between value and stakeholder involvement. Kelly and Male (1993) promote value management charettes as a means of aiding project briefing through independent facilitated workshops where all the stakeholders are treated equally which also helps with integrating the team

3. Systems Integration and Healthcare

The National Health Service is a system of systems that needs to be integrated.This wider system defines standards and guidance set out by statute and government departments. It also includes the wider design and construction industry and their behavioural characteristics and the influence of contractual and financial models.

The wider delivery model consists of several different systems with linked dependencies creating a system of systems. In order to deliver healthcare effectively and efficiently the NHS requires a large property portfolio to provide diagnostic and treatment facilities which cannot be carried out in the community.

This system of systems involves three delivery models: healthcare in the form of medical treatment; medical architecture which researches evidenced-based designs and develops standards and guidance; and, the project delivery model of design and construction.

Systems integration is defined by Gilkey (1960) as being the process of bringing together the component subsystems functions into one system and ensuring the subsystems function together as a system. Zaitun et al (2000) look at horizontal systems integration and project management in the public sector in relation to data control and the use of IT concluding one of the objectives of having an integrated system is to avoid duplicating data at several locations. It demonstrates standardisation and efficiency.

Prencipe (2003) identifies two distinct categories of systems integration in multi-technology, multi-component products, namely ‘synchronic’ and ‘diachronic’. Synchronic systems integration refers to the static (intra-generation) technological capabilities required to set the product concept design, decompose it, coordinate the network of suppliers, and then recompose the product within a given technological family. By contrast, diachronic systems integration refers to the dynamic (inter-generation) technological capabilities required to envisage and then move progressively towards different and alternative paths of product architectures across new product families. Gold-Berstein and Ruh (2005) describe three forms of integration: Vertical integration (e.g. to create functional silos); Star or spaghetti integration (e.g. flexible interconnected subsystems); and, Horizontal integration (e.g. dedicated communication between subsystems). The theoretical framework that focuses on vertical integration is transaction cost economics (TCE). Jacobides and Winter (2005) where "the cycle pushing toward specialisation gets reversed when new and superior capabilities arise from knowledge bases that are misaligned with the existing vertical structure of the industry" and is indicative of the healthcare delivery system. Davies et al (2011) introduces Complex Products and Systems (CoPS) after a 10-year study into the importance of systems integration into projects involving high value in different sectors (non-construction), but where the findings can be applied to construction.

Appendix E Supplementary Case Studies

1. P21/P22 Case Studies

1.1 Introduction

The ProCure21+ National Framework is a framework agreement with six Principal Supply Chain Partners (PSCPs) and their supply chains, selected by OJEU tender process for capital investment construction schemes. Any NHS client or joint-venture may use the framework for capital construction works without having to go through the OJEU process themselves. Under ProCure21+ the client and the PSCP follow the ProCure21+ procurement principles and process for design and construction of the proposed works, as set out in the ProCure21+ NEC3 Contract Template and associated guidance.

The ProCure21 National Framework was launched in 2003 and following a two-year extension in 2008 came to a conclusion in September 2010.

Key features of Procure21+ were:

- **Timing**. The ProCure21+ replaced ProCure 21 on 12 September 2010 and lasted for six years. Interested bidders were required to submit their expressions of interest by **9 July 2009**.
- **Value**. ProCure21+ schemes were expected to range in value from £1m to £80m, with the average being £8m.
- **Number of principal supply chain partners (PSCPs)**. Six to twelve PSCPs would be appointed under the framework. As with ProCure21, SPVs single purpose vehicles could bid, provided they satisfy certain requirements regarding their financial stability, resources, authority and accountability.
- **Location**. A PSCP must demonstrate it could provide national coverage across England.
- **No guarantee of work**. Being on the ProCure21+ framework did not guarantee work. However, the NHS considers it “highly improbable that a PSCP could gain no work through the framework.” Unsuccessful bidders could take consolation from the fact that ProCure21+ would not be a mandatory procurement route for NHS clients.
- **Forms of contract**. ProCure21+ would use the NEC3 suite of contracts. (ProCure21 uses NEC2.)

- **Environmental issues**. A bidder's environmental credentials would be considered in the bidding process. For example, bidders would have to demonstrate compliance with environmental legislation, provide "evidence of the successful application of environmental management systems in a construction project environment" and show that they "proactively contribute to the development of sustainable schemes". Compliance with BREEAM will be a key performance indicator. [extract from Procure21+ website]

Two of the three case studies case studies are related to Case Study 4; one of them is an enabling works contract carried out prior to the PFI Scheme as part of the other batch project and the other is a joint project with another trust providing specialist cancer treatment facilities on the site of Case Study 4. Both involved the same PSCP designers and subcontractors and are smaller stand-alone newbuild projects of less than £10 million. The third case study in Temporal Period 5 was a larger scheme of around £20 million involving a new build extension and refurbishment of the existing nucleus hospital.

1.2 New Pathology Department

The existing pathology department needed to be demolished. It also gave the opportunity for new up to date haemodialysis, microbiology and Containment Level 3 laboratories to be provided. P21 was selected as this enabled the client to use the same contractor and architects as for the PFI by appointing them in advance of the main scheme. It was too small in value to be a PFI in its own right.

Although we had a separate team for the project, I was involved in the early stages in preparing the brief. Having just completed the Pathology Department at Case Study 3 I was aware that provision would have to be made for automated equipment, Figure 61 although at that time it was not included in HBN guidance. The experience at Case Study 3 enabled me to prepare a brief with realistic room areas which would accommodate the new technology. The design team was the same team who had worked at Case Study 3.

The architect who had worked on the Pathology Department in Case Study 3 scheme was in charge of the project. A highly skilled and competent architect she got on well with the users and produced a viable scheme both in terms of cost and quality. Unfortunately, she did not get on well with the design manager (he had worked on Case Study 3 and was an engineer) as she wanted to run the project as a 'traditional' architect and had very high quality standards. Following pressure from the site team, the Architect's Project Director decided to replace the architect. This proved detrimental to the project as a whole, towards the end of the project I visited site accompanied by one of the surveyors who had also worked on Case Study 3, the completed automated laboratory equipment in the main laboratories looked great and the precision and care with which the original architect had designed it was obvious but the installation of the concealed plumbing units in other rooms was should not have been allowed to happen. Instead of pipework being concealed within the prefabricated plumbing units it came out of the side and down through the floors. The drainage holes had been cast in the wrong places and the units fitted in the locations shown on the drawings. Nobody had bothered to check. The surveyor told me the site agent looking after this part of the works had previously worked on civils projects and had no fit-out experience. I also discovered the original architect's replacement was not a qualified architect.

Unfortunately, at this stage there was little that could be done without a great deal of expense to rectify the situation and the client was very pleased with the overall result, providing supporting references for future projects.

Figure 61 Automated Laboratory Equipment

1.3 Satellite Cancer Centre

The building was set up by a large cancer trust and is managed by the Trust in Case Study 4 being part of the estate and therefore the two trusts decided to use Procure 21 with the same team as the PFI project. This was a highly technical project involving the installation of two linear accelerators and as a result we had many meetings with the users, the medical physicists and the radiation protection officers.

I was originally involved in an overseeing role but ended up trying to sort out the contract administration. In the Procure 21 process the client needs to appoint a project manager – either from within their organisation or a consultant. The trusts decided it would be better it was someone outside of the trusts to avoid bias and opted for a project manager (ex-quantity surveyor) who had carried out work for them previously. We had suggested they should appoint the ex SPV construction manager who had worked on Case Study 3 and was now working as a consultant as he was experienced in large scale projects, had integrated well in the team and knew the Trust team very well. The project manager who was appointed although he had managed small healthcare projects procured traditionally was not familiar with Procure 21 and did not fully understand his role

The team which we selected did not gel together. The Project Manager who had been responsible for the multi-storey car park in Case Study 4 (which was in fact a specialist subcontract and had little involvement with mechanical and electrical services) was given this project although he was quite young. The Project Director thought this project would be good for him – although extremely capable he needed more experience. The Commercial Manager was also young but very bright and experienced having worked on both Case Studies 3 and 4. He was very thorough but found himself working with two individuals who were poles apart- the Project Manager and the Design Manager. The design manager selected for the project was the one who had joined the team at the start of Case Study 4, an architect, older than both the project and commercial managers, considered himself to be very experienced, he was very affable but could not understand that design management meant managing the design and not sketching missing architectural information. He had no concept of following design procedures and each month I had to sit down with him and go through the documents required for the Project Review Meetings.

Neither the project manager or the design manager understood the necessity for working with the Mechanical and Electrical engineers/ subcontractors (supply chain partners) as a result when the packaged plant room was craned into position on the roof there were problems with the fixings. As I had a good relationship the engineers and the subcontractor, I ended up bringing the parties together.

Both trusts were very pleased with design and the final building, but the management of the project proved rather difficult.

1.4 Women's and Children's Unit

The project had several problems, we were not the first contractor to be appointed, the previous contractor had pulled out and once involved with the project I could see the reason why. The amount of money which the trust was receiving from the Department of Health was insufficient for the client's requirements. There were similarities with Case Study 3 relating to the area/cost issues and the fact the new building was connecting to an existing Nucleus hospital where one of the templates needed major refurbishment. The architects who were novated by the trust had produced a layout which was unviable. This is where the similarities ended. The Trust's team was inexperienced with an Estates director and an external management consultant who had not been involved in construction. We suggested an external project manager, to comply with Procure 21 requirements whom they appointed. Although very competent, a structural engineer, but lacking healthcare experience, he liked to delegate and tended not to listen when concerns were raised and only wanted to hear good news. He had also been involved in a previous failed P21 bid and put too much faith in some of the individuals involved in that project who proved to be less than competent.

Our team included the Case Study 4 Project Director who, although he had overseen a large P21 project, was not computer literate and had caused problems on Case Study 4 (largely overruled by the Batch Project Director (who had now retired) and myself) and the Commercial Manager from the other batch project who was only interested in promoting himself, prepared to give the client what they thought they wanted but could not afford, by reducing specifications. They did not want a design manager whose interest was in managing client expectations, they were only self interested. It was not a happy team as I had overruled both of them previously (being in a senior position) when I had considered them to be damaging both the relationships with the clients and the completed project. I realised early on there were serious problems with layouts – rooms missing – no pantry in the ward, no disposal rooms etc. rooms which were the wrong shape and size and areas which could not be built unless corners of the existing building were demolished! The project was being funded in order to bring facilities up to current HBN standards, but this was virtually impossible within the constraints of the nucleus template. The architects had produced layouts ignoring the structural frame and what the commercial manager considered to be a 'cheap' refurbishment was a major reconfiguration. The project director displayed a complete lack of understanding of buildability. He suggested a link corridor, which was on stilts, providing a fire escape from the operating theatres could be retained and extended to connect to the new Maternity Department, whilst demolishing part of the nucleus template below just because it was shown on the architect's drawing. Needless to say, this part of the building had to be re-planned.

The user group meetings were disastrous – the Trust failed to get the right people to attend, did not allow sufficient time for the meetings and provided the most unsuitable meeting rooms. I tried to suggest that we should have a proper timetable as we had on Case Studies 3 and 4 but the Trust would not listen. The architect went on maternity leave and the firm replaced her with another architect who realised the scheme had serious flaws. At one point having established a good relationship with one of the matrons who informed us that they required a large storage area – she took the new architect and myself on a tour of the existing facilities, we reconfigured a large windowless area - due to deep planning into stores. She was very pleased with this, but the Trust was extremely displeased as they wanted to use the space for administrative offices, this was despite the fact there were no windows or borrowed light they wanted to accommodate 16 secretaries in the room and considered my suggestion as interference.

The project director left the company suddenly and the managing director (who was also from a commercial background) decided the commercial manager should take charge of the project. He was only interested in agreeing the contract sum, starting to build, and due to the fact the area/cost was unaffordable started to change specifications in order to make savings. At the same time, he tried to keep me out of the loop by failing to notify me of meetings.

I left the project just after work started on site, as did the commercial manager, and the construction manager, from Case Study 4, took over as project manager although he left several months later. This was meant to be a flagship 'BIM' project but due to how it had been set up and with the poor level of understanding that did not happen. I refer to it in hindsight as 'time warp' as there were so many things which happened which could have been avoided from 'lessons learnt'. Fundamentally it was flawed and rather than try to resolve the problem as in Case Study 3, both the contractor and the client chose to bury their heads in the sand.

2.Design, Bid Build Prison Case Study

2.1 Description

This case study involves a project to provide a new visits block for prisoners and new staff facilities at an HMP prison in 1997. The reason for including this project was the brief was prepared following a value management workshop. It was a traditional JCT with quantities contract and I was involved as the Project Architect and Design Team Leader during this same temporal period. This project started around the same time as Case Study 2. The initial advert to bid for the design of the project was for teams of architects, structural engineers and services engineers to put forward a proposal of how they proposed to develop the scheme. Scottish Prison Service (SPS) Estates issued various documents including an in-house scheme prepared for cost purposes. Teams were also invited to visit the prison before preparing their bids. The appointment of the quantity surveyors was a separate issue; they would be selected from the SPS approved list.

The proposed site for the visits block was on the car park at the main entrance adjoining the five metre-high stone perimeter wall. The proposed SPS scheme involved demolishing the wall and accessing the works through a new perimeter fence which would necessitate the use of 'escorts' - prison officers to accompany and oversee the contractors accessing the site. The proposed SPS plan of the building also had some serious internal circulation problems. Having visited the site with the structural and services engineers there seemed to be an opportunity to retain the existing five metre-high perimeter wall. The ground level on the prison side had a difference of 1800mm to that on the outside, it also had two original doorways which had been built up and therefore afforded the possibility of constructing the building from the car park side thus avoiding using escorts and opening up the original doorways towards the end of the project. We based our proposal around this idea and were shortlisted for interview by the Project Manager, the Project Sponsor and the Head of Estates. Following our presentation to the client panel and a separate fee bid we were appointed for the project. The appointed quantity surveyors turned out to be a firm that I had worked with on many healthcare projects and were extremely good cost consultants.

The Project Manager set up a steering group to discuss carrying out a value management workshop. He appointed a facilitator and the object of the workshop was to determine if we could retain the prison wall as they had liked the idea which we had proposed. The Project Sponsor was present and for the first time the Prison Governor. Normally on prison projects the governor is not involved, decisions are made by the Project Sponsor, but in this case the governor had insisted he was involved as he had serious concerns about the layout which had been proposed by SPS.

He was very different from other governors as he was from an academic background; having lectured in prison training college he was very keen to adopt new management concepts. He was very much in favour of the value management workshop.

The facilitator organised a two-day workshop in a hotel in which the design team, including the quantity surveyor, SPS Project Sponsor, the governor, deputy governor, operations governor and several prison officers all took part. This proved to be extremely useful and the end result was that we could proceed with the concept of retaining the perimeter wall. It also enabled me as a designer to understand the flows required in the building. After the workshop the Project Sponsor arranged a series of visits to several other prisons and the State Mental Hospital to look at visits facilities.

Having gathered all this information I prepared a schedule of accommodation (also utilising the prison design guides) and a description of what was required. The schedule outlined what would be required at each level. The cost of this was checked by the QS before it was presented to the steering group. Following this approval, the initial scheme design was prepared. The governor made some specific requests regarding finishes - he wanted stone flooring in the entrance (the original Victorian Halls had this) and the operations governor had firm views on the design of the Closed Visits Area which led to a rather unique layout with which they were delighted. The QS took on board all these comments and built in provisional sums as well as costing the expensive elements resulting in the project being built for the original budget.

The project progressed well and was a traditional JCT 80 with quantities (same as Case Study 1). The main contractor who won the contract turned out to be same contractor who built Case Study 1 and some of the staff had worked on the project – they had also recently completed another project for SPS and as a result it did not take long for all parties to work well together. I chaired monthly site meetings and attended the regular steering group meetings with the Project Manager, the SPS Project Sponsor and the prison governor.

3. Critical Incidents

There was only one critical incident on this project which was related to the production of information. I had left the practice from where I worked on Case Study 1 and joined another practice involved with major healthcare projects. One of my conditions of moving to this practice was to transfer this project with me. The project was out to tender when I moved practice and the client SPS agreed to this arrangement as the practice I was moving to had also worked for them. The project transfer went well except for the transfer of the information due to a change in computer programmes. During this period there were about three industry recognised programmes and although the original drawings were done on what was considered to be the preferred programme in architects' practices, and was subsequently the one used for Case Study 2, the practice chose to use a different one as the architect allocated to help on this project was familiar with it. This proved to take longer than necessary and as a result wasted resources, making the project less profitable for the practice than it should have been.

4. Integration

Using a value management workshop or 'Charette' to develop the client's brief not only produced a project brief which successfully delivered the client's expectations but also helped to build a more integrated team which could discuss and resolve problems when they occurred as the result of a better understanding of each other's point of view. Ideally the contractor would have been part of the value management workshop, but this was not possible due to the design-bid-build delivery model. In this case however the contractor was very proactive and keen to be part of the team. This may have been helped by the fact I had worked with them before on Case Study 1 and as a result the relationships were not adversarial.

Again, as with NHS projects, furniture is usually procured centrally and from approved suppliers. The governor however wanted bespoke furniture for the Open Visits Rooms where a prisoner could sit with visitors, but without drugs being passed under a table. The rooms all had CCTV, but this could not pick up drugs being passed under a standard table and chairs. He also considered formal tables and chairs as unfriendly and wanted an integrated unit. The result was that a design competition was held for final year product design students at the Glasgow School of Art. The governor and his team prepared the brief and held a briefing session with the students. Six teams submitted designs with scale models and following their presentations the governor and his team selected one design. The design was then developed by one of the large commercial furniture manufacturers and went into production. The three students who had designed the chair/table unit were each awarded £1,000. This was a really good example of integration and also fulfilling early promises – often 'live' student projects are never carried out.

5. Positive Integration

There were three positive integration:

- The value management charette
- The introduction of electronic access systems
- Stakeholder engagement in the design of bespoke furniture

6. Findings and Evidence of a Requirements Crunch Point

In this project the requirements crunch point takes place early on in the design process before Stage C due to the carrying out of the value management charette to produce the client's requirements. These requirements were then translated into room areas, room relationships and a specification for which a project budget was calculated. Following the approval of the scheme, the project was tendered traditionally and as a result of robust preparation no cost savings were required in order to accept the tender. Although this was a shorter construction period than the major hospitals, few changes were required – more issues regarding the completion of certain design elements such as the inclusion of a ‘sauna’ in the prison officers’ fitness suite where the biggest concern was if news was leaked to the press!

Appendix F: Integrated Healthcare Design Studies and Workshop

1.1 Integrated Design Management in Healthcare

Over the temporal periods projects have been become more complicated, more sophisticated with advancing technology resulting in more experts to be engaged. The fear of blame and uncertainty has resulted in all parties trying to transfer risk to someone else but as demonstrated through the case studies this has not been achieved successfully. Rather than increase the number of parties involved in complex hierarchies, engaging multiple consultants 'guarding the guards' and employing individuals to carry out unfamiliar roles a simpler approach with shared responsibilities is required.

The wider delivery system in the form of the NHS needs to become more proactive in setting out and monitoring its requirements as set out in Figures 62 and 63 and Tables 62 and 63

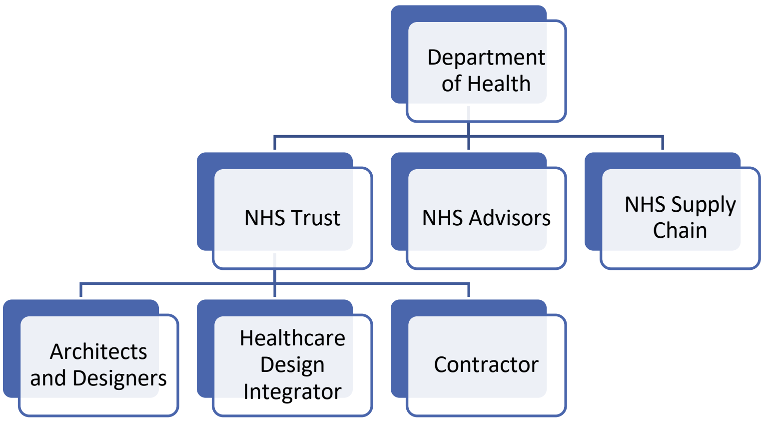


Figure 62 The Integration of the Wider System and the Project System

Table 62 Integrated Design Management Levels

Wider Delivery Model	**Level 1**	Role of government setting out standards and guidance for the design of healthcare facilities; involves research and development to be carried out by design professionals. Requirements to ensure that education and training is available to enable competent professionals to be engaged on project delivery
Project Delivery Model	**Level 1**	Role of Systems Integrator with design experience to integrate the project team and interface with the wider delivery model
	Level 2	Architect led design coordination
	Level 3	Designers, Design Cost Manager and Design Programme Manager
	Level 4	Construction Design Managers and Design Information Manager

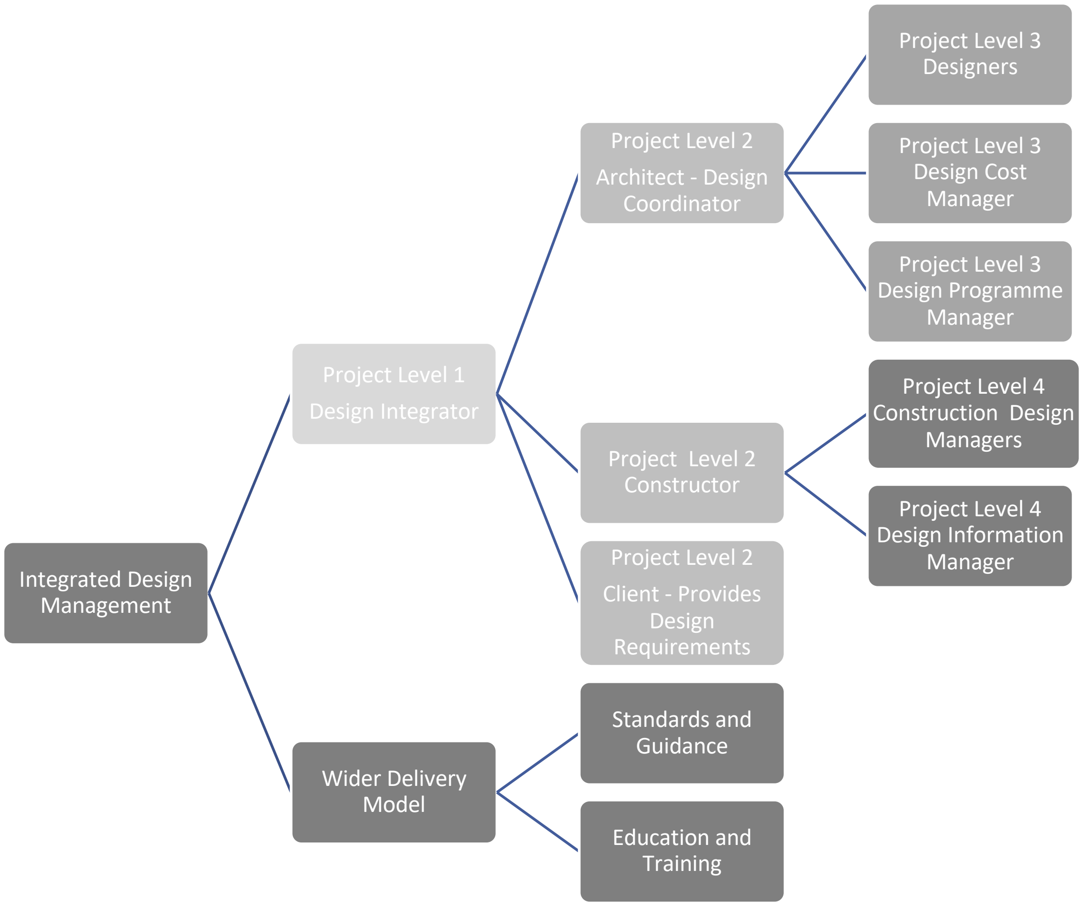


Figure 63 Integrated Design Management

Table 63 Design Management Activities

Activities, Roles and Responsibilities related to Project Stages		
Design Stages: Integrated Design	Design Integrator Architects and Engineers Trust Healthcare Planner	Design Co-ordination Structural and Mechanical and Electrical Services
Design Information Management	Design Integrator Design Information Manager	How the information is communicated between parties, BIM model
Design and Construction Integration	Design Integrator Architect, Design Manager and Design Cost Manager	Buildability and Procurement
Construction	Design Integrator Design Manager	Ensures that the construction complies with the agreed requirements

Construction	Design Integrator Design Cost Manager	Monitors cost and change control
Construction	Design Integrator Design Information Manager	Ensures that the correct information is distributed to members of the construction team

The change from Design-Bid-Build (DBB) to Contractor Led Design and Build (D+B) had a huge impact on Design Management by splitting activities between the architect and the contractor without clearly defining roles and responsibilities. Figures 64 and 65 below illustrate how these activity flows have changed according to contract changes.

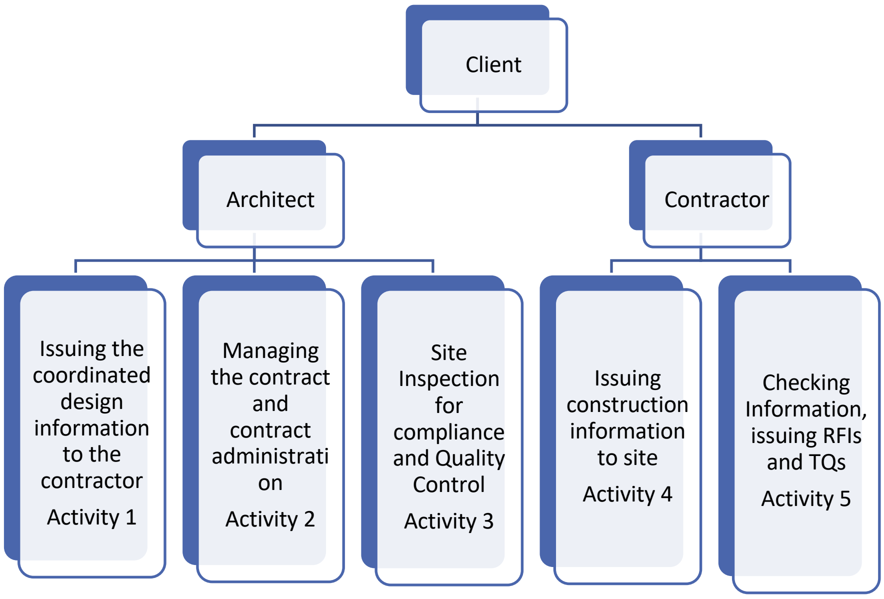


Figure 64 Design Bid Build Design Management

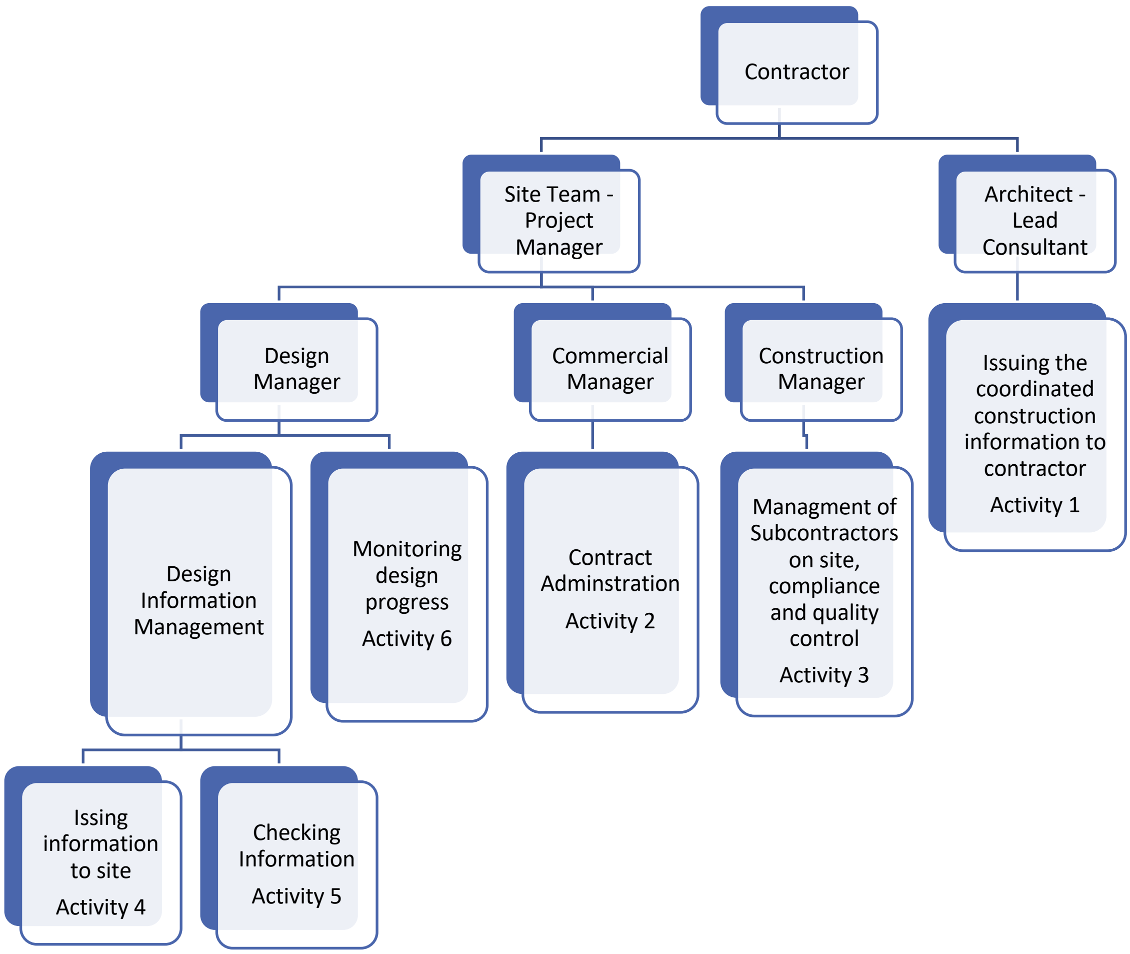


Figure 65 Design and Build Design Management

The differences between Figures 66 and 67 in terms of design management is that Activities 2 and 3, contract administration and compliance and quality control have been transferred to the commercial and construction teams respectively as set out in Table 11. This table also includes reference to an integrated model where the new role of design cost manger undertakes the contract administration removing the commercial influence as suggested by Law (2018). Activity 3 of site inspection and quality control is shared between the architect and the construction design manager to eliminate 'contractor self-certification', issues which were apparent in the failures during Temporal Period 5.

1.2 Healthcare Specific Design Approach to Zoning and Layering

The open building layering concept is one part of the healthcare design layering system. As demonstrated in the case studies a layered approach to briefing need to come first which I called Zoning. The form of accommodation schedule developed through the temporal periods enabled the co-location of departments to be grouped together to achieve maximum efficient in terms of structure, distribution of services and departmental relationships. This method of accommodation scheduling was initially used to identify the clients' requirements were being met ensuring that rooms are not missed out as occurred in some of the case studies before this framework was applied.

It can also identify where the high capital cost areas where located and a means of ensuring systems such as the nurse call were provided in the correct rooms; relationship between patient areas and nurse working areas becoming the baseline. It gave the structural engineers a rough guide in the early design stages where the heavy loads were likely to occur, and the services engineers a basis from which to design distribution schematics.

Zoning takes place in three areas:

- Departmental Zones: Types of department
- Cluster Zones: Room groupings within departments
- Activity Zones: Activities within rooms

Table 64 describes Departmental Layers

Table 64 Departmental Layers or Zones

Layer	Description	Departments	Requirements
Patient Areas			
1.	Inpatient Accommodation	ICU, HDU, Intermediate Nursing Care and Assessment Units	Continuous operability, high proportion of repeatable rooms, recognised room clusters Low, medium and high levels of hospital infrastructure requirements
2.	Outpatient Accommodation	Outpatient clinics	Normally 12 hour operability, high proportion of repeatable rooms, recognised room clusters Low to medium level
3.	Treatment and Diagnostic	Emergency Department Operating Theatres Cardio Catheter Laboratories Imaging (Radiology, CT and MRI)	Continuous operability, mixture of large, medium and small rooms, Low level of repeatable rooms High level of hospital infrastructure requirements
Non-Patient Areas			
4.	Clinical Support	Pharmacy including Aseptic and Radio-pharmacies Pathology and Mortuary Medical Equipment	Continuous operability, mixture of large, medium and small rooms, Low level of repeatable rooms High level of hospital infrastructure requirements

Patient, Staff and Public Areas			
5.	Non-Clinical Support	Main Entrance Administration Spiritual Care Education Staff Changing Catering Facilities Management	Continuous operability, mixture of large, medium and small rooms, Low level of repeatable rooms Low level of hospital infrastructure requirements
6.	Communication and Engineering Services	Lifts, Stairs and Main Corridors (Hospital Street) Plantrooms and Main Services Risers	Hospital Infrastructure

Departmental Zones include groups such as: Treatment and Diagnostic; Emergency Care, Operating Theatre Departments, and Imaging Departments, departments where deep planning is required with large open spaces, high ceilings incorporating complex technology, major medical equipment, heavily serviced with limited public access. This is in contrast to Inpatient Ward accommodation which benefits from shallow footplates, lower ceilings, less technology and facilities for visitors. There are other zones catering for outpatients, clinical and non-clinical support. The understanding and use of zones aid the layering concept, particularly in relation to the Primary Layer. The identification of 'hot' and 'cold' areas in reference to emergency care can determine which areas involve high levels of repetition, like ward areas, and which ones are unique, such as main entrances. The framework can also accommodate different levels of prefabrication from full scale volumetric to 'flat pack' and individual components. The use of zones avoids the difficulties of attempting to plan different types of departments within a standard grid arrangement with resulting compromises and promotes understanding of overall healthcare planning by looking at each department's requirements. It differs from the Nucleus system demonstrating the benefits of systems integration, but without its rigid template. In this framework there are six zones compared with the four layers proposed by the Netherlands Board for Healthcare Institutions (2007).

The second level which I have described as clusters where grouped activities within departments are 'clustered' together as in Table 65.

Table 65 Departmental Room Clusters

Cluster		Typical Areas
1.	Patient Accommodation	Bedrooms, En-suite toilets, Treatment rooms, Day areas
2.	Nurse Working Areas	Staff bases, Clean and Dirty Utilities
3.	Office Accommodation	Sister’s Office, Reporting Areas, Meeting Rooms
4.	FM Accommodation	Pantry, Cleaners’ Room, Disposal Room
5.	Storage	Store Rooms, Equipment Bays
6.	Public Areas	Reception, Waiting Areas, WCs, Overnight Stay Facilities
7.	Staff Facilities	Staff Rest Room, Staff Changing, WCs,

Cluster Zones occur within departments such as an operating suite consisting of an operating room, anaesthetic room, scrub, preparation, dirty utility and exit bay. Other clusters in ward areas would include nurse working areas, clean utility, dirty utility, near patient testing and staff bases.

The third level in healthcare design, which also correlates with the Tertiary System, is the layout of the individual rooms. This is where Activity Zones occur within rooms, one room may include a patient treatment zone, handwashing zone and visitor zone within a single room. It is in this activity zone layer where ADB has for many years been the default briefing and design database. ADB reflected the HBNs and producing room data sheets, room layout sheets and equipment lists.

The use of layers to operationalise healthcare design integration provides a contribution to knowledge. The concept of layering and zoning allows for up to three firms of architects to design and develop each layer. Large projects require large architectural teams and with scarce resources and often smaller healthcare focused architectural practices, layering maximises resources. All three architectural practices require specialist healthcare knowledge and as indicated in Table 66 there is an overlap between layers. The role of the mechanical and electrical services engineers incorporates all three layers as it provides the infrastructure for the hospital. The Layer 1 Architect needs to coordinate the design with the Mechanical and Electrical Engineers and the Structural Engineer in order to provide a ‘shell and core’ which can deliver the requirements for the Level 2 and 3 Architectural Designers. At Level 3 there is the opportunity for architectural practices to employ more architectural technologists.

Table 66 Integration of Design Layering

Level	Construction	Design Activities	Healthcare Zoning
1.	Clinical Functionality Level 1 Building Concept **Primary System**	Clinical Design Departmental Relationships Communication Routes Structural Integration Mechanical and Electrical Infrastructure **Architect 1**	Departmental Zoning 1. Inpatient Accommodation 2. Outpatient Accommodation 3. Treatment and Diagnostic 4. Clinical Support 5. Non-Clinical Support
	Design Integrator: Architect 1: Structural Engineer: Mechanical and Electrical Engineers, Trust Healthcare Planner		
2.	Clinical Functionality Level 2 Internal Spatial Layout **Secondary System**	Healthcare Planning Opportunities for off-site manufacture **Architect 2**	Departmental Layouts Room Relationships Room Clusters
	Design Integrator: Architect 2: Structural Engineer: Mechanical and Electrical Engineers, Trust Healthcare Planner		
3.	Clinical Functionality Level 3 Equipment Room Layouts **Tertiary System**	Individual Room Data and Room Layout Sheets **Architect 3**	Room Layouts Standard Rooms
	Design Integrator: Architect 3: Structural Engineer: Mechanical and Electrical Engineers, Trust Healthcare Planner		

The colours indicate the different levels of involvement, red is major, orange is substantial green is low and blue relates to the client involvement.

The case studies have demonstrated that although on first glance there were no visible frameworks following analysis using the healthcare design layering approach each one incorporates some fundamental principles. The examples where issues have arisen, if a more stringent framework approach had been taken, could have provided not only the client with a better solution but resolved construction difficulties for the contractors.

1.3 Standards and Guidance

The current guidance documents consist of HBNs and HTMs where the building components have been relocated within the HBNs and the HTMs refer to engineering services. Table 67 sets out a wider framework of documents reflecting the Layering /Zoning approach, where Zone 1 relates to the Primary Layer of 'shell and core', Zone 2 reflects the Secondary Layer of the internal fit-out of partitions and Zone 3 the individual room layouts for fitted furniture, equipment and loose furniture in the Tertiary Layer. A number of the documents reflect all zones layers, but some apply to only two or three layers with overlaps. Included in this list is a reference to a Component and Equipment Database which relates to an update of ADB to reflect current practice and terminology and which can link to generic rooms, clusters and BIM. A separate category is included for Major Medical Equipment and the reintroduction of Hospital Building Components allows these last two categories to link to an NHS Approved Supply Chain and potential modular construction and off-site construction.

Table 67 Healthcare Standards and Guidance

Document	Description	Outputs	Application
Mandatory Policy Documents Revised/New	Infection Control Fire Safety, Security	Design and specification	Zone 1 Zone 2 Zone 3
Hospital Departmental Planning Notes Revised HBNs	Departments Models of Care Healthcare Planning Communication	Healthcare Zoning Schedules of Accommodation Activities Departmental and Room Relationships	Zone1 Zone 2
Hospital Space Planning Notes Revised HBNs	Room Clusters Generic Rooms Individual Rooms	Generic Layouts for clusters and rooms	Zone 2 Zone 3
Hospital Technical Memoranda Revised HTMs	Mechanical and Electrical Systems	Specifications Components	Zone 1 Zone 2 Zone 3
Hospital Building Components Revised HBN/HTM	Doors, Screens, Casework, Sanitary fittings	Specifications and components	Zone 2 Zone 3
Major Medical Equipment New	Imaging Equipment, Operating Theatre equipment, HSDU, Pharmacy, Pathology	Specifications and components Equipment	Zone 1 Zone 2 Zone3
Component and Equipment Database Revised ADB	Casework, fittings, mechanical, electrical and plumbing services, mobile and fixed equipment and loose furniture	Room Data Sheets Room Layout Sheets Equipment	Zone 3

2. Integrated Design and Project Delivery for Major Hospital Projects Workshop

The methodology used in this thesis involves identifying temporal bracket periods, fundamental to defining the levels of design management and the proposal of integrated project delivery. In order to test my definitions a two-hour workshop was held on the 5 March 2020 (see Appendix J) where the findings related to these temporal periods were presented to a small invited group, followed by a discussion and a short questionnaire. The group consisted of two representatives from Public Health Sector Estates: delivery and advisory leads, three representatives from the construction industry: main contracting – a civil engineer and a quantity surveyor, subcontracting, an electrical engineer and a healthcare architect involved with standards and guidance. The discussion was chaired by Dr Grant Mills (my first supervisor) and also attended by Professor Aeil Roberts (my second supervisor).

The presentation outlined the approach taken in this thesis, describing the five temporal periods which are bounded my major projects (case studies) and academic studies, Table 68:

Table 68 Temporal Periods

Temporal Period	Case Study	Academic Studies
1. 1975-1993	1. Traditional/ DBB	MSc Construction Project Management
2. 1993-2001	2. PFI/D&B	-
3. 2001-2016	3. PFI/D&B	MSc Planning Buildings for Health
4. 2007-2012	4. PFI/D&B	
5. 2013-2020	5. PFI/NEC/D&B	PhD Studies

In the presentation the descriptive names of the temporal periods were not disclosed until the end in order to establish whether the participants agreed with them. Critical incidents which had been identified within these temporal periods were described in relation to what had caused them and at what stage in the projects they had occurred. The concepts of integrated design management and the role of a systems integrator were introduced together with the principles of integrated project delivery and project insurance.

During the discussion, some typical comments included “I can identify with all the items on the list of critical incidents”, and in relation to concerns that I had raised about competencies when construction staff had been allocated to roles for which they had no training just because they were available, one of the contracting representatives said, “come to think of it, I have experienced this when we put someone with no healthcare experience in charge of a healthcare project and it didn’t work out”. In relation to the wider delivery model, the importance of providing prescriptive standards and guidance was favoured by both the client bodies and the contracting organisations.

At the end of the presentation I asked them to fill in a short questionnaire based on the Likert scale, summarised in Table 69

Table 69 Questionnaire

Q.	**Description**	**Response**
1	Do you think a new delivery model is required?	5 out of 6 agreed (one didn’t respond)
2	Do you think IPD (Integrated Project Delivery) is a possibility?	1 strongly agreed, 4 agreed and 1 didn’t know
3	Do you think Project Insurance is a good idea?	2 strongly agreed, 3 agreed and 1 didn’t know
4	Do you think a Systems Integrator would be advantageous	1 strongly agreed, 4 agreed and 1 didn’t know
5	Do you think the description of Prescriptive Integration reflects Period 1?	1 strongly agreed, 4 agreed and 1 didn’t know
6	Do you think the description of Dysfunction Integration reflects Period 2?	1 agreed, 4 didn’t know and 1 disagreed
7	Do you think the description of Adaptive Integration reflects Period 3?	3 agreed, 3 didn’t know
8	Do you think the description of Disintegration reflects Period 4?	1 agreed, 4 didn’t know and 1 disagreed

Although it is a small sample, the range reflects different roles within the wider and project delivery models and the responses do give an indication of the different views from the different sectors. the questions are in two sections:

Questions 1-4 relate to general concepts, questions 5-8 relate to the temporal periods therefore when the participants were asked to state how long they had worked in the healthcare sector, this affected how they responded to the descriptions relating to the questions 5-8. Many of them were not involved in temporal period 1 but could recognise it as a period of prescriptive integration historically. Period 2 was more recognisably difficult as dysfunctional, particularly by the wider delivery model as its impact was more within project delivery, changing the relationships of the architect and contractor with only a contracting representative agreeing and a public sector representative disagreeing. In period 3, the split was equal between agreeing and don't know and this related to how the participants had been involved during this period. The final period of disintegration was reflected one contracting representative who recognised this description, one public sector representative who disagreed and four who didn't know. Interestingly all six acknowledged that there was something wrong with the delivery model when five current examples of major hospitals were serious delay and cost issues were highlighted in the presentation.

In the general questions, five out six either strongly agreed or agreed with the proposals, of the tree don't knows – each in a different category the respondents were from the public sector but different individuals.

Different responses between the contracting (project delivery) and the public wider delivery sectors is not unexpected, but what is apparent from this small sample is the acknowledgement that something needs to change. During the discussion there was strong favourability from the public sector to return to prescriptive integration and when asked "what should the next temporal period be described as?' 'prescription integration' was suggested together with a return to the level of standardisation – which existed in the nucleus building era. Overall some form of standard components and prescriptive standards and guidance was generally thought to be desirable, a new form of integration needs to be developed as it is difficult to 'turn the clock back' when nucleus itself 'died' due to its inability to accommodate change. One of the participants advocated "prescriptive integration with flexibility" this reflects the situation in Case Study 1 where Scotland adopted the HTMs and HBNs but not the Nucleus template. This also confirms the findings from my MSc dissertation relating to design integration of spatial planning, structure and services. We are now in a different temporal period from nucleus which was designed to provide District General Hospitals – a secondary level of healthcare which could be built to "prescriptive requirements" to hospitals which include specific tertiary levels of care necessitating a level of flexibility.

This prescriptive period also reflects traditional delivery methods where the client and architect bore the project risks for delivering on time and budget, something which by temporal period 4 the contractors were finding difficult to achieve and with onerous risk transfer is starting to impact on current projects resulting in a reluctance for contractors to tender projects or adding large sums to mitigate potential risk. Five of the six participants considered project insurance as advantageous with only one not sure.

Most of the participants were keen to know more about the concept of a systems integrator and what constitutes an integrated delivery model as they are terms not familiar to them. Further breakdowns and more detailed information regarding the critical incidents and how these could be addressed was requested by the contracting participants.

Post occupancy evaluation was something which was considered beneficial to all parties.

The Power Point Presentation, Figure 66 and Questionnaire, Figure 67 are attached

UCL

1

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This presentation/workshop looks at issues relating to project delivery methods, lessons from the past covering four temporal periods and how this can inform future projects, aid design management and promote the role of architects in systems integration.

Anne W. Symons, PhD Candidate, MSc (Planning Buildings for Health), MSc (Construction Project Management, B. Arch (Hons), RIBA, ARIAS, MCIOB

2

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My background

- Architecture degree – first introduction to systems integration – Louis Kahn – Richards Medical Centre
- Junior project architect on healthcare projects
- Principal in private practice – supervising officer on design-bid-build: Case Study 1
- MSc Construction project management 1993: Procurement methods for hospitals in Scotland
- Healthcare Architect/Project Manager – design and build : Case Study 2
- MSc Planning Buildings for Health 2006: Template Tyranny: Integration of Services and Structure in hospitals
- Project architect/ senior design manager – design and build: Case Study 3
- Batch Design Manager – design and build: Case Study 4
- Healthcare design advisor – design and build: Case Study 5

3

UCL

Why auto-ethnography?

- Uncommon in construction research except for behavioural studies
- Subjective – reflects my project experiences as a systems integrator from 'both sides of the fence' - architect as 'Supervising Officer' in traditional design-bid-build and being responsible for design working for a contractor in design and build

4

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Methodology

- Case study analysis
- Major acute hospital projects of similar size and complexity in different temporal bracket periods
- Narratives for each study
  - Identification of Critical Incidents
  - Identification of Significant Development
- Analysis
- Conclusions
- Recommendations

5

UCL

Proposal

- How to apply Integrated Project Delivery to Major Public Sector UK Hospitals to achieve client requirements
- Longitudinal study in the field of integrated design management
- Research findings from four temporal brackets over a period of 40 years
- Identification of failings with past and current models
- Possible actions to prevent future failings

6

1

Contribution to Knowledge

- the identification of levels of integration, by whom and at what time during project lifecycles and their relationship with the wider delivery of hospital projects.

7

Outcomes

- The adoption of an integrated project delivery model for major hospital projects based upon:
  - Systems integration
  - Principles of lean construction
  - Framework procurement and monitoring
  - Central government guidance and regulation
  - Recommendations for Training and Knowledge Transfer

8

Introduction

- 60 years since the RIBA set up a Healthcare conference at the Bartlett School of Architecture
- 50+ years since the SHHD carried out Building in Use Studies
- 45 years since the birth of Nucleus
- 30 years since the introduction of PFI
- 28 years since the death of Nucleus
- 2 years since the demise of PFI

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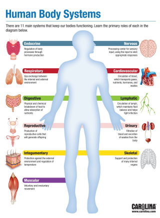
Why is major hospital construction different?

- Public procurement
- Complex architectural design – spatial planning
- Sophisticated mechanical and electrical services installations
- Subject to innovation and new technology
- Multiple stakeholders
- Need to understand medical practices

10

Systems Integration Synergies



Human Body System	Building System Relationship	Discipline
Circulatory	Heating	Mechanical Engineer
Digestive and Excretory	Power Source	Mechanical Engineer
Endocrine	Healthcare Planning	Healthcare Planner
Integumentary and Exocrine	Cladding	Architect
Immune and Lymphatic	Healthcare Planning	Healthcare Planner
Muscular	Internal Fit out	Architect
Nervous	Communication	Electric Engineer
Renal and Urinary	Water Supply and Drainage	Plumbing Engineer
Reproductive	Standardisation	All
Respiratory	Ventilation	Mechanical Engineer
Skeletal	Structural Frame	Structural Engineer

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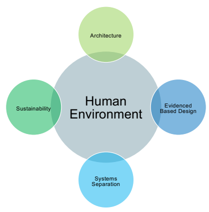
The Wider Delivery System: Environment



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19/03/2020

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Temporal Period 4: Completed with issues

Royal Sick Children's Hospital Edinburgh

July 2019
Brookfield Multiplex

- Handed over to the Trust in February 2019 (2 years late)
- Failed to open in July 2019 due to tender error on 2012
- *"Cost of remedial work soaring because contractors didn't want the job"(MSP, 16 Jan. 2020)*
- NDP Project
- Design and Build

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Temporal Period 4: Awaiting completion

Liverpool Royal Infirmary

Collapse of Carillion 2018

- PFI due to open in 2017
- Design and Build
- Work recommenced – publicly funded
- Management Contractor appointed October 2018
- Completion due 2020
- Major structural faults
- Revised opening date 2022

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Temporal Period 4: Awaiting completion

Midlands Metropolitan Hospital

Collapse of Carillion 2018

- Originally PFI Project
- Design and Build
- Works recommenced Jan 2020
- Publicly funded
- NEC4 Contract, Design and Build
- Completion due 2022

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Temporal Period 4:

Aberdeen Royal Infirmary

Still awaiting contractor appointment

- Appointment due February 2020
- Currently 2 years late
- Cost increase from
- £163.7million to
- £223.6million
- NPD
- Design and Build

22

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Question

Have or are these projects delivering on:

- Time?
- Cost?
- Quality?

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Case Studies

		Phases				
		1	2	3	4	5
Temporal Period 1	Case Study 1	0	0	1	9	0
Temporal Period 2	Case Study 2	0	3	2	14	1
Temporal Period 3	Case Study 3	0	4	5	8	0
Temporal Period 3	Case Study 4	0	4	4	11	0

Project phases

1. Establishing project requirements
2. Developing project requirements
3. Agreeing project requirements
4. Delivering project requirements
5. Project in Use

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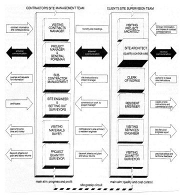
4

Roles and Responsibilities



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Lead designer (RIBA Plan of Work 2020)

"The lead designer is crucial on any project – they direct the work of the design team, coordinating design efforts and liaising with the project team, client, stakeholders and the contractor, to determine project constraints and to refine the client's brief as it develops."

Dale Sinclair, The Lead Designer's Handbook, 2019

- Separate role from that of the project architect
- Knowledge and experience of particular building type is essential
- Knowledge of design management-orientated tools and technologies

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Skills and professional transferability

Accessible

- RICS acceptance of different degrees subject to examination
- CIOB acceptance of different degrees subject to examination
- MICE related to civil engineering and building engineering and can lead to Project Director on construction projects

Restricted

- BMA/GMC : Medicine
- RIBA/ARB : Architecture

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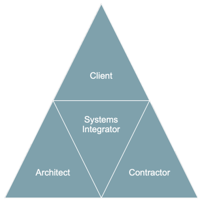
Integrated Project Delivery



- Tripartite Contract
- Systems Integrator
- Project Insurance

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Cathedral Hill Hospital Project

Integrated Project Delivery

- AIA form of contract: client, designers and contractor
- Principles related to Lean product development at Toyota: 'Right people, right work, right time'
- Chief Engineer is appointed to guide the team – 'someone who has "walked in the customers' shoes to gain a deep understanding of their needs"
- Literature review concluded that it lacked a clear definition of what design management means – *Lostuvali et al (2014)*

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Delivery model requirements

- No blame culture
- Understanding of client requirements
- Ability to incorporate new technology without punitive penalties
- Cost control (different from cost certainty)
- Delivery of perceived quality
- Delivered on time

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19/03/2020

Framework

- Department of Health (Government) framework:
  - Systems Integrators
  - Healthcare Architects
  - Healthcare MEP Engineers
  - Structural Engineers
  - Main contractors
  - Nominated Subcontractors (MEP and specialists)

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Guidance and Regulation

Set up a National Health Building Agency to carry out research and development:

- Provide advice to Trusts regarding procurement and selection of design teams
- Review and update HBN and HTMs at regular intervals
- Provide clear guidance relating to mandatory requirements
- Re-establish CDB
- Rationalise ADB
- Re-introduce guidance on departmental cost allowances

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Training and Knowledge Transfer

- Compulsory POE
- Mid career training
- Professional recognition including demonstration of CPD

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Proposed Requirements for a Systems Integrator

Architect

- Architecture degree
- Period in industry
- MSc Construction Management Degree
- Specialisation in building type

Contractor

- Construction Management / Engineering Degree
- Period in industry
- MSc Architectural Degree
- Specialisation in building type

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Temporal Periods Descriptions

Period		Delivery Model
Prescriptive Integration	1975-1992	Nucleus/Design-Bid-Build
Dysfunctional Integration	1993-2002	First Wave PFI/Design and Build
Adaptive Integration	2002-2012	Second and Third Wave PFI/Design and Build
Disintegration	2013-2019	PF2 / Design and Build

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What will the next Temporal Period be?

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Figure 66 Power Point Presentation

Integrated Design and Project Delivery for Major Hospitals

Type of Organisation					
Role					
Background Discipline					
Number of years involved with Healthcare					
Questions	**Strongly Agree**	**Agree**	**Don't Know**	**Disagree**	**Strongly Disagree**
Do you think a new delivery model is required?					
Do you think IPD is a possibility?					
Do you think Project Insurance is a good idea?					
Do you think that a Systems Integrator would be advantageous?					
Do you think the description of Prescriptive Integration reflects Period 1?					
Do you think the description of Dysfunctional Integration reflects Period 2?					
Do you think the description of Adaptive Integration reflects Period 3?					
Do you think the description of Disintegration reflects Period 4?					

5 March 2020

Figure 67 Questionnaire