BY-PRODUCT AS MAIN PRODUCT

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Abstract

This thesis investigates spatial attraction in urban space and arising potential for spatial interaction. It grounds on Space Syntax theories that spatial attraction is governed by network configurations of the urban grid but also by the particular nature of land use activities which attract across distance in space. An open question is raised concerning the interplay between those attracting forces and the configuration of the urban grid: how can spatial attraction be conceived of as the main driver in creating surplus-value for trips through urban space - and what are the consequences for both local building attractors but also for the performance of the urban grid as a means to communicate space?

The research is carried out through the analysis of the Barbican Arts Centre (BAC) and the Royal Festival Hall (RFH) as two London based cultural venues. On the one hand, both places are acting as local attractors within their urban context due to their land use activities as concert halls. On the other hand, both places reveal pathological malfunctions related to spatial attraction.

Based on the notion of the urban grid itself being a spatial attractor, this thesis focuses on the by-product of movement, which is the series of spaces passed through when moving from an origin *a* to a destination *b*. A method is tested which considers the local context around each case study as a field of attracting forces. Space Syntax axial analyses transforms urban space into the graph structure of an axial map, whereas land use data is assigned to buildings or groups of buildings of same land use to represent interfaces of activities. It is hypothesised that combinations between attracted movement flows and interfaces are either amplifying or reducing the effects of the by-product in urban space.

The application of the analyses reveals no contribution of the by-product on the segregated site of the BAC, and little impact of the by-product on the RFH. Thus, a more general question can be asked: do local building attractors necessarily have to rely on spatial attraction in the form of the by-product of movement? Or do specific kinds of local attractors overcome low segregation by means of their specific transpatial nature? The conclusion shows that local attractors are able to do so - to the expense of not amplifying but reducing the by-product effects for the local urban context. Hence, it is speculated about the advantages of the urban grid as a physical, faster and more powerful communicator of space in contrast to transpatiality as a virtual, constraint and less efficient communicator.

Keywords

Spatial attraction, spatial interaction, decay, urban grid, by-product

"An urban system, by definition, is one which has at least some origins and destinations more or less everywhere. Every trip in an urban system has three elements: an origin, a destination, and the series of spaces that are passed through on the way from one to the other. We can think of this passage through these spaces as the by-product of going from a to b. We already know that this by-product, when taken to the aggregate level, is determined by the structure of the grid, even if the location of all the a´s and b´s is not"

(Hillier 1996, Space is the Machine)

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3. Acknowledgements

I would like to express my gratitude towards Dr. Ruth Conroy Dalton, who is the supervisor of my thesis. Her excitement and interest in the topic of this thesis gave me strong support, without which this report would have looked different. She was guiding me with long-sightedness and encouraged me to take small steps to explore unknown area. After all, her tutorials were exceeding pure advice on my research progress in order to additionally spread motivation.

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Many thanks goes to all my colleagues of the MSc AAS. Discussing, and joking, about Space Syntax from different cultural points of view proved to be a rich and necessary level of reflection during the time of the thesis and the whole year of the master study. These discussions turned out to be very important to re-think and judge the recently gained Space Syntax knowledge.

Many thanks, as well, to my parents who supported my studies without necessarily un- 1
derstanding what Space Syntax is. Both are not at all related to space and design. Thus, they simply trusted me in what I do. Thanks.

Special thanks to my two brothers, who are maybe the most careful critics of my work, because they know me so well. Their feedback was a source of inspiration - and it was very helpful in finding my own position towards Space Syntax.

4. List of illustrations, tables and equations

5. Introduction

Urban space is connecting individual places within settlement structures not only to make them accessible but, by the way that happens, it also mediates and communicates how some places interact with others.

Space Syntax is a set of theories and techniques which conceives of and analyses the urban grid as a network of connected spaces in order to apply graph theories to investigate these complex spatial networks. Some spaces in each network are found to receive more movement than others due to their location in the network. In Space Syntax theory, the by-product of a trip within an urban network is the sequence of spaces one has to pass through on the way from an origin a to *a* destination *b*.

This thesis looks at concepts of spatial attraction to ask how it governs flows of movement and how the combination of those flows with building interfaces effects potential for spatial interaction. Two local building attractors in the city of London were chosen as case studies. The Barbican Arts Centre and the Royal Festival Hall are two major art venues (concert halls) of comparable size and program. They are located in central London. Both attractors buildings feature an introverted, almost pathological, spatial relation to their surrounding urban context which makes them interesting as comparative case studies to research spatial attraction as an initial stage for spatial interaction.

Continuous studies over the last two decades have created a specific notion of spatial attraction in Space Syntax (Hillier B. / Hanson J. 1984; Hillier B. / Penn A. / Hanson J. / Grajewski T. / Xu J. 1993; Hillier B. 1996; Hillier B. 1999; Hillier B. 2001). The overall assessment of these studies is, that the configuration of space itself is the main force generating spatial attraction. The emphasize lies on the notion of space as a network and thus on the impact of network-effects on specific places within a network. A distinction of configuration, movement and attraction grounds the development of spatial attraction in Space Syntax literature. Natural movement, which is defined as the proportion of movement determined by the configuration of the grid, becomes the main generator of urban movement. It is considered to be an attractor itself (Hillier B. / Penn A. / Hanson J. / Grajewski T. / Xu J. 1993).

As a result of the theory of natural movement, the concept of the by-product of movement arises as the route of going from origin *a* to destination *b*. In an urban network, this route is of course not a straight line through neutral space, but a trip through the diversity of a number of spaces. By-product can attract movement-seeking land use activities which themselves are attracting additional movement and hence can multiply existing movement to effect urban land use pattern and built density, as well as information-rich environments as the basic condition for the ´urban buzz´ (Hillier B. 1996).

In addition to Space Syntax notions of spatial attraction, this thesis explores Gravity Models as used in Urban Geography, because their calculation of weighted graph-networks takes into consideration distance decay of spatial attraction. In Space Syntax, Ruth Conroy Dalton and Nick Sheep Dalton recently developed a distance-decay[1] function to process axial maps. This syntactic function will be tested in this report (see chapter 7.4).

Referring to a descriptive statement about an urban planning project by FOA, Foreign Office Architects, shall illustrate the scope of urban space as a mediating system in a network of possible origins and destinations:

"Quanta
We are almost convinced that, like matter and space, the city is an ether that dissolves into air at varying degrees of concentration. In our attempt to spread the essence of urbanity on Cartuja Island, this served as the initial hypothesis.
Crystals
As architects we are concerned with the process whereby that ether acquires a certain concentration and is precipitated. The projection of urbanity into matter causes certain material organizations to appear. It is this process of crystallization that interests us more than the assignment of uses and performances to different territories. We could invent a variety of programmes and arrange for their interaction, but we believe that they are better able to allocate themselves - provided that we supply the right crystals. Here we have focused our experiment on the purely material qualities of the city, as if we had to implant the first crystals in order to initiate the precipitation of urbanity on the island.
Attractors
Our strategy has been to locate different areas within which to concentrate the solution and provoke the precipitation of urbanity. It is purely a matter of density: ideas/m2, ambitions/m2, dreams/m2, ptas/m2, ergs/m2, etc. " *(FOA, 1995)*

The statement[2] above is a descriptive text to FOA´s proposal for a redevelopment project on Cartuja Islands, Sevilla, Spain, which was the site for the EXPO 1992. It is cited here because it gives a speculative impression of FOA´s notion of spatial attraction in urban space. FOA render a concept of urbanity which implies that the city is both a material and an immaterial thing. The immaterial part of urbanity comprises the entire space of human imagination. It would be like an ether dissolving into the air, whereas the material part would be able to act like crystals being able to provoke specific particles of this ether to precipitate in specific places. Although it is not further

1 Distance-decay is recently developed as a syntactic application to process axial maps in Webmap. Its theoretical background is discussed in a paper in progress by Ruth Conroy Dalton and Nick Sheep Dalton: Applying Depth Decay Functions to Space Syntax Network Graphs, Paper in progress at UCL Bartlett School of Graduate Studies, 2005

2 A notion of urbanity as an ether dissolving into the air at varying degrees of concentration; sketched by FOA in a competition for the redevelopment of Cartuja Island, Sevilla, Spain, which was the site for the EXPO 1992 laid out here how this process of precipitation actually takes place, this statement is found useful to approach the issue of spatial attraction (*for further explanation see to FOA 1995*).

On a rather metaphorically level, it implicitly illustrates two parameter of spatial attraction which are detected by Space Syntax as well: first, that urban space consists of a number of different origins and destinations - and second, that routes link them together creating continuous flows of movement.

The research of this thesis is carried out through the comparative analysis of the two cultural venues: Barbican Arts Centre and the Royal Festival Hall, which are both concert halls in central London. Basically, it considers the areas around each venue as a field of attracting forces and tests if, and how, these effect movement flows to coincide with interfaces of adjacent places to create spatial interaction.

First, a local urban context is defined for both places which centres the location of the BAC respectively the RFH in walking distance of approximately 10-15 minutes to the edges. This area is considered a field of attracting forces. It is transformed into a configurational model by applying traditional Space Syntax axial analysis. To process these high resolution axial maps tough, the recently developed syntactic function of distance-decay is tested, because it incorporates a notion of distance into the axial graph, which makes it theoretically different from traditional integration measures in Space Syntax (see chapter 7.4). Distance-decay is used to detect lines of through-movement and of to-movement as global and local spatial attractors.

Land use data has been collected to cover all parts of the local urban context where significant movement flows are detected. By drawing axial lines for each entrance of urban object[4]
these data represents the diversity of different activities taking place. A constituted axial map is combining these axial lines of building interfaces with the axial lines of urban morphology.

Axial analyses have also been conducted for the interior layout of the venues in order to locate entrances as interfaces to the local urban context.

However, as the main research tool, Pajek[5], a graph software to analyse and visualise large networks, is applied. It allows to display the constituted axial map as a node graph in an energy layout which resembles the distribution of nodes according to their graph-theoretical location (Kamada-Kawai algorithm - see chapter 7.7). Syntactic measures concerning the whole graph are applied to represent through-movement and to-movement. Furthermore, individual routes are analysed to test how the two art venues are effected by - and are effecting - movement flows. Tables are recorded to summarize the density of building interfaces and urban axial lines on these routes to account for possible spatial interaction.

Finally, data will be compared and discussed for both art venues on an interpretive level to see if more general pattern can be found which describe the role of spatial attractors in either maximising or reducing by-product effects in urban space.

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4 urban objects were defined as buidlings or groups of buildings of same land use

5 Pajek, a software for analysing and visualising large scale networks, written by V. Batagelj and A. Mrvar. see chapter 7.7 for more information

The following sections will introduce the cultural venues of the Barbican Arts Centre and the Royal Festival Hall. It shall be mentioned that this thesis from now on uses the abbreviations of BAC (Barbican Arts Centre) and RFH (Royal Festival Hall) to refer to the two venues.

A map of London shows the location of the BAC and RFH in central areas of London. Their central global[6] location confirms their national importance as places for art, classical music in particular. They are essential components of cultural life in London and the United Kingdom.

Thus, they are considered to be places which are addressing and attracting visitors due to the transpatial character of their activities. Spatial parameters, like the configuration of the urban grid, are in a complex mutual relation with non-spatial parameters, like promoted activities or places of ritual importance in society, which are able to attract movement as well. However, this thesis mostly focuses on the issues of spatial attraction, and on how it can facilitate spatial interaction. It refers to transpatiality again in the conclusions.

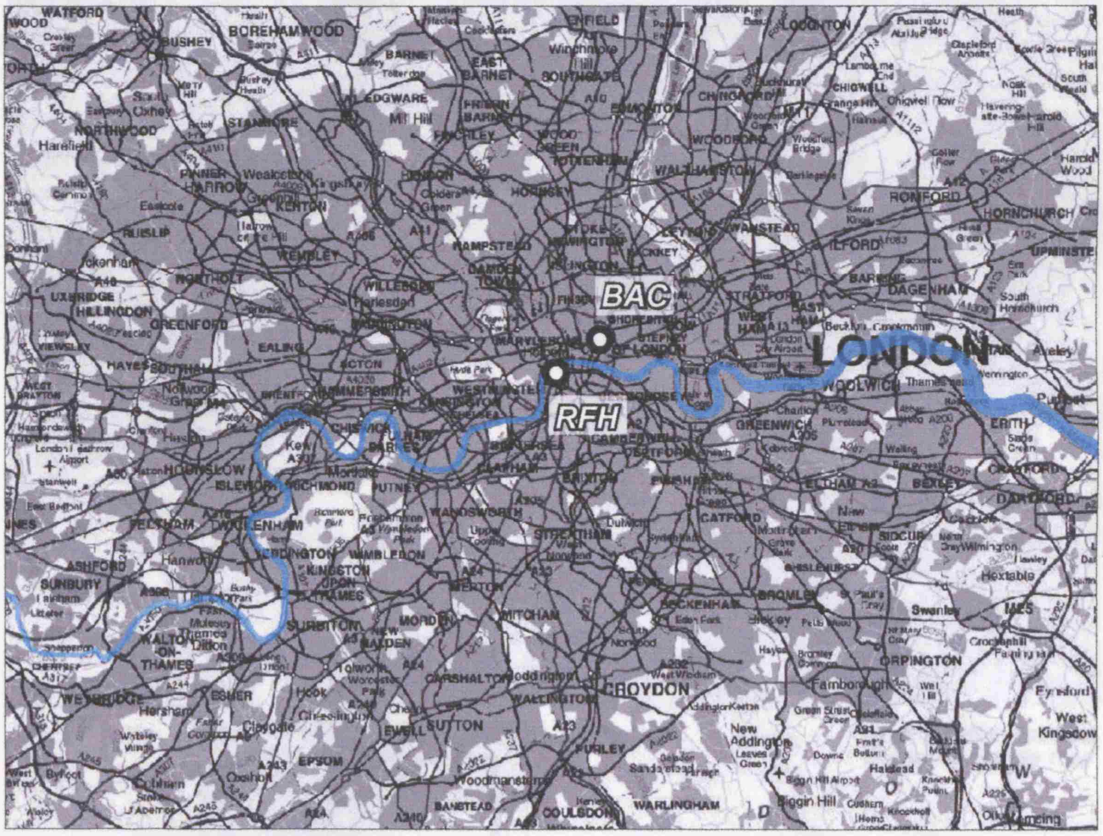

fig. 5.1 London, map

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3 global - as opposition to local - refers to the entire size of a system - the city of London in that case. Global and local are being used throughout this study to distinguish between parts or the whole of a system.

The spatial attraction of the BAC and the RFH is studied in relation to their urban context. Urban flows will be looked at as through-movement and to-movement to account for spatial attraction. Since through-movement is determined rather by global configuration of the urban grid, an area will be defined for each site as a study context. This area will be called ´local urban context´. The local urban contexts for the two sites are shown below - for their boundary-description see chapter 7.2.

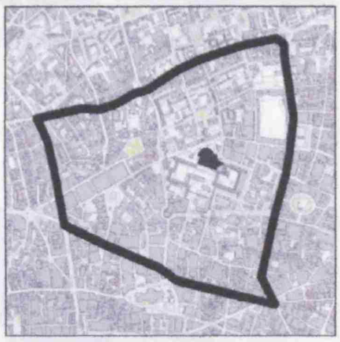

fig. 5.2 BAC, local urban context

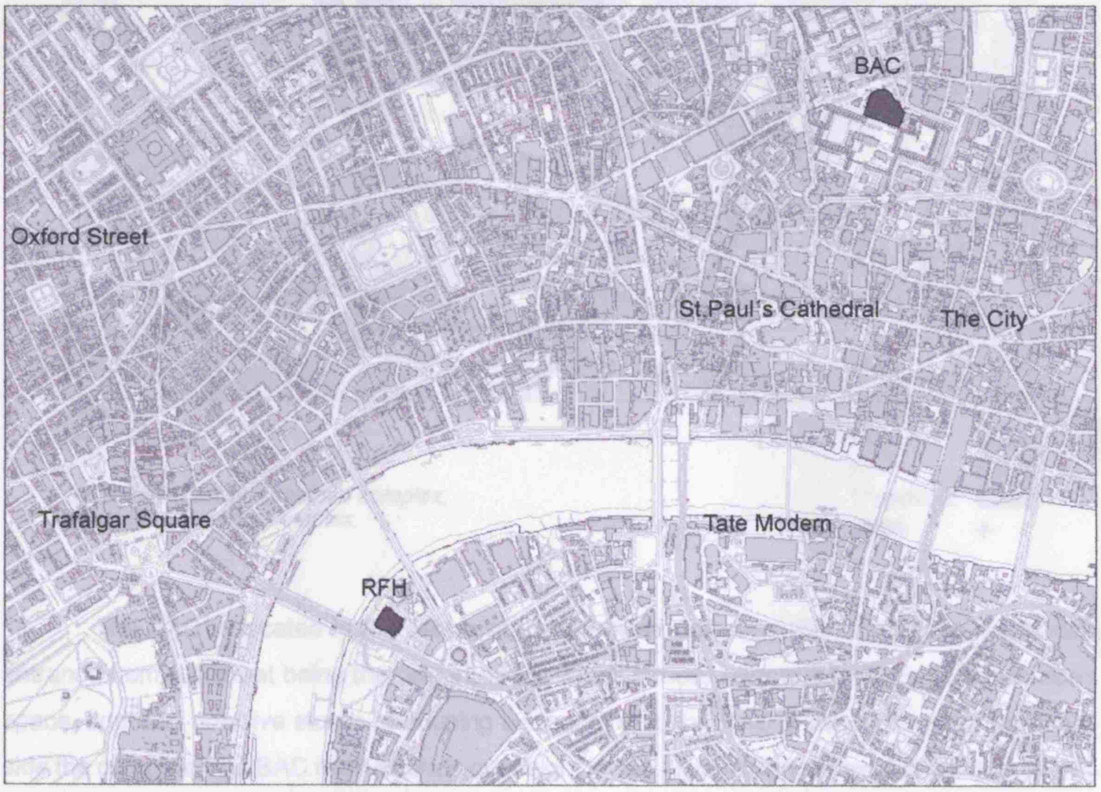

fig. 5.3 central London, Ordnance Survey map

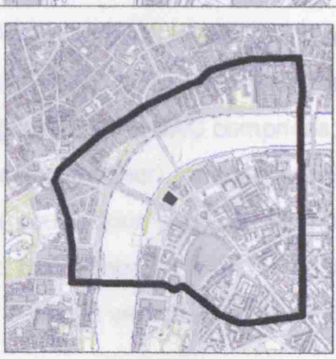

fig. 5.4 RFH, local urban context

The BAC is part of the massive Barbican complex north of the City of London, which was built on a an area flatten by bombs in WWII. The entire complex comprises a mix of housing, schools, offices a conference centre and the BAC as its most public facility. The development of this multiuse-complex roots back in the 1950ties. Completed in 1977 it mostly represented an attempt to bring back residential population into the City. A system of elevated highwalks and motorways including parking were established. Consequently, the complex becomes accessible from the surrounding grid of the urban space only by entering through one of twelve gates. Most of those gates will immediately lead on to the system of elevated highwalks. Three gates remain on street level - on of them is the back-entrance to access the BAC from Silkstreet (see fig 5.5).

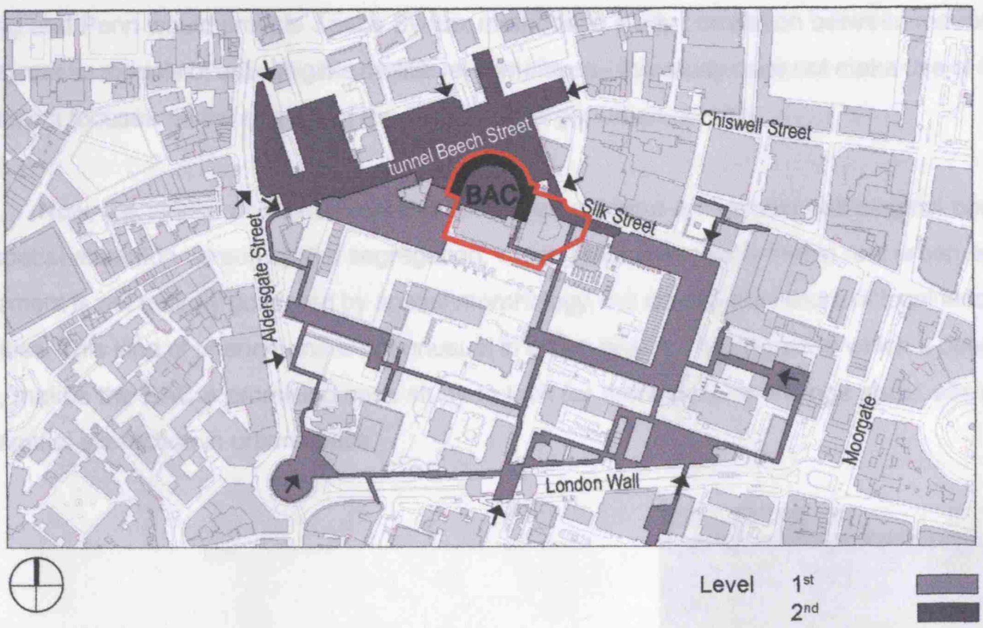

fig. 5.5 BAC inside Barbican complex, gates into Barbican complex

The BAC is located in the centre of the Barbican complex. With the above mentioned entrance from Silkstreet being the only interface which directly connects to the grid of the urban space, and with massive stocks of housing surrounding it, the BAC is almost invisible from outside the complex. The BAC itself extends over eight levels - five entrances exist altogether to give access to the BAC on different levels. The main entrance is on street level, attached to a plaza-like square, which overlooks the large courtyard of the entire Barbican complex.

The programm of the BAC comprises: an auditoriuim for concerts (access ground floor), a theatre (access ground floor), cinemas (access level -3 and level 4), a library (access level 2), two art galleries (ground floor, and level 3), a conference centre (level 4 and above), trade exhibition halls. Due to lack of spatial relations between the levels, activities remain very segregated from each other. A single vertical circulation core, which consists of a seperate staircase and 4 elevators, form a continuous spatial backspine to the whole internal organisation of the BAC. Nevertheless, extensive parts of the foyer spaces are accessible to the public and are partly occupied independend from cultural events.

The above mentioned circulation system of elevated highwalks creates a morphology, which segregates the whole Barbican from its surrounding urban fabric (see syntactic analysis of axial map chapter 7.2). Natural movement as through-movement governed by the urban grid seems to be excluded to a very high degree, whereas movement of locals occurs occasionally in peak-times (see gate count analysis chapter 7.1). To facilitate wayfinding through the unintelligible labyrinth of the highwalks of the Barbican complex, continuous yellow lines were drawn on the ground as a navigation system. These lines indicate ways for visitors to reach the BAC from the above mentioned gates, where the Barbican connects to the grid of the urban space. A study[4] by Chang and Penn would provide Space Syntax methods to study correlation between movement and syntactic models of unintelligible mulitlevel complexes - this study does not make use of them because it focuses on the relation of the BAC to its larger urban context.

Now, the spatial phenomena of the BAC is an extreme and almost pathological case of transpatial attraction versus spatial segregation, which illustrates clearly that in real urban space movement is not entirely governed by spatial morphology, but also by the nature of local land use activities. This kind of phenomena is not unusual in urban space. The degree to which it operates here, makes the BAC a promising case study to look for more general findings about attraction and spatial interaction in urban space.

fig. 5.6 BAC, navigation system yellow line

7 Chang D. / Penn A. (1998) Integrated multilevel circulation in dense urban areas: the effect of multiple interacting constraints on the use of complex urban areas

The RFH was planned and constructed during the 1950s and 1960s of the 20th century. It is part of the South Bank - an agglomorattion of cultural venues in close spatial proximity to each other. Originally, several buildings at the South Bank were interconnected to each other and to Waterloo Station through a system of elevated highwalks. This system was seperating pedestrians from vehicular traffic. It has been reduced over the years to a reminder which still spans between Hayward Gallery, Queen Elizabeth Hall and th RFH (see fig 5.6)

The RFH basically consists of one elevated concert hall which is covered by a building envelope. The box of the concert hall is elevated for accustic reasons - it could not be sunken into the ground because of underground railways passing directly beneath the site. Thus, the RFH typologically represents a freestanding building volume that envelopes the elevated auditorium. Extended foyer spaces underneath the auditorium are both serving the concert events but additionally function as extensions of public space into the building (e.g. free concerts in weekends in foyers).

Four entrances form the interface of the buidling towards its surrounding urban space (see fig 5.6). Three of those entrances are on the level of elevated highwalks, two of which are main entrances facing the terrace between the building and the riverwalk below, whereas the third remains as a side entrance with a small spatial interface to the urban space. The fourth entrance

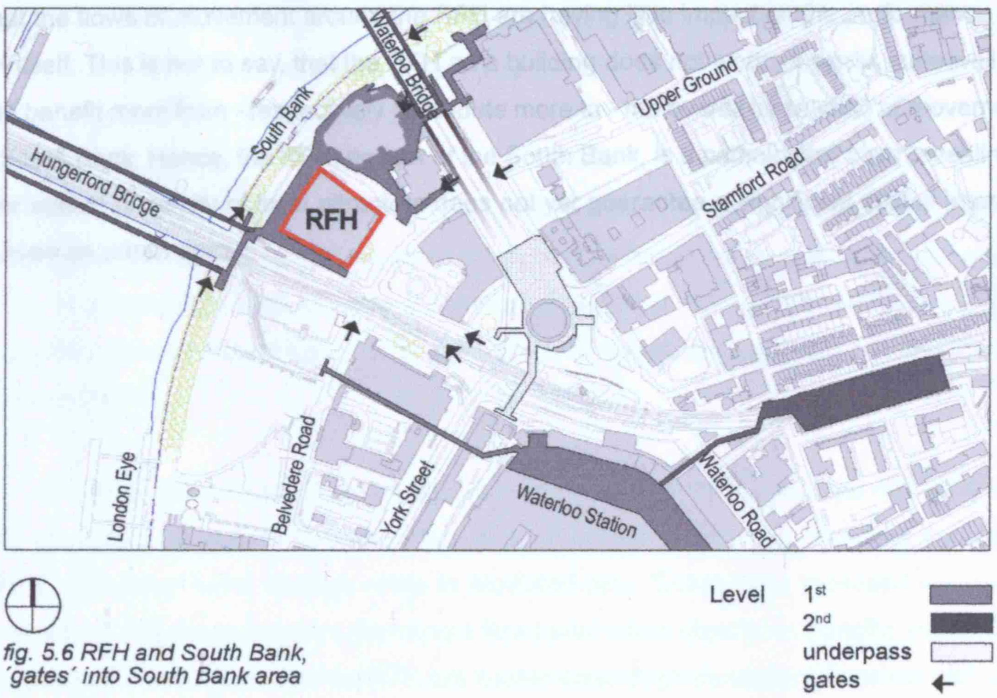

fig. 5.6 RFH and South Bank, ´gates´ into South Bank area

is on street level and is used both by visitors but also by RFH-staff and delivery.

The RFH features a lively atmosphere inside the building. Its main attracting force is its concert hall hosting music performances, which are taking place usually in the evenings. Besides, its building´s extensive open foyer spaces act as a kind of re-construction of urban space inside the building.

As an essential building of the cultural area of the South Bank, the RFH is a local attractor amongst an agglomeration of many more local attractors: the National Theatre (RNT), the Hayward Galery, the Queen Elizabeth and Purcell Room (QPR), the IMAX-cinema, the London Eye, the Jubilee Gardens and its adjecent County Hall. Some of these cultural or entertaining venues are linked by the river walk along Themse. Furthermore, a stock of office buildings, Waterloo Train Station as a major (inter)national traffic hub, a university-building and residential areas are in close spatial proximity. But none of these local attractors really succeeds in interacting much with its neighbours. None of the flows of attracted movement merge together to provide greater co-presence and allow coincidences to take place - except the recently improved river walk, who benefit from the linear sequence of some of the attractors along its way.

"Now if cities are, as they were always said to be, ´mechanisms for generating contact´, then this means that some locations have more potential than others, because they have more by-product and this will depend on the structure of the grid and how they relate to it. Such locations will therefore tend to have higher densities of development to take advantage of this, and higher densities will in turn have a multiplier effect." (Hillier, 1996)

Why does the RFH not benefit from its proximity to several more local attractors? How is it, that the flows of movement around the RFH are having little impact on the performance of the RFH itself. This is not to say, that the RFH as a building does not work - it works quite well. But I could benefit more from - respectively contribute more to - the overall by-product of movement on the South Bank. Hence, the RFH, as part of the South Bank, is a pathological case revealing that sheer spatial proximity of local attractors does not yet guarantee a significant spatial interaction - or even an urban buzz.

The structure of this study comprises seven chapters. Chapter five has introduced the two case studies of the BAC and the RFH. Furthermore, it has outlined the phenomena which make those two local attractors a feasable case study.

Chapter six, literature review, presents the theoretical background of the study. It reviews recent theories of spatial attraction in Space Syntax and compares them to theories in Urban Geography to point out basic conformities, some similarities and fundamental differences. Overall, Space Syntax models are found more appropriate to conceptualise spatial attraction in urban space, because they seem to take into account the complexity of connections linking large numbers of origins and destinations.

Chapter seven describes the research methods which are applied. Spatial observations were conducted in the form of Gate Counts around the BAC and the RFH in order to measure existing movement flows on site. Land use data was collected to relate activities to axial maps. Two different kind of axial maps are being used in this research. On the one hand, high resolution axial maps are processed applying the decay function to account for spatial attraction. On the other hand, constituted axial maps are produced to load information about land use activities onto axial maps. Finally, Pajek, a software for graph analysis in social sciences, is tested to visualize and analyse axial maps as graph systems. Pajek allows to pick specific movement flows between selected pairs of origin and destination, and furthermore provides an energy-layout options for an alternative illustration of urban networks.

Chapter eight discusses limitations which occured during the research process, like: converting land use data of several floors into a single representative layer, dealing with the appropriate size of investigation area, creating a constituted axial map from a high resolution axial map, reading the Kamada-Kawai layout of a node-graph in Pajek, and applying the Maximum-flow function in Pajek.

Findings of the research are presented in chapter nine, which are on the one hand related to the application of various software - e.g. decay function in Webmap, syntactic measures in Pajek. On the other hand, findings relate to produced data. Tables were produced which record the density of interfaces between movement flows and urban objects on specific routes. These data will show that the BAC and the RFH are neither on through-movement flows nor part of local to-movement centres.

Chapter ten discusses those findings in the light of the concept of by-product. The BAC is found to be isolated from any through-movement due to the morphological layout of the whole barbican complex. The BAC offers potential for spatial interaction mostly to internal residential premises of the Barbican complex.

The RFH is found to have some potential for spatial interaction towards through-movement flows and also local centres of movement. The particular design of the interfaces between the building and the urban space does however not emphasize on strong interaction. Thus, both venues are found to function rather introverted - they do not have strong spatial interfaces to the surrounding urban space.

As a conclusion, chapter eleven speculates about the impact of the discussd findings on the performance of the grid as a means to communicate urban space. This chapter sketches different attracting mechanisms of the urban grid in opposition to land use activities. It emphasizes on the importance of density and coincidence inherent in the concept of the by-product of movement. This ultimately suggests that the urban grid can be conceived of as a unique means of communication to convey a multiplicity of possible destinations along movement flows, whereas transpatiality seems to be able to convey local destinations through much more virtual and thus limited means.

6. Literature review

Modelling spatial attraction has been applied over many decades in professions related to large scale spatial planning – like urban geography, sociology (migration), economics (trade) and transportation. Gravity models, who belong to the larger family spatial interaction model, are reviewed here, because their concepts of relating origins to possible destinations as nodes in a weighted network-graph represent similarities with spatial attraction concepts in Space Syntax.

However, the main difference between spatial attraction in urban geography as compared to spatial attraction in Space Syntax is, that the former rely on mass as the determining their increase of attraction (size/weight of origins and destinations), whereas the latter depend on the specific configuration of the void (emptiness) to increase attraction (see end of chapter 6 for more detail)

In architectural and urban planning, concepts of spatial attraction have become ´popular´ to refer to within the last decades because of a growing interest in the complexity of space-time systems. There might be several reasons for this shift of interests. On the one hand, the emergence of advanced technological possibilities to grasp complex systems are certainly having impact on the thinking of designers/researchers about time and space, allowing to achieve new insight on the functioning of cities, for example. On the other hand, the nature of cities and settlements themselves keeps slightly changing, informed through a mutual process of interaction with societies and new technologies. Examples of unsuccessful urban planning of the last century are finally adding to the attempt to emphasize on dynamic parameters in understanding of how urban space works.

A comparison between the notions of attraction used in modelling flows in urban geography and the notion of attraction used in Space Syntax shall be done next. The intention is to bring to light possibilities and difficulties in both approaches.

Gravity models belong to the wider family of Spatial Interaction Models. Their history goes back to the 19th century when migration and railway traffic have been modelled. They are tools to describe various spatial phenomena like migration, passenger transport, trade, shopping behaviour or similar, which they are aiming to formalize. Interaction (flows) between nodes can be predicted, given that all nodes are simultaneously places of origins and destinations to all connected nodes in the network.

In simple gravity models, interaction is being predicted depending on the overall network-configuration, on individual node-parameters like size/resources/etc and finally on a representation of distance between the sites. Essentially, the gravity models state that interaction (flow) between two sites or regions is proportional to the product of the sizes (however measured) and the inversion of the distance between the two sites (however measured).

In those basic gravity models, the flow of Tij from origin i to destination j is modelled as $Tij = ViWjFij$ (equation 6.1) where Vi indicates the size of the origin i, Wj the size of destination j, and Fij is the facility of movement between i and j - a decreasing function of distance or travel costs. General notions of origins and destinations as well as of a decay-distance functions are valid parameters in spatial attraction models.

In the 1970ties, Wilson introduced a family of Spatial Interaction Models based on the concept of entropy-maximising to overcome limitation of basic Gravity Models, which were unable to take account of growth in a system. Wilson imported the concept of entropy from statistical physics to spatial interaction modelling. In reviewing Wilson´s Entropy in Urban and Regional Modelling (1970), Batty claims that applying entropy-maximising concepts to the, at that time, emerging field of urban modelling brought more consistency into the entire subject. "What Wilson did was to adapt and popularise a powerful method in statistical thermodynamics where the distribution functions of molecules of gas could be derived through maximising a function of entropy, subject to constraints on their energy. He argued that entropy was a function of spatial diversity or heterogeneity – accessibility – and that if this is optimised subject to constraints on the interaction that originated or was destined for particular locations and the distance (energy) travelled, the functions that emerged were akin to gravitational and potential models that formed the basis of social physics." (Michael Batty on Wilson´s Entropy in Urban and Regional Modelling, 2004)

In Wilson´s Spatial Interaction Models, flows can be either origin-constrained (production-constrained), destination-constrained (attraction-constrained) or doubly constrained. To explain how constraining effects the concept of gravity models, this thesis report refers and cites De Vries J. / Nijkamp P. / Rietveld P. Alonso´s General Theory of Movement (2000) who give specific examples each:

"The assumption is then that the total amount spent [in shopping behaviour] is proportional to the population or its purchasing power, and independent of the number and size of shopping centers.

given (1) $T_{ij} = V_i W_j F_{ij}$ (equation 6.1)

Then the total outflow from i, Oi, is given and we have the restriction

(2) $\sum_i T_{ij} = O_i$ (equation 6.2)

(3) $T_{ij} = A_i O_i W_j F_{ij}$ (equation 6.3)

where the additional variable A_i is needed as a proportional factor. A_i can be solved from (2) and (3) as

(4) $A_i = \{\sum_j W_j F_{ij}\}-1$ (equation 6.4)

if a new shopping centre opens, we get an extra term in the summation in (4), so all A_i decrease, and, by (3) , also the flows become smaller, representing the substitution effect.

An example of the destination-constrained model could be hospital admission, if we assume that the capacity of hospitals is fixed and fully utilized. Then D_j (total inflow to j) is given. In this case the restriction is

(5) $\sum_i T_{ij} = D_j$ (equation 6.5)

and using a proportionality factor B_j the flows are modelled as

(6) $T_{ij} = B_j V_i D_j F_{ij}$ (equation 6.6)

Similar as above, we can solve Bj from (5) and (6).
The production-constrained and attraction-constrained models have identical structures. If origins and destinations are interchanged, the one turns into the other.

The production-attraction-constrained, or doubly constrained, model results if both O_i and D_j are given, and only the allocation is determined by the model. In that case there are two sets of restrictions, (2) and (5). Using two sets of proportionality factors the equation for the flows is

(7) $T_{ij} = A_i B_j O_i D_j F_{ij}$ (equation 6.7)

solving for A_i and B_j we get

(8) $A_i = \{\sum_j B_j D_j F_{ij}\}\text{-}1$ (equation 6.8)

(9) $B_j = \{\sum_j A_i O_i F_{ij}\}\text{-}1$ (equation 6.9)

so they are mutually dependent." (De Vries J. / Nijkamp P. / Rietveld P. Alonso´s General Theory of Movement, 2000)

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A second example shall be given to illustrate the advantage of the doubly constrained spatial interaction model in featuring variable parameters in a graph-model (values of both nodes and arcs can vary). In their paper Modelling settlement structures in ancient Greece: new approaches to the polis (Rihll T.E. / Wilson A.G.,1992) Wilson and Rihll apply the doubly constrained model to reconstruct settlement structures in ancient Greece, in order to learn more about the importance of specific nodes or subnetworks in the overall settlement. This would allow decisions on further archeological works of excavation to take place.

Having information on many ancient greek polis and their importance, this model was calibrated to predict the role of those polis, where little information was hold, through their relation to other polis within the network. A mathematical model was set up on the basis of entropy-maximising, which allowed to shift single parameters of the mathematical equations to test the effects on relations between the polis. The model considered size, importance (resources), interaction (ease of communication) and distance between individual polis´ as nodes in a network. Thus, parameters like the ease of communication or the resources available at a polis, were shifted until they matched the condition of the known polis´. Looking then at how the little known polis´ perform in the network revealed in response information about their size, importance, etc.

The model was using variable parameters in an overall constraint assumption of spatial interaction in order to look at the distribution and emergence of the interaction in the network if single parameters were shifted.

Are Wilson´s Spatial Interaction Models then applicable to spatial attraction in urban space as well? If the application of Gravity respectively Wilson´s Spatial Interaction Models are shifted from regional scale to the scale of urban space, one issue becomes evident: the way in which space is - or is not - inherent in the model. The network of sites representing possible places of origins and destinations will change with the scale. Whereas on the regional scale, connections between the network-nodes (cities) are represented as straight lines, this is not the case for network-nodes (destinations) in urban space. Connections between those nodes are much more complex – they cannot be represented by single straight lines from origins to destinations. The configuration of the grid of urban space becomes the system which is mediating possible spatial connections between the nodes. The configurational nature of the grid would have to be taken into account in order to be able to apply Spatial Interaction Models on the scale of urban space. This indicates a shift of importance from the origin/destination points to the system of arcs connecting the nodes.

Gravity models operate on graphs with weighted arcs and nodes. Both specific characteristics of the nodes (origins and destinations) and the arcs between them are taken into account to weight, for example: size of cities, the resources which they offer (attractiveness), different kinds of measurements the distance between nodes (metric distance, travel-costs, etc). This is, to calculate the degree of interaction between nodes, resulting in the emergence of clusters of nodes with stronger interaction. Unlike Gravity models, the traditional axial map in Space Syntax is a graph which operates on unweighted arcs. Nevertheless, if one aim of the thesis is to take into consideration not only the grid as a spatial attractor but also land use as a programmatic attractor, it will have to speculate somehow about ways to represent the difference in attracting forces of land use. The degree of transpatiality of an activity could be a key to this issue – the more transpatial an activity is to its context (society), the more powerful it will attract people across space.

There are four theories building upon one after another in Space Syntax, which can be read as a sequence to account for how spatial attraction can be conceived of. Those are the theories of Natural movement (Hillier / Penn / Hanson / Grajevski / Xu, 1993), Cities as movement economies (Hillier, 1996), Centrality as a process (Hillier, 1999), and of the City as Object (Hillier, 2001). The most significant overall assessment inherent is, that the configuration of the grid itself is the most powerful parameter in generating movement. It could thus be named an attractor by itself, which is operating by means of pure morphological constraints on the movement of people from origin points to destination points all over a city. A second kind of attractor are those destination points all over the city. They are generating movement through specific land use (activities) or even aesthetic qualities respectively experiences, and are operating on a much more local level. Thus, emphasize will be laid on the difference and the interplay between those two particular notions of the grid as an attractor (global, spatial) and of land use activities as an attractor (local, programmatic).

Natural movement is defined as the proportion of urban pedestrian movement determined by the grid configuration itself. It does not include movement being generated by local attractors (land use activities) . Distinguishing between the configuration of the grid, movement and attractors allows to define natural movement on the one hand and forces of attraction on the other hand as clearly separated parameters in the general . Setting up a logical cause-and-effect relation between those three parameters shows that the configuration of the grid is the primary generator, which shapes the pattern of movement of people. Higher integration of lines in the axial map indicates high movement rates and thus suggests spatial attraction, whereas segregated lines indicate weak spatial attraction. Local attractors are distributed – or are actually distributing themselves – according to the existing pattern of movement generated by the configuration on the one hand, and depending on the degree of movement they need themselves on the other hand. They can thus either amplify natural movement, or rather equalize it. Attractors can become very powerful generators of movement themselves. They can locally exceed the impact of natural movement generated by the configuration of the grid. The influence of such powerful local attractors is shown in a study by Space Syntax on the area of King´s Cross, London, for example, where very high movement was observed on street segments in close proximity to King´s Cross station (major transport hub in central London) but drops significantly on segments of the same streets more remote from the station (Natural movement (Hillier / Penn / Hanson / Grajevski / Xu, 1993).

Having defined this set-up of how configuration, movement and attraction are interrelated (Natural movement (Hillier / Penn / Hanson / Grajevski / Xu, 1993)), the theory of Cities as Movement Economies suggests, that urban space operates on economical processes of ongoing distribution and allocation between configuration, natural movement and land use activities. Those processes include both global and local scales, where movement-seeking activities (e.g. retail, or transpatial activities1) are attracted to locations with high natural movement and non-movement seeking activities (e.g. residential) are being attracted to locations with low natural movement. Movement in location with already high movement can be multiplied by the additional activities – possibly resulting in what can be called an urban buzz, which incorporates dense and information-rich urban spaces able to accommodate different activities at the same time, referred to as multiplier effects in the theory of Cities as Movement Economies. Finally, these processes of attraction can materialise in a pattern of dense mixed use areas set against a background of more homogeneous and less dense areas of residential land use.

Hillier further suggests: "Every trip in an urban system has three elements: an origin, a destination, and the series of spaces that are passed through on the way from one to the other. We can think of passage through these spaces as the by-product of going from a to b. We already know that this by-product, when taken at the aggregate level, is determined by the structure of the grid, even if the location of all the a´s and b´s is not. Location in the grid therefore has a crucial effect. It either increases or diminishes the degree to which movement by-product is available as potential contact." (Hillier, 1996). And: "Most urban space use is movement. Most movement is through movement, that is, the by-product of how the grid offers routes from everywhere to everywhere else." (Hillier, 1996).

As a results, the movement economy process works on two levels, giving rise to the emergence of subcentres (centrality), if certain configurational conditions are fulfilled. In the theory of Centrality as a process, Hillier explains that the above mentioned processes not only adapt to the existing configuration of the grid, but they start to transform the grid itself towards higher metric integration in central or sub-central areas. Whereas globally more integrated linear spaces (axial lines) receive much through-movement, they can start to develop two-dimensionally on a local scale with growth of a settlement (Siksna process). This linear growth away from the main global integrator enables the kind of ´moving-around´movement, which is rather convex in its form. It tends to minimize local trip length by optimizing the metric integration of the local grid structure. Smaller block sizes then enable shorter trip lengths in more permeable two-dimensional convex areas. Attraction increases in relation to higher metric integration.

Since in the theory of Centrality as a process metric integration was found to be the major configurational attribute of the grid to attract movement, the question emerges, why a topological analysis still prevails over metric analysis? Hillier points out two reasons, why a topological model is a more accurate representation of real space-time complexities. First, it is argued, that the problem of geometrical centrality of a spatial system is overcome much more successful, when conceiving of a city to be a system of configurational inequalities – instead of metric analysis. Hillier: "... - that [the configurational inequalities] is, the differences in integration values in the lines that make up the axial map – which generates a system of attractional inequalities – that is the different loading of the lines with built form densities and land use mixes – and note that in the last analysis, configuration generates attraction. (Hillier, 2001). The spatial system (as object) then benefits from those differences, because they create relations of global-local-attributes.

Hillier´s conclusion brings the notion back to spatial attraction. He claims that integration equations – based on discrete geometry - play the same role in configurational models as the Newton equations do in attraction based modelling. Hillier cites Mottram: " Configurational models are light-based rather than mass-based: they reflect the world we see rather than the world of distance and mass" (Mottram, 2001).

Recent research in Space Syntax outline that two different kind of network effect can theoretically be identified in a graph-system - integration accounts for to-movement and choice accounts for through-movement (Hillier B. / Iida S., 2005). Spatial attraction in real urban networks emerges as the interplay of both. It depends on the size and the structure of the graph. Whereas high accessibility (integration) of a node to their neighbouring nodes governs to-movement, through movement is governed by the structure and length of the sequence of nodes between origins and destinations. The greater the graph length, the more emphasize is put to this between-structure of the graph (choice).

Finally, the role of cognition in spatial interaction is raised through the paper Measuring the effects of layout upon visitors´spatial behaviours in open plan exhibition settings by Peponis / Conroy Dalton / Dalton / Wineman, in which they are comparing the results of measuring visitors´ behaviour in open plan exhibition settings with different models. The first model which they apply to research visitors´ movement pattern is a purely configurational model. It is named positional model. Relative accessibility and cross-visibility are the two kinds of layout descriptors

used.
Their second model is named compositional model. The main difference to the first model is the impact of labelling the exhibits according to their informational content in the actual exhibition-design. Thus, it can be hypothesised, that a visitor's movement is not only informed purely by morphological forms. It can also be affected by the informational content of the individual exhibits and their interrelation. This represents clearly an additional cognitive parameter. Peponis / Conroy Dalton / Dalton / Wineman developed a method to measure the degree to which the same thematic labelled exhibits were spatially adjacent – a concept of 'spatial grouping'. Spatial grouping is represented as a graph, whose connecting arcs take into account the label of the adjacent exhibits. Analysing this graph of produces two measures (exhibit-sensitive and label-sensitive grouping index) to indicate if individual and labelled exhibits are rather dispersed or grouped in spatial proximity.

Translating this concept of spatial grouping into urban space can contribute towards an attempt to map attracting forces, if the urban morphology is conceived of as a layout of urban objects with interfaces (e.g. frontages of buildings effecting the constitutedness of spaces) effecting wayfinding and thus movement on a local scale.

Chapter two, the literature review, presents the theoretical background of the study. It reviews recent developments of spatial attraction in Space Syntax and compares them to theories in Urban Geography to point out basic conformities (graph-systems of nodes and arcs), some similarities (weighted versus unweighted nodes in graph), and one fundamental difference (mass as an attracting attribute versus emptiness of space as an attracting attribute). Overall, Space Syntax models are found more appropriate to conceptualise spatial attraction in urban space, because they seem to be able to better take into account the complexity of arcs (empty void of grid) linking large numbers of origins and destinations.

7. Research methods

7.1 Spatial observations - gate counts

Spatial observations were conducted in the form of ´gate count method´ to record pedestrian movement around the BAC and RFH. Four categories were chosen to divide the flow of people into: tourists, locals, suits and staff. Each gate was observed for three minutes. The amount of people passing by was then multiplied by twenty to achieve a total number of pedestrians per hour. Six rounds of observations were carried out, covering time slots from: 8-10am, 10-12am, 12-14pm, 14-16pm, 16-18pm and 18-20pm.

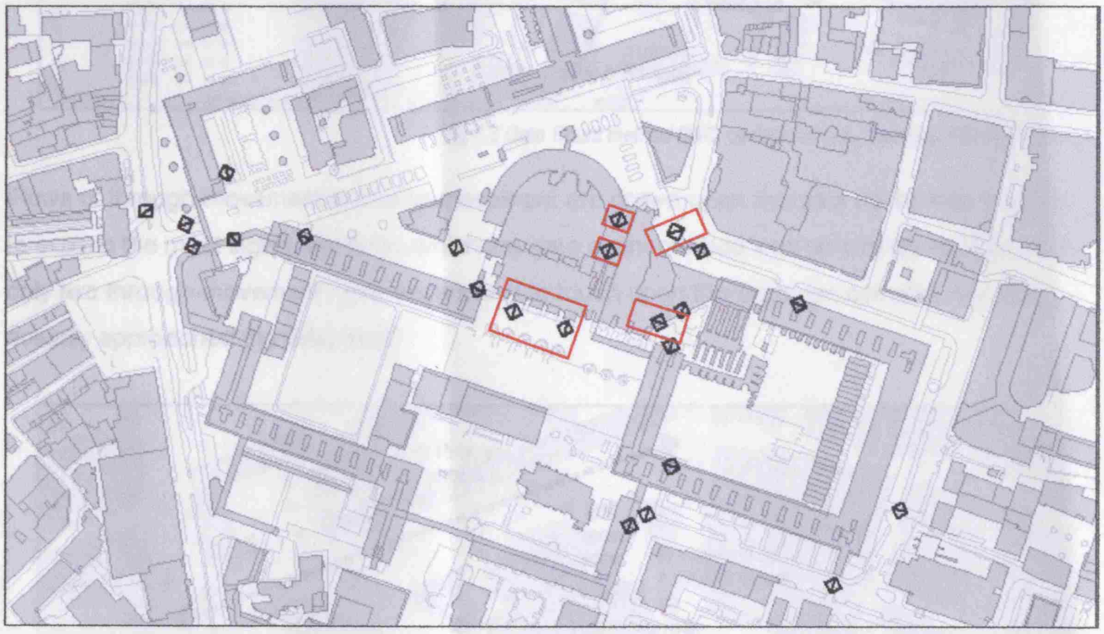

fig 7.1 Gate Count method BAC, 5 entrances into the BAC

At the BAC, 23 gates have been observed around the BAC for two days to collect data about the flow of pedestrian movement to and from the 5 entrances into the BAC (see fig 7.1).

On Saturday, 23rd of July, 651 people have been counted. The weather was mild but cloudy with little rainfall in between. The overall flow of movement on the site was governed by a classical concert performed at the BAC´s auditorium as the main event in the evening.

On Thursday, 18th of August, 1311 people were counted passing through gates. The weather was sunny and warm during the whole day with emerging clouds and first showers in the evening. In spite of no performance taking place on that evening in the concert auditorium or the theatre, the overall amount of people counted was twice as much as on 23rd July.

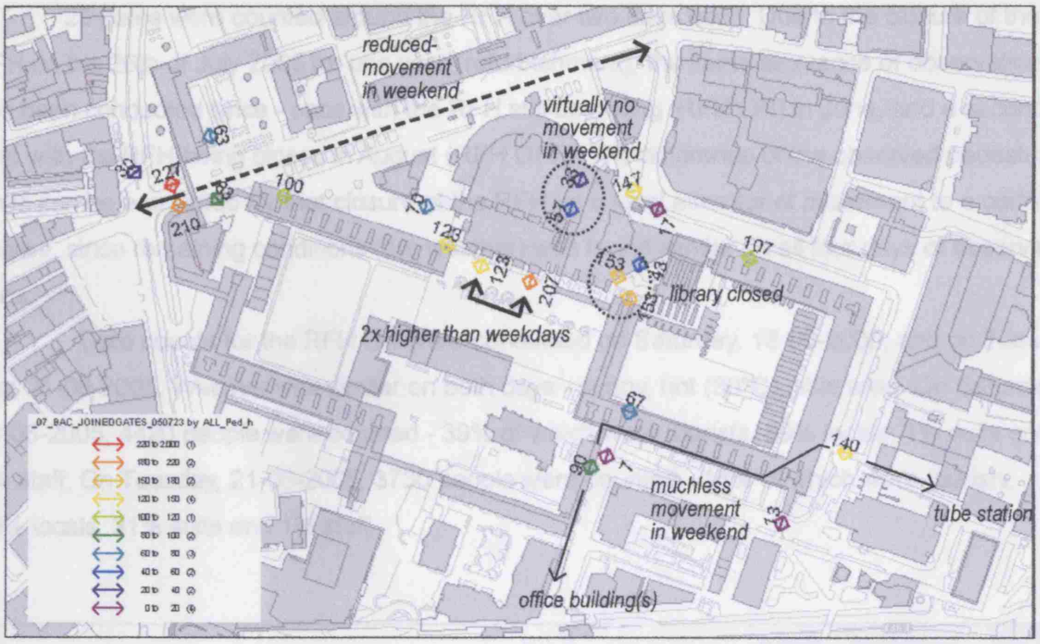

fig 7.2 Gate Count method BAC, pedestrian ALL, Saturday 23th July 2005

Flows of through-movement and of to-movement are drawn upon the gate count map in order to explain the most significant flows which the gate count method was able to grasp. Altogether, only two through-movement flows were found to touch upon the Barbican complex, but none actually approached the BAC itself.

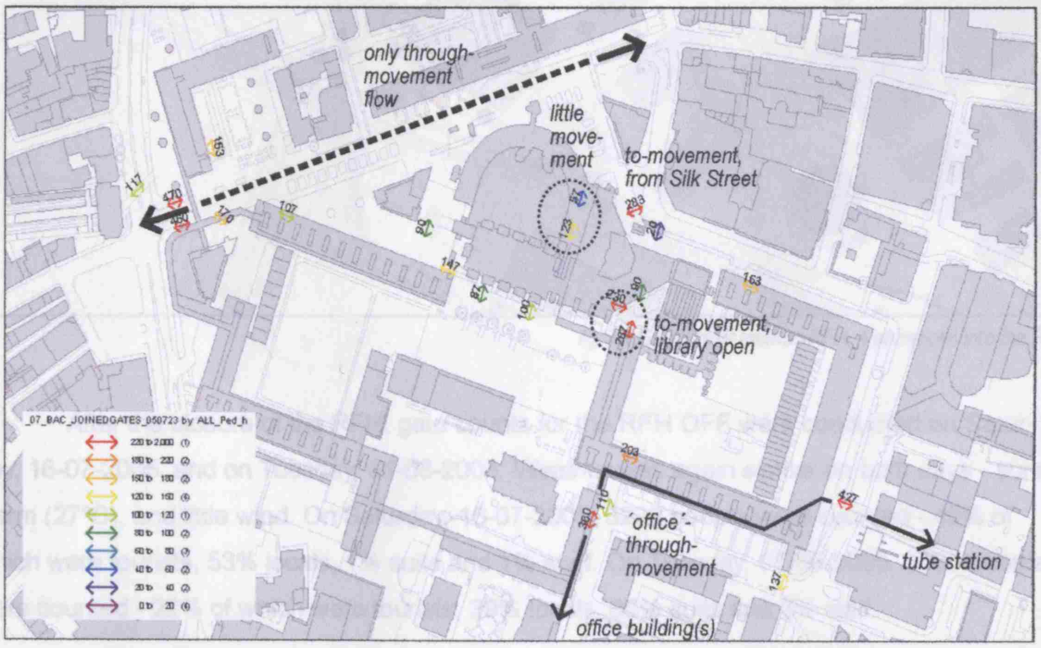

fig 7.3 Gate Count method BAC, pedestrian ALL, Thursday 8st August 2005

28 gates were counted around the RFH over two days each. Due to the closure of the RFH on the 26th of July 2005 for one year (refurbishment), the same sequence of observations has been conducted twice - once with the RFH still operating (RFH ON) in June, and a second time with the RFH being closed in August (RFH OFF). The difference of the observed pedestrian flows can be accounted for that closure of the RFH as a local attractor of movement to a certai degree, since remaining conditions (the weather) was found similar on all four days of observations.

Gate counts for the RFH ON were conducted on Saturday, 18-06-2005, and on Tuesday, 21-06-2005. Weather was similar on both days - sunny, hot (30°C), little wind. On Saturday, 18-06-2005, 4420 people were counted - 39% of which were tourists, 59% locals, 1% suits and 1% staff. On Tuesday, 21-06-2005, 3730 people were counted - 18% of which were tourists, 50% locals, 31% suits and 1% staff.

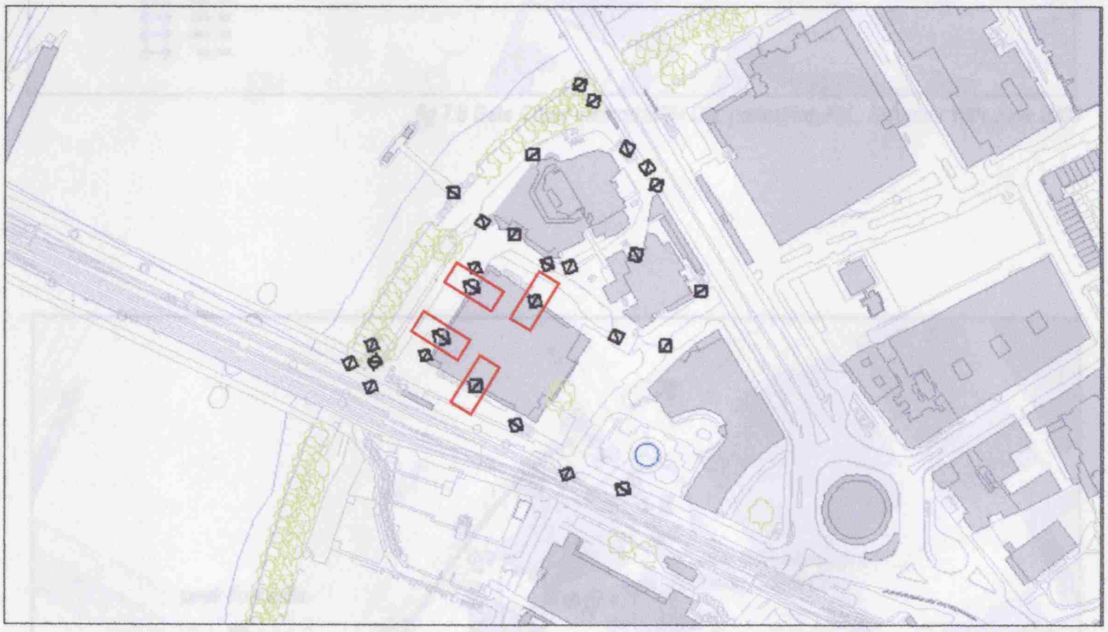

fig 7.4 Gate Count method RFH, 4 entrances into the RFH

After the closure of the RFH, gate counts for the RFH OFF were conducted on Saturday, 16-07-2005, and on Tuesday, 01-08-2005. Weather was again similar on both days - sunny, warm (27°C), and little wind. On Saturday, 16-07-2005, 3220 people were counted - 45% of which were tourists, 53% locals, 1% suits and 1% staff. On Tuesday, 01-08-2005, 3100 people were counted - 22% of which were tourists, 39% locals, 36% suits and 3% staff.

The closure of the RFH allows to calculate its portion of the overall movement in the observed area - which makes 27,15% in the weekend and 16,7% weekdays. Figures 7.5 and 7.6 show the gate counts and illustrates of the most significant observed flows of through-movement.

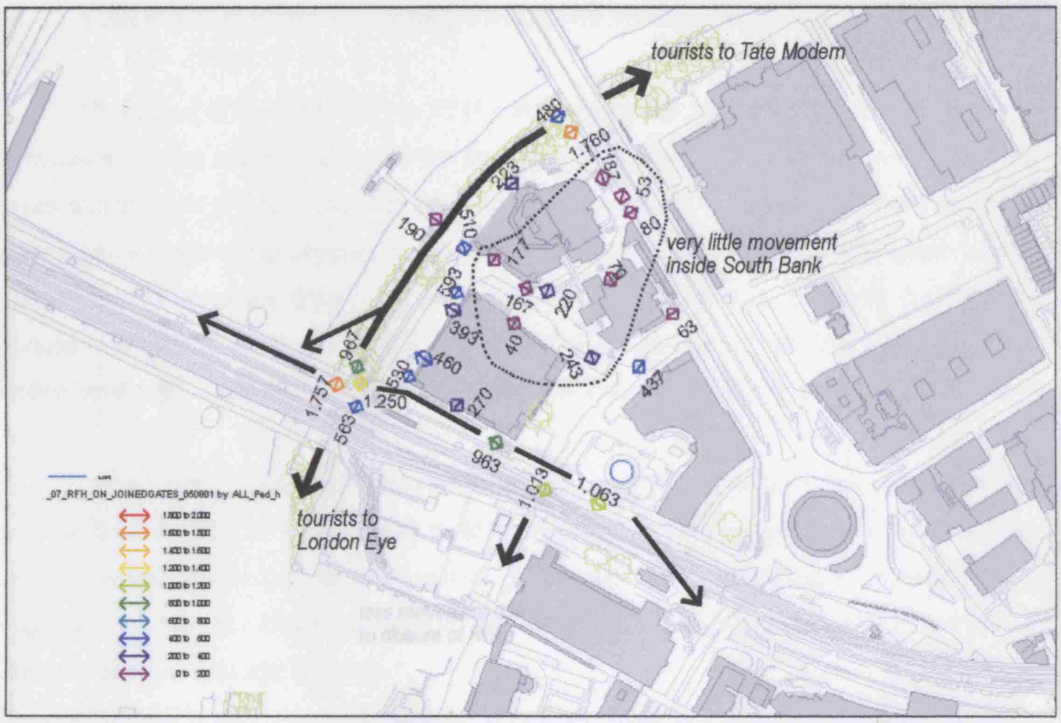

fig 7.5 Gate Count method RFH ON, pedestrian ALL, Saturday 18th June 2005

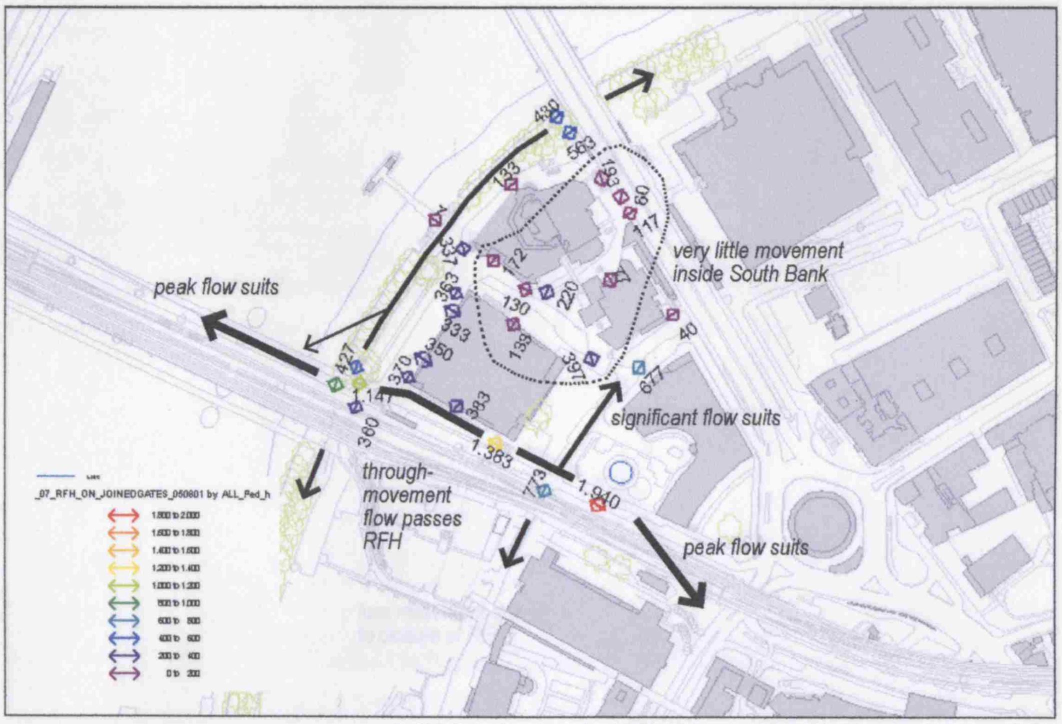

fig 7.6 Gate Count method RFH ON, pedestrian ALL, Tuesday 21st June 2005

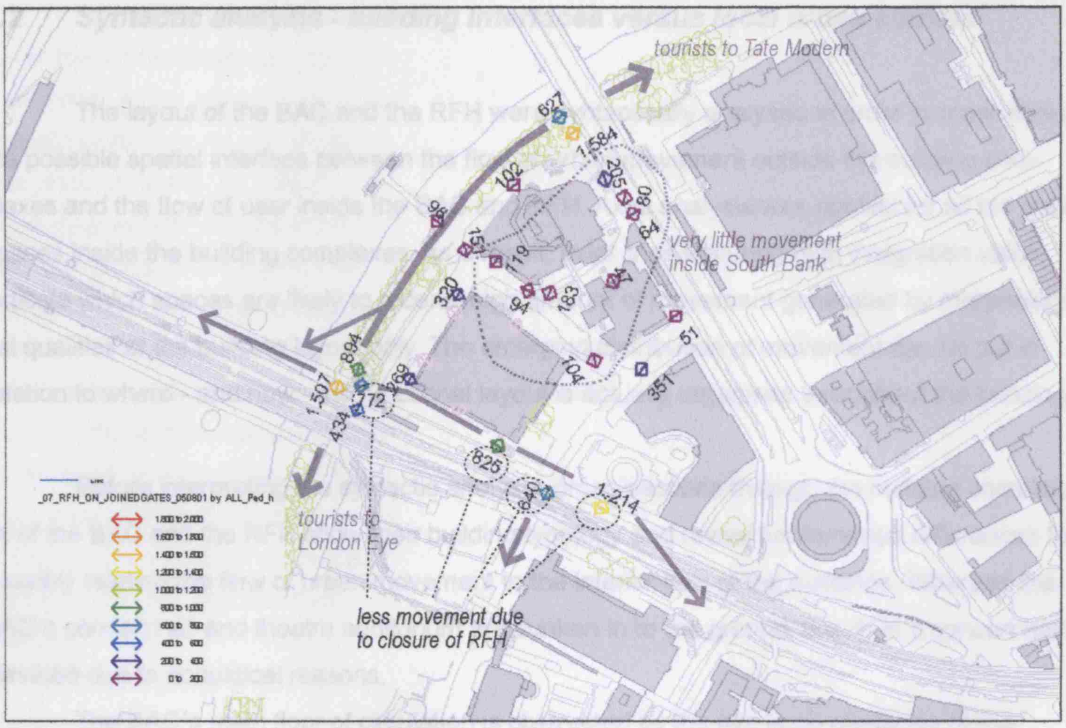

fig 7.7 Gate Count method RFH OFF, pedestrian ALL, Saturday 16th July 2005

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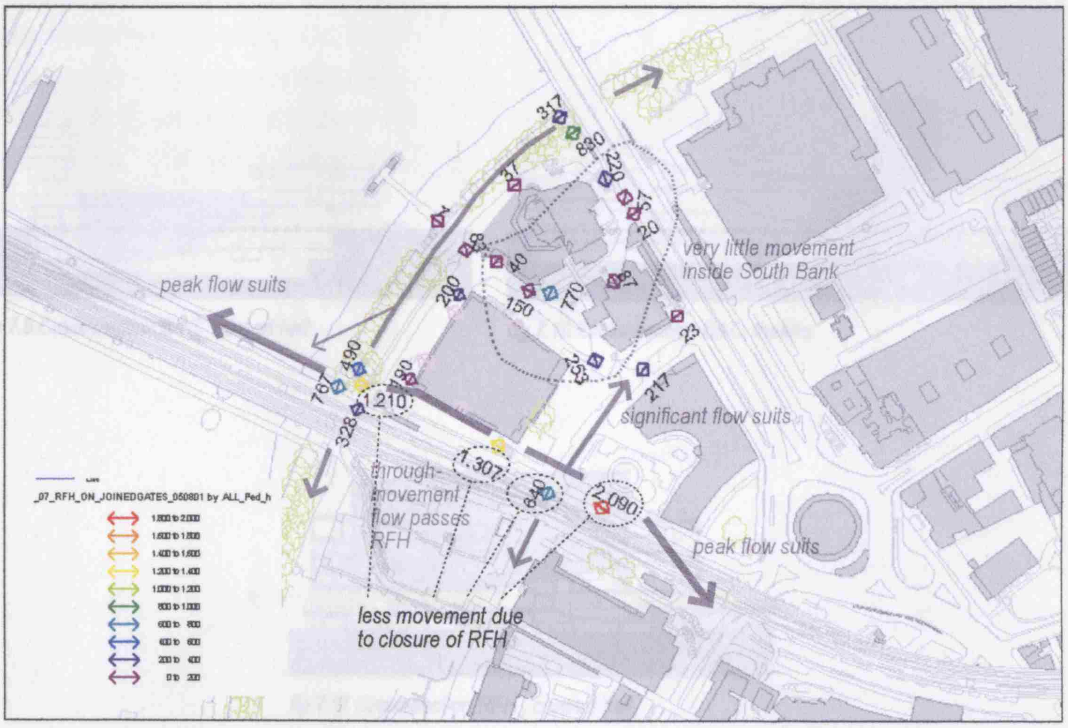

fig 7.8 Gate Count method RFH OFF, pedestrian ALL, Monday 1st August 2005

7.2 *Syntactic analysis - building interfaces versus local urban context*

The layout of the BAC and the RFH were syntactically analysed in order to learn about the possible spatial interface between the flow of urban movement outside the building complexes and the flow of user inside the BAC and RFH. Axial analysis was applied for all the public spaces inside the building complexes. As a result, axial lines featuring high integration value indicate which spaces are likely to receive high amount of movement generated by morphological qualities of the building layout only. The emerging distribution of movement can be put in relation to where - and how - the functional layout is actually organised throughout the building.

Before interpreting the syntactic analysis, cross-sections through the building complexes of the BAC and the RFH show their building typology and reveal fundamental differences for possibly relating the flow of urban movement to the interior flow of the buildings. Whereas the BAC´s concert hall and theatre auditorium are sunken in to the ground, the RFH´s concert hall is elevated due to acoustical reasons.

The BAC´s main floor of circulation is obstructed by the two large obstacles of the concert hall and theatre auditorium. The RFH´s main floor of circulation is on level 1 which also features highwalks with urban movement on two sides outside the building (North-West side, South-West side).

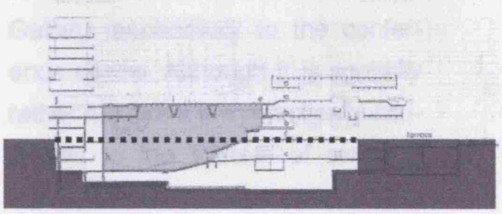

fig 7.9 Cross-section BAC, concert hall

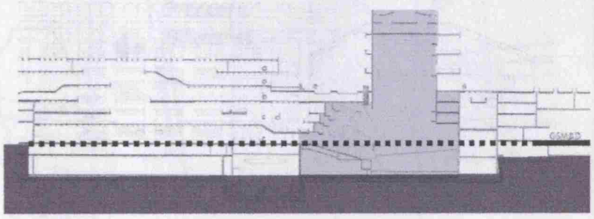

fig 7.10 Cross-section BAC, theatre

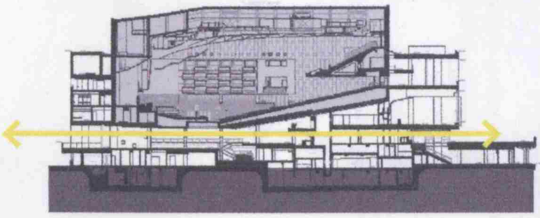

fig 7.11 Cross-section RFH , concert hall

The public accessible spaces of the whole Barbican complex comprises eight levels. The only spatial connection to link all levels with their diversity of different activities is a vertical circulation core: a staircase which is closed off - and 4 elevators. Several other spatial connections link selected floors to each other (ramps, stairs, etc).

Due to this distribution, the syntactic analysis picks out the integration core of the BAC as the spaces being connected to the circulation spaces between ground floor and level 2.

Whereas ground floor accommodates the main entrance (close to integration core) and the entrance from Silkstreet (syntactically segregated), the second level features both the entrance from the elevated highwalk and the entrance from Frobisher Crescent. On third level remains the entrance to the Art Gallery respectively to the conference centre. Although it is spatially rather hidden, it is syntactically connected to the system of elevated highwalks.

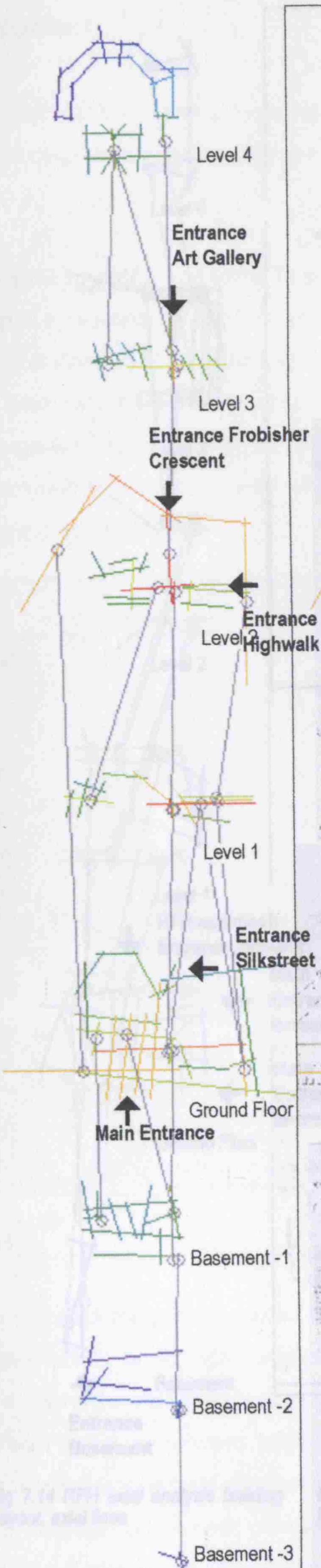

fig 7.12 BAC axial analysis building layout, axial lines

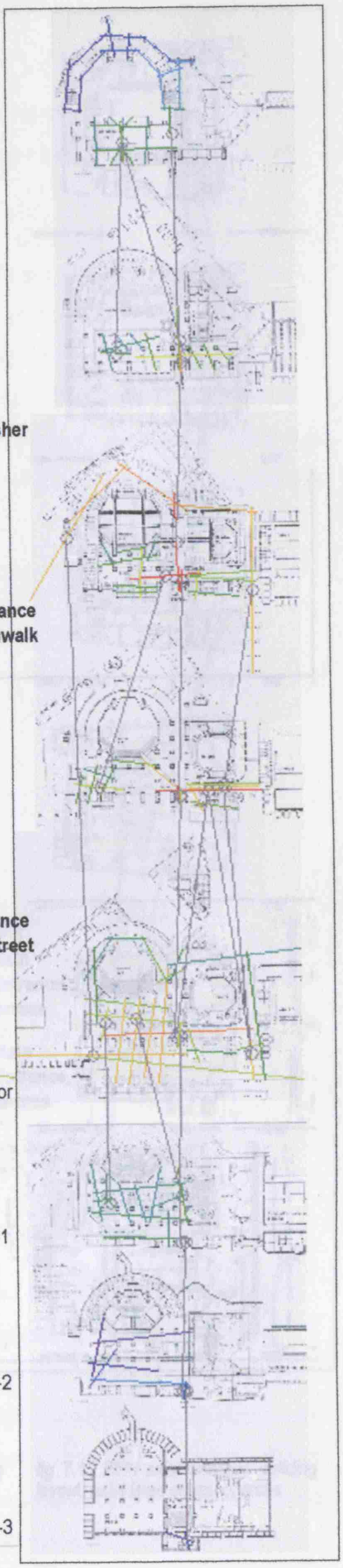

fig 7.13 BAC axial analysis building layout, axial lines on top of plans

The building of the RFH with its almost perfect symmetry provides accessible space over six levels. Whereas the basement with two active facades sits on street level (including one entrance, former main entrance), the elevated ground floor receives more importance because it features three entrances which are connected to the elevated highwalks with some urban movement flow passing by.

The buildings integration core spans as one deep space from the entrance RFH-approach across the foyer spaces of the RFH.It is connected to two other deep spaces heading from the main entrances from the riverside terrace across the foyer spaces. This simple but powerful syntactic system of long crossing views across the entire ground level with two main stairways stepping all the way up beside the elevated concert hall to level four forms the RFH´s spatial structure. The three entrances on ground floor correspond very well with this structure - the fourth entrance in the basement does not show syntactic importance in spite of the fact that it is the only entrance on street level.

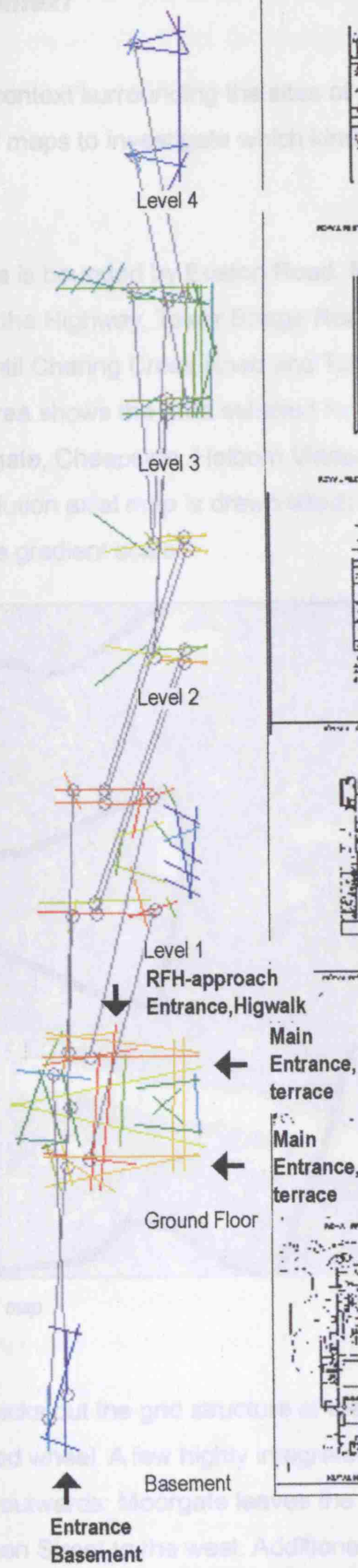

fig 7.14 RFH axial analysis building layout, axial lines

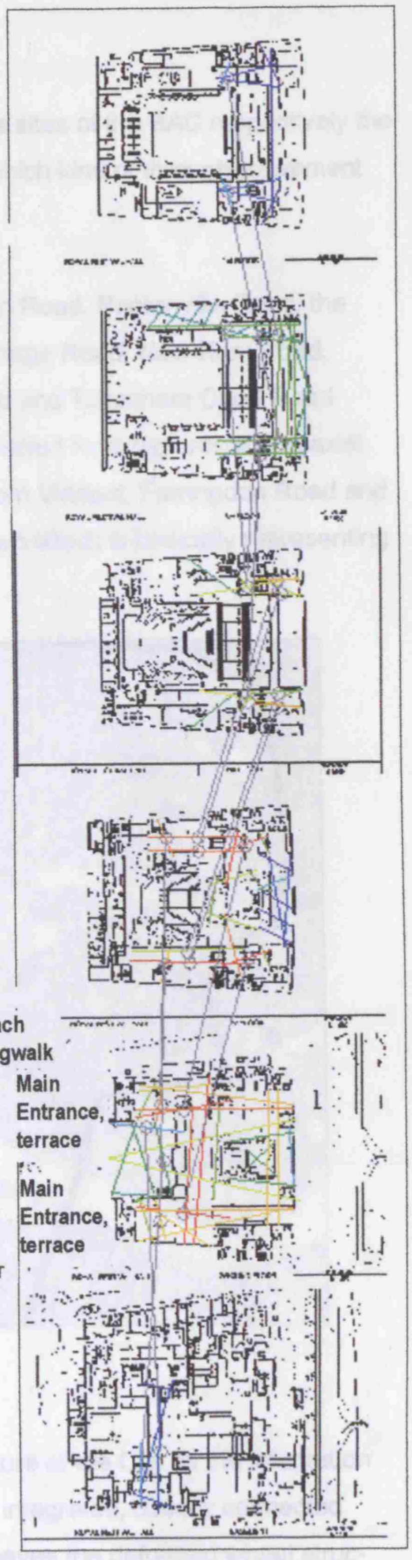

fig 7.15 RFH axial analysis building layout, axial lines on top of plans

7.3 *Axial maps larger urban context*

Axial maps of the larger urban context surrounding the sites of the BAC respectively the RFH were drawn as low resolution axial maps to investigate which kind of through-movement the sites are likely to receive.

For the BAC, the modelling area is bounded by Euston Road, Pentonville Road, the Grand Union Canal, Cambridge Heath, the Highway, Tower Bridge Road, New Kent Road, Waterloo Road and Waterloo Bridge, until Charing Cross Road and Tottenham Court Road close the circle. The small catchment area shows the area selected for a high resolution axial map. It is bounded by City Road, Moorgate, Cheapside, Holborn Viaduct, Farringdon Road and Old Street. Within that area a high resolution axial map is drawn which is basically representing morphological qualities on a much more gradient scale.

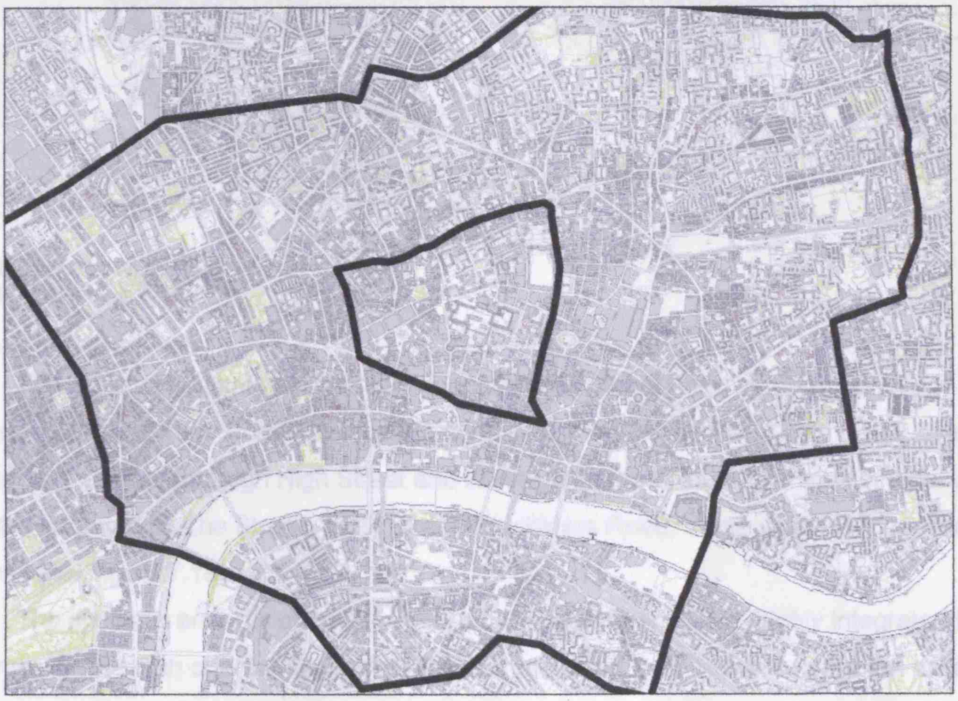

fig 7.16 Boundaries BAC for low res axial map (large) and for high res axial map (small)

The low resolution axial map picks out the grid structure of the City as the integration core which takes the form of a deformed wheel. A few highly integrated, directly connected axial lines extend this integration core outwards: Moorgate leaves the deformed wheel structure to head north, Newgate and Cannon Street to the west. Additionally, Blackfriars Road and Old Street are well integrated but more autonomous from that integration core. The area of the Barbican itself shows a high degree of segregation. In spite of its location just north-west of the integration core, its central axial lines reveal integration values which are rather typically for the edges of an urban system. The lengths of the axial lines is very short, and none is crossing the entire area of the Barbican. There is significant movement surrounding the Barbican: London

Wall to the south, Aldersgate Street to the West, Beech Street and Chiswell Street to the north and Moorgate to the west. Altogether, the area of the Barbican is picked out as an entirely alien structure that obviously does not allow much through movement.

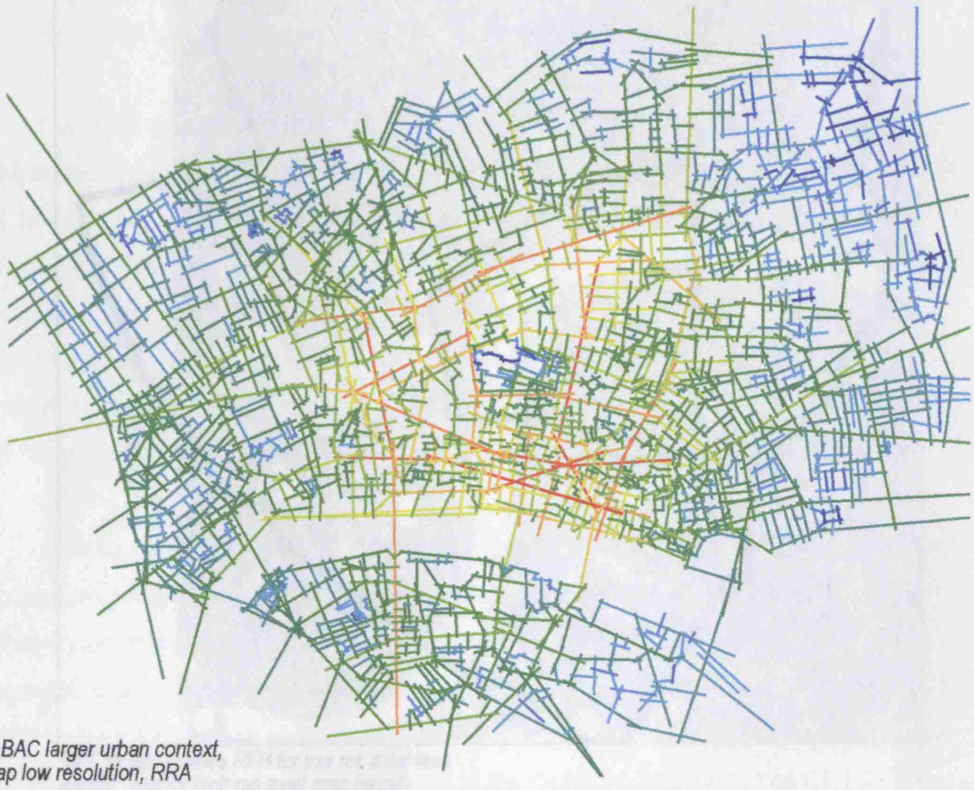

fig 7.17 BAC larger urban context,
Axial map low resolution, RRA

The larger urban area of investigation for the RFH is bounded by Vauxhall Bridge Road, Park Lane, Oxford Street, Portland place, Euston Road, Pentonville Road, City Road, Moorgate, London Bridge, Borough High Street and Kennington Park Road. The smaller local urban context is bounded by The Strand, Fleet Street, Blackfriars Road, Westminster Bridge Road and Whitehall (see figure 7.18).

The syntactic analysis of the low resolution axial map show two highly integrated long axial lines: north-south oriented Blackfriars Road crosses the river Themse to link the area of Holborn to the South Bank. Axial extensions of Oxford Street, which runs from west to east, are finally connecting to Blackfriars Road (New Oxford Street, High Holborn). This forms the integration core of the large urban area around the RFH. More locally, the South Bank and the RFH are passed by the well integrated Waterloo Bridge, which continues north to the Strand and south to St.George´s Circus and Elephant&Castle. As part of the urban grid attached to the river Themse, the South Bank as the site of the RFH is overall not well integrated. This might be due to a historical lack of the extension of the urban grid onto the former marsh land and later industrial areas next to the river. Its grid structure is fragmented and consists of short lines.

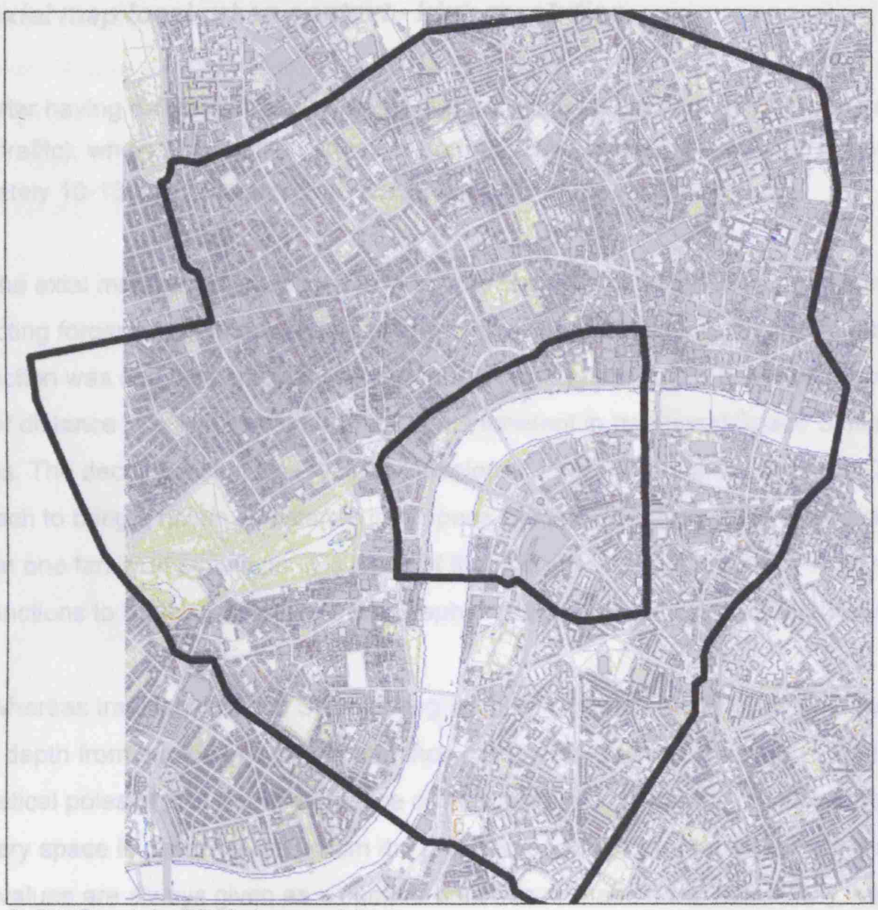

fig 7.18 Boundaries RFH for low res axial map (large) and for high res axial map (small)

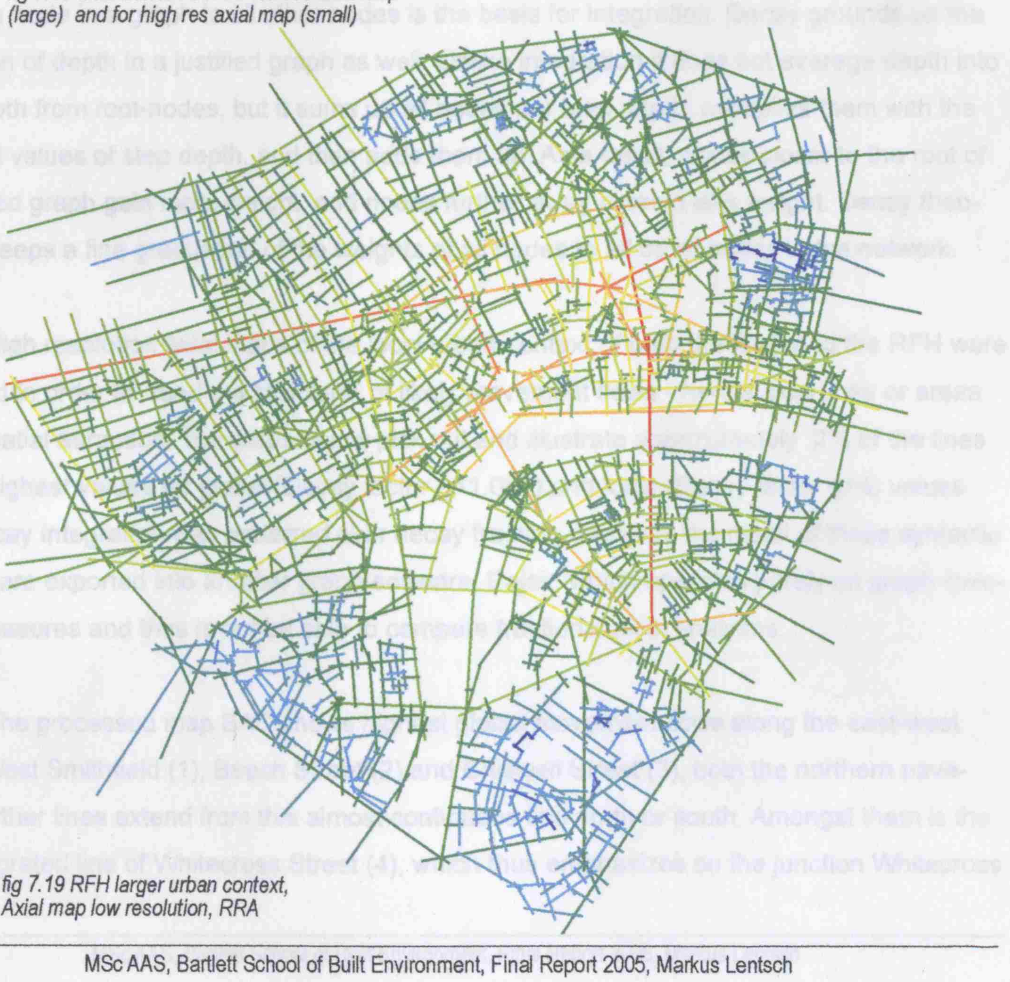

fig 7.19 RFH larger urban context, Axial map low resolution, RRA

7.4 *Axial map local urban context - high resolution*

After having defined an area through ´natural boundaries´ (e.g. streets with heavy vehicular traffic), which centred the venues of both the BAC and RFH in a walking distance of approximately 10-15 minutes each, high resolution axial maps were drawn.

The axial maps were processed in Webmap testing a distance-decay function to analyse attracting forces of the urban grid respectively their decay back into the urban fabric. The decay function was chosen particularly to account for spatial attraction, because it incorporates a notion of distance in graph networks which is not inherent in traditional Space Syntax integration values. The decay function was recently developed by Ruth C. Dalton and Nick Dalton as an approach to bring a notion of distance into Space Syntax models and unify syntactic measures within one family of equations. It is issue of their recent paper in progress ´Applying Depth Decay Functions to Space Syntax Network Graphs´ at the Bartlett School of Graduate Studies, UCL.

Whereas traditional Space Syntax integration values are calculated by first evaluating mean depth from a node in a graph, and then comparing this specific mean depth to the two theoretical poles of a unilinear sequence on the one hand, and a maximally shallow graph where every space is one level deep from the root-node on the other hand. By doing so, the integration values are always given as a number between one and zero. Essentially, mean depth from each node in a graph to all other nodes is the basis for integration. Decay grounds on the distribution of depth in a justified graph as well. Unlike integration it does not average depth into mean depth from root-nodes, but it sums up all nodes per step depth, multiplies them with the reciprocal values of step depth, and then adds them up. As a result, nodes closer to the root of the justified graph gain more weight, and nodes further away receive less weight. Decay theoretically keeps a fine graduation of the weights of all nodes to all other nodes in the network.

High resolution axial maps of the local urban context of both the BAC and the RFH were processed in order to ´read the structure´ of likely movement flows - hence axial lines or areas of high spatial attraction. The maps below pick out and illustrate approximately 2% of the lines with the highest values for global (Decay factor g=1.001) and local (Decay factor g=4) values each. Decay integration was preferred over decay fraction, because the result of these syntactic analyses are exported into another graph-software, Pajek, which operates purely on graph-theoretical measures and thus is not be able to compare fractional axial analyses.

The processed map BAC shows highest global movement flows along the east-west lines of West Smithfield (1), Beech Street (2) and Chiswell Street (3), both the northern pavement. Further lines extend from this almost continuous line north or south. Amongst them is the most integrated line of Whitecross Street (4), which thus emphasizes on the junction Whitecross

Street/Chiswell Street/Silk Street.

Local centres are picked out again on West Smithfield (5), on Fortune Street (6) and on Chiswell Street (7) north of the Barbican. London Wall (8) and Little Britain / St.Bartolomews Hospital (9) are picked out south of the Barbican, which receives neither significant local nor global movement flows.

fig 7.20 BAC local urban context,
Axial map high resolution,
Decay Integration factor 1.001, g

fig 7.21 BAC local urban context,
Axial map high resolution,
Decay Integration factor 4, local

As for the RFH´s local urban context, the axial lines with the highest decay values are the western pavement of Waterloo Bridge (1), The Strand (2) and the axial lines constituting the sunken pedestrian roundabout at the end of Waterloo Bridge / IMAX-cinema (3). Quite high decay values are further featured by several axial lines spreading from the end of Waterloo Bridge - like York Street (4), Stamford Street (5), Waterloo Street (6), and also the RFH-approach (7) connecting Hungerford Bridge to Waterloo Station.

Local centres of spatial attraction are found as a pattern of eight autonomous sub-centres over the whole area. They include The Strand (8), Northumberland Avenue (9), Westminster Bridge (10), York Street (11), Cornwall Road (12), Upper Ground (13), The Queen´s Walk RNT (14) and Temple Avenue (15) east of the Temple area. Second, the area of the South Bank itself features a - meanwhile reduced - system of elevated highwalks with main entrances to the RFH, the Queen Elizabeth and Purcell Room, and Hayward Gallery only from that segregated circulation system.

Second, the area of the South Bank itself features a - meanwhile reduced - system of elevated highwalks with main entrances to the RFH, the Queen Elizabeth and Purcell Room, and Hayward Gallery only from that segregated circulation system.

fig 7.22 RFH local urban context,
Axial map high resolution,
Decay Integration factor 1.001, global movement

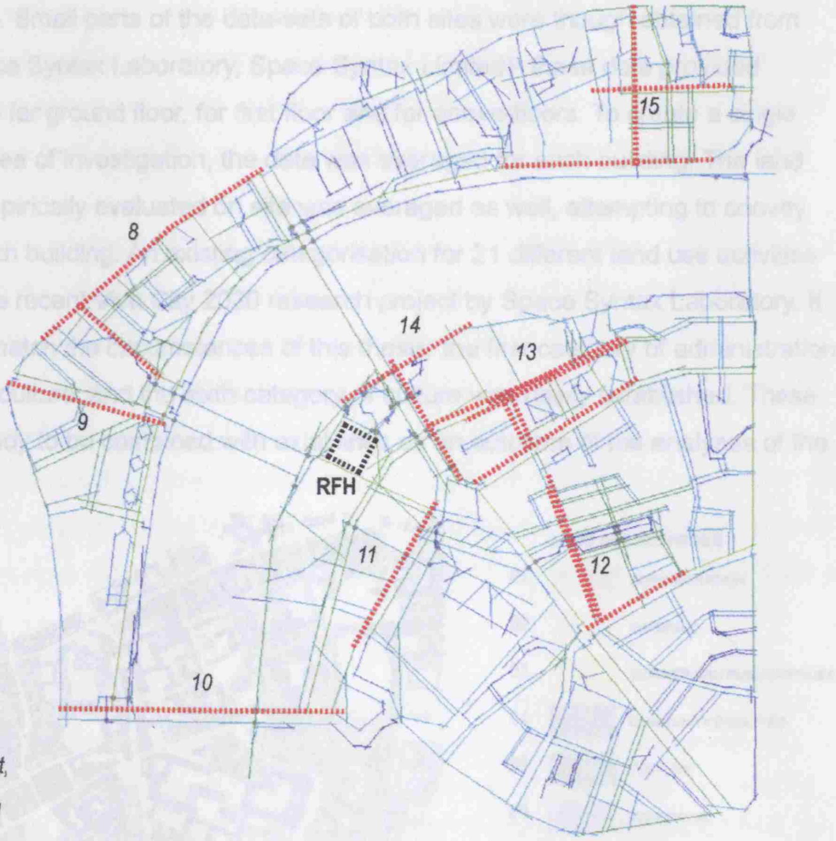

fig 7.23 RFH local urban context,
Axial map high resolution,
Decay Integration factor 4, local

7.5 Land use activities

Land use data was collected for almost the entire local urban context of both sites covering all significant global and local attraction areas. It was obtained mostly through empirical investigation on site. Small parts of the data-sets of both sites were though obtained from research projects (Space Syntax Laboratory, Space Syntax Limited)- these data provided information on land use for ground floor, for first floor and for above-floors. To create a single land use map for the area of investigation, the data was averaged for each building. The land use data which was empirically evaluated on site was averaged as well, attempting to convey the main activity for each building. An existing categorisation for 21 different land use activities was taken over from the recent Viva City 2020 research project by Space Syntax Laboratory. It was slightly altered to match the circumstances of this thesis: the first category of administration was substituted for agriculture, and the sixth category of culture was newly established. These data-sets were hold ready to be combined with axial lines as an outcome of the analyses of the constituted axial maps.

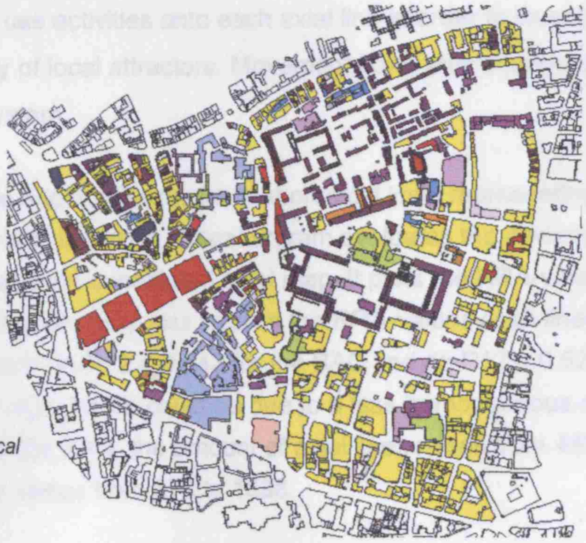

fig 7.24 BAC local urban context, Land use activities,map

fig 7.26 Legend Land use activities

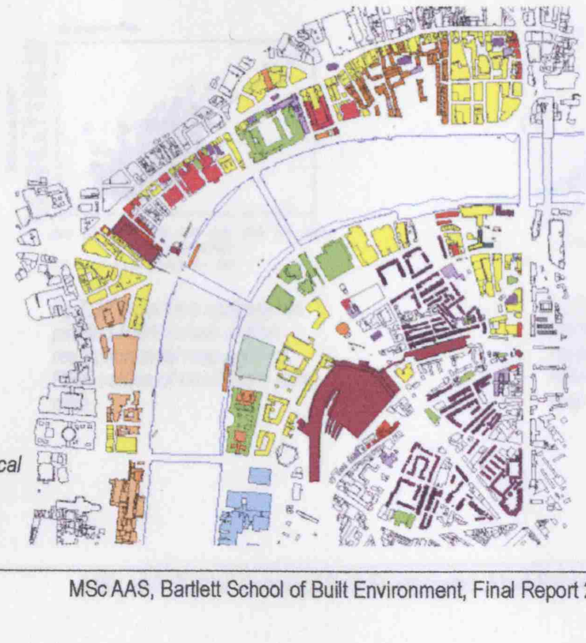

fig 7.25 RFH local urban context, Land use activities,map

7.6 *Constituted axial map - relating building-interfaces to urban space*

This section of the thesis sets out to combine both the morphology of urban space as the main generator of movement with the layout and interfaces of urban objects (buildings or groups of buildings of same land use) into a constituted axial map. The constituted axial map then consists of the high resolution axial map - plus axial lines which were drawn as perpendicular lines away from the building entrances. Each entrance of a building is hence represented by a line to indicate active frontages. This is done in order to add two kinds of information into the axial map.

First, the number and distribution of buildings and their entrances shall indicate to which degree the axial lines of the urban grid are constituted. Drawing a constituted axial map clarifies, if an axial line just passes a building without interacting (lack of interface) - or if it interacts. In urban space, high movement-rates (through-movement) can exist due to more global network-effects without much local interaction (e.g. Beech Street - BAC, see chapter 9).

The second reason justifying the constituted axial map is the attempt to load information about land use activities onto each axial line in order to investigate the local distribution respectively decay of local attractors. Movement flows thus change and decays with each step depth in the axial system.

The additional amount of short axial lines representing the interfaces of buildings may alter the syntactic values. A scattergram evaluates the deviation between the high resolution axial map and the constituted axial map. It plots the RRA-values of all lines of the high resolution axial map on the y-axis against the RRA-values of all lines of the constituted axial map on the x-axis with an $R^2 = 0.843$ for the BAC and an $R^2 = 0.522$ for the RFH. The deviation for the RFH is high, which could be due to a less homogeneous distribution of buildings/entrances.

For the BAC, the amount of axial lines raises from 482 to 1172, whereas for the RFH the number raises from 873 to 1338.

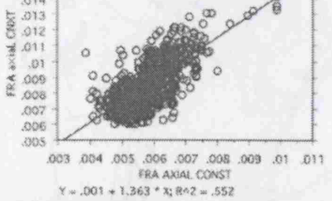

fig 7.27 Deviation scattergram plotting RRA-values of high resolution axial map against RRA-values of constituted axial map

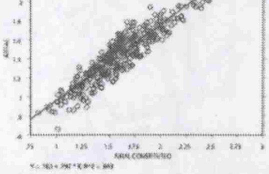

fig 7.28 Deviation scattergram plotting RRA-values of high resolution axial map against RRA-values of constituted axial map

Figures 7.29 and 7.30 below show the constituted axial maps of the BAC and RFH to allow graphical comparison with the high resolution axial maps. It finally has to be mentioned that the information which is next being exported into Pajek1 consists of the pure node-graph without processed syntactic values.

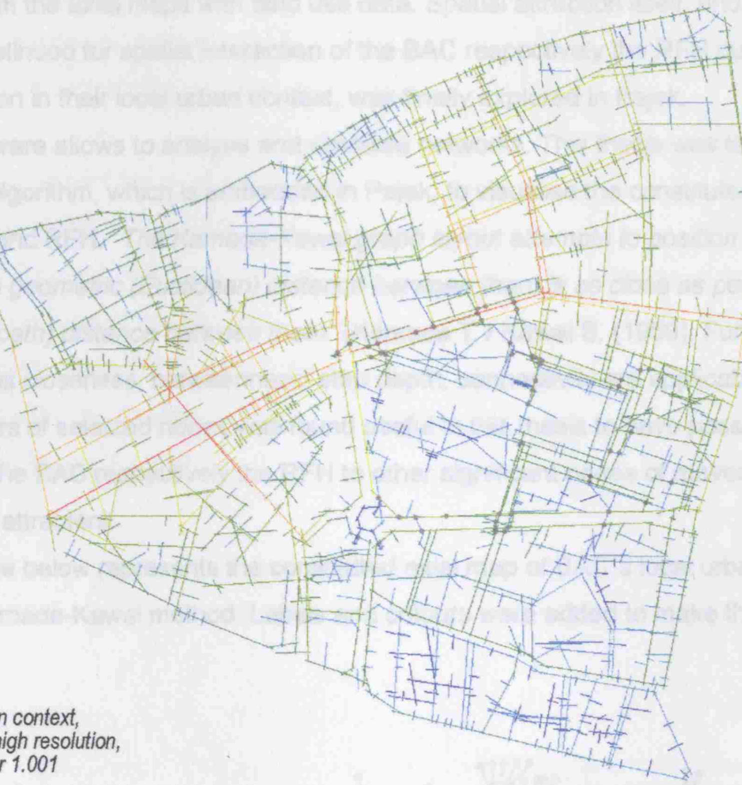

fig 7.29 BAC local urban context,
Constituted Axial map high resolution,
Decay Integration factor 1.001

fig 7.30 RFH local urban context,
Constituted Axial map high resolution,
Decay Integration factor 1.001

7.7 *Pajek*

Pajek[8], a software for the analysis and visualisation of large networks, was used to combine data from the axial maps with land use data. Spatial attraction itself, and how it contributes to the likelihood for spatial interaction of the BAC respectively the RFH due to their the topological position in their local urban context, was finally explored in Pajek.

The software allows to analyse and visualise networks. This thesis was testing the Kamada-Kawai algorithm, which is embedded in Pajek, to visualise the constituted axial maps of both the BAC and RFH. *"The Kamada-Kawai graph layout attempts to position nodes on the space so that the geometric (Euclidean) distance between them is as close as possible to the graph-theoretic (path) distance between them"* (Kamada T. / Kawai S. (1989). Furthermore, measures such as closeness, betweenness, step depth, connectivity are applicable. Maximum flow between pairs of selected nodes was found useful in this thesis to have possible routes processed from the BAC respectively the RFH to other significant nodes of movement flows- or to nodes of local attractors.

The figure below represents the constituted axial map of BAC´s local urban context displayed by the Kamada-Kawai method. Labels and colours were added to make the map legible.

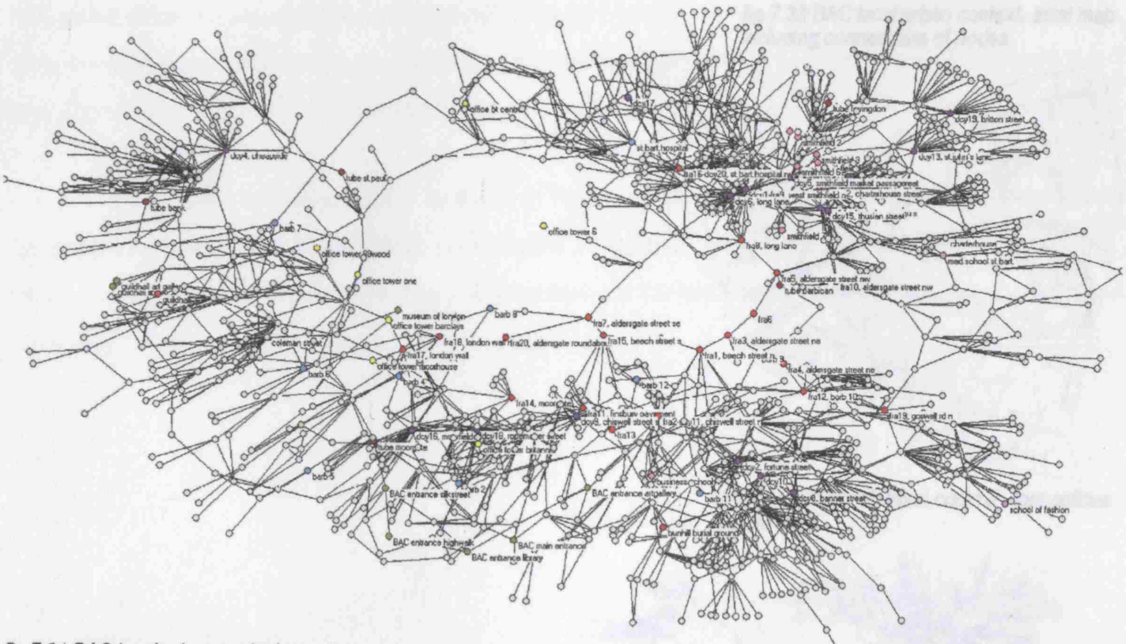

fig 7.31 BAC local urban context as node map,
Layout Energy (Kamada-Kawai),

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8 Pajek, a software for analysing and visualising large scale networks, written by V. Batagelj and A. Mrvar, Slovenia, is available for academic use on the internet - http://vlado.fmf.uni-lj.si/pub/networks/pajek/default.htm

The map above was obtained after importing the processed axial map into Pajek. The graph-images on the right illustrate the 'transformation' of the graph from the axial map into the Kamada-Kawai map. All maps are different representations of the same graph.

Figure 7.32 shows the axial map (constituted), whereas figure 7.33 adds the map of connections on top of the same axial map. The plain node-map of connectivity, figure 7.34, is imported into Pajek, where the energy layout Kamad-Kawai is applied to visualize attracting forces, figure 7.35.

fig 7.32 BAC local urban context, axial map

fig 7.33 BAC local urban context, axial map including connections of nodes

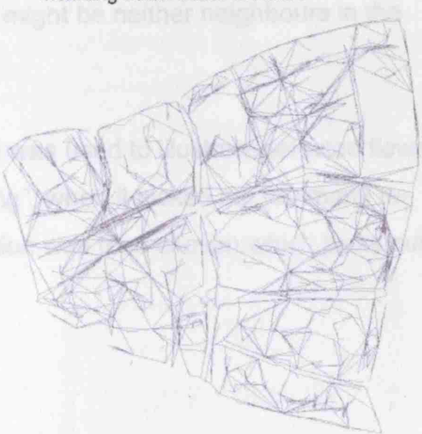

fig 7.34 BAC local urban context, connections (node map)

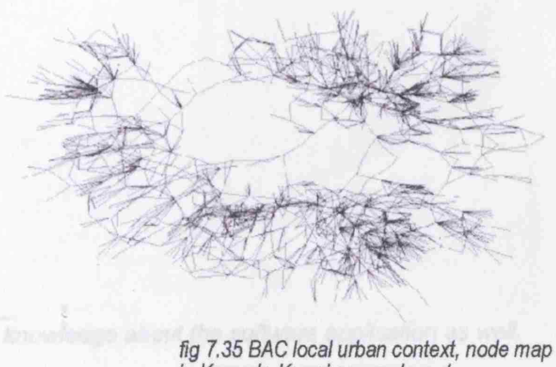

fig 7.35 BAC local urban context, node map in Kamada-Kawai energy layout

8. Limitations

Some complications which occurred during the research process are mentioned here, because they were found to be possible limitations to the investigations.

A major decision was concerning the size of the local urban area to investigate. Since the method is combining rather local information (land use activities, to-movement) with rather global information (through-movement) within one graph, it has to decide for a balanced size of the investigated area. If the area is too large, it becomes virtually impossible to assign land use activities to represent all interfaces of urban objects in the area. If the area is too small, it will not account for reliable through-movement results.

Turning high resolution axial maps into constituted axial maps presents another possible limitation. This is, because to add hundreds of short, mostly one-connected, axial lines indicating building entrances, can distort the syntactic values of the original axial map. This thesis was therefore looking at scattergrams to measure the deviation of integration values. Whereas the deviation seems to remain acceptable for the BAC, it might be too high for the RFH (see chapter 7.6).

The Kamada-Kawai energy layout in Pajek represents an opportunity and a limitation at the same time. Its visualisation of an entire graph makes it difficult to ´read´ local graph properties, because connecting lines overlap and adjacent nodes might be neither neighbours in the non-energy node map nor in the spatial layout.

Finally, the Maximum Flow function in Pajek, which was used to illustrate selected flows of movement, was considered to be sometimes ´missleading´, when it picked out too many remote routes between a pair of nodes[9]. Alternatively, a function was then chosen which picks out only one shortest route, instead of two or three.

9 Actually, this limitation might well be a limitation in knowledge about the software application as well.

9. Findings

This chapter discusses software-related findings as well as findings related to the produced data.

High resolution axial maps were processed with different decay-factors to look for global and local movement flows (see chapter 7.4) for both venues´ urban context. Correlation was found between decay and integration measures, as can be seen in the scattergrams below. This thesis does not attempt to explain these correlation - it just notes them. It shall be referred here to the paper in progress ´Applying Depth Decay Functions to Space Syntax Network Graphs´ by Ruth Conroy Dalton and Nick Sheep Dalton, which will shed more light on this issue.

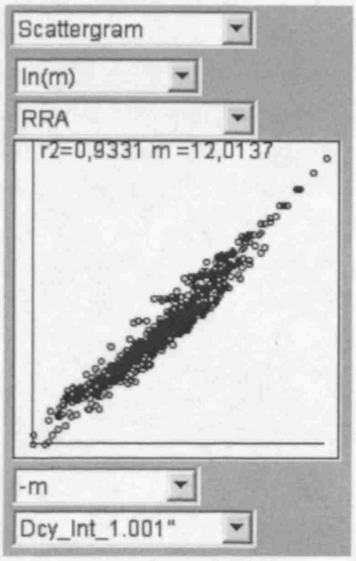

fig 9.1 BAC, Deviation scattergram plotting RRA-values of high resolution axial map against Decay-values 1.001 of high resolution axial map

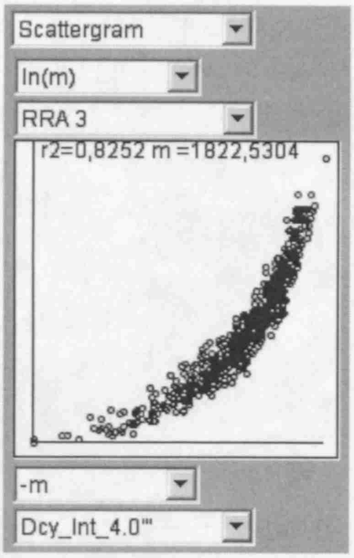

fig 9.2 BAC, Deviation scattergram plotting RRA3-values of high resolution axial map against Decay-values 4 of high resolution axial map

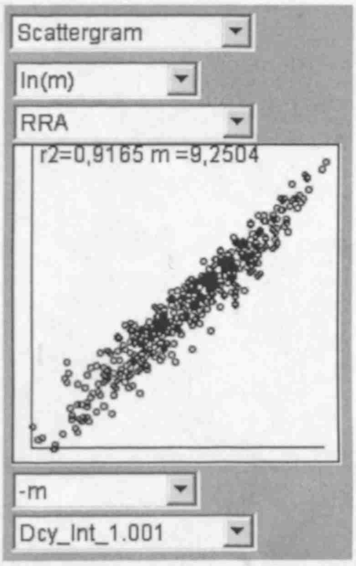

fig 9.3 RFH, Deviation scattergram plotting RRA-values of high resolution axial map against Decay-values 1.001 of high resolution axial map

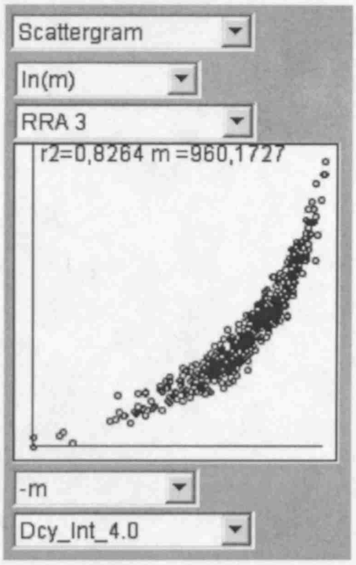

fig 9.4 RFH, Deviation scattergram plotting RRA3-values of high resolution axial map against Decay-values 4 of high resolution axial map

A correlation was found in Pajek between the Space Syntax measure of decay-factor 1.001 (through-movement) respectively decay-factor 4 (to-movement) and the graph-theoretical measures of Betweenness and Centres. Figure 9.5 shows the Kamada-Kawai layout for the BAC´s context with coloured nodes of the most significant decay1.001 nodes (red) and decay4 nodes (purple). A comparison with figures 9.6 (betweenness) and 9.7 (centres) illustrates the correlation.

Further application of Pajek takes advantage of combining, analysing and visualising urban axial lines and building interfaces within one graph. Focus is put on analysing routes between the BAC respectively RFH and specific nodes representing through-movement or to-movement as evaluated in axial maps before (chapter 7.4, decay). Local attractors were empirically selected as additional destination-nodes of routes (e.g. London Eye, for RFH context).

Most likely routes between selected pairs of nodes are then processed using Maximum Flow function in Pajek. The sequence and connectivity of nodes on those routes have been recorded to finally receive tables which display density of building interfaces and axial lines of urban space for each route. These tables were used as tools to trace proximity of origin nodes (BAC, RFH) to movement flows and detect any interfaces between land use activities and movement flows. This shall test how much by-product the BAC respectively the RFH are likely to receive as a result of spatial attraction.

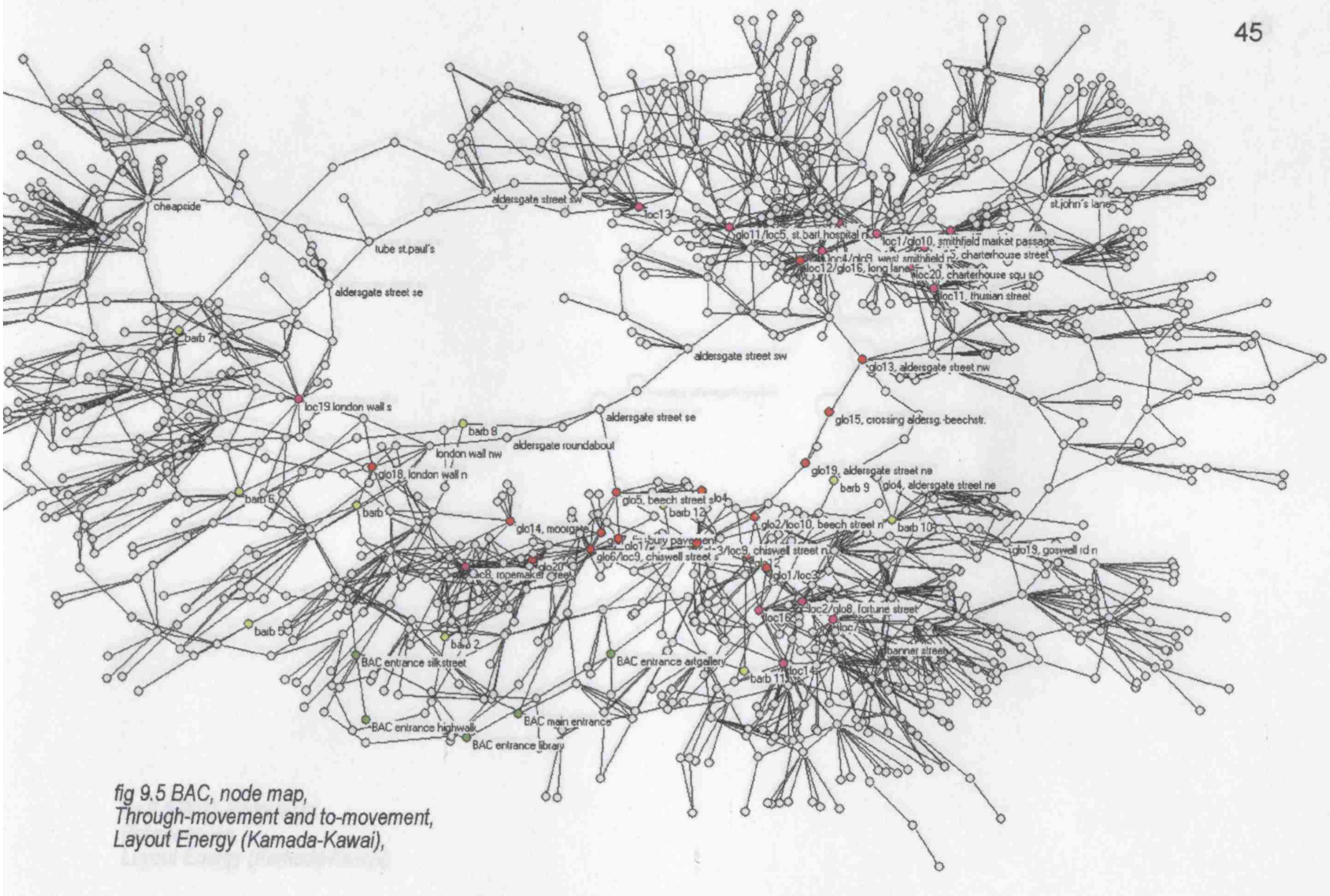

fig 9.5 BAC, node map,
Through-movement and to-movement,
Layout Energy (Kamada-Kawai),

In detail, the following tables horizontally list nodes as their ID-numbers with the origin of a route to the left and the destination to the right (step depth). Underneath the main bar, they vertically list connected axial lines of urban space (AL) or connected axial lines of building interfaces (BI) corresponding to the land use category as defined in chapter 7.5 (e.g. BI 03 for an office building). Complete maps including the ID-number of nodes are added in the appendix.

In general, the BAC-data confirms that axial lines with high integration or decay-value feature higher amount and diversity of land use activities. One exception was found: Beech Street, as a tunnel underneath the Barbican, does of course not feature interface-density but receives a lot of through-movement.

The syntactic configuration of the exterior of the BAC was found to mismatch its functional layout. Its most integrated entrance is from Silk Street - not the main entrance. Silk Street also features more interfaces and connectivity, because it is part of the urban grid. The main entrance was never picked out as part of a route to access the BAC. Obviously, it is too fragmented. Another access from the urban grid onto the square in front of the BAC was picked out regularly, which is the 'hidden' path through the car-park and delivery road from Silk Street. This path is topologically quite well integrated - but functionally neglected.

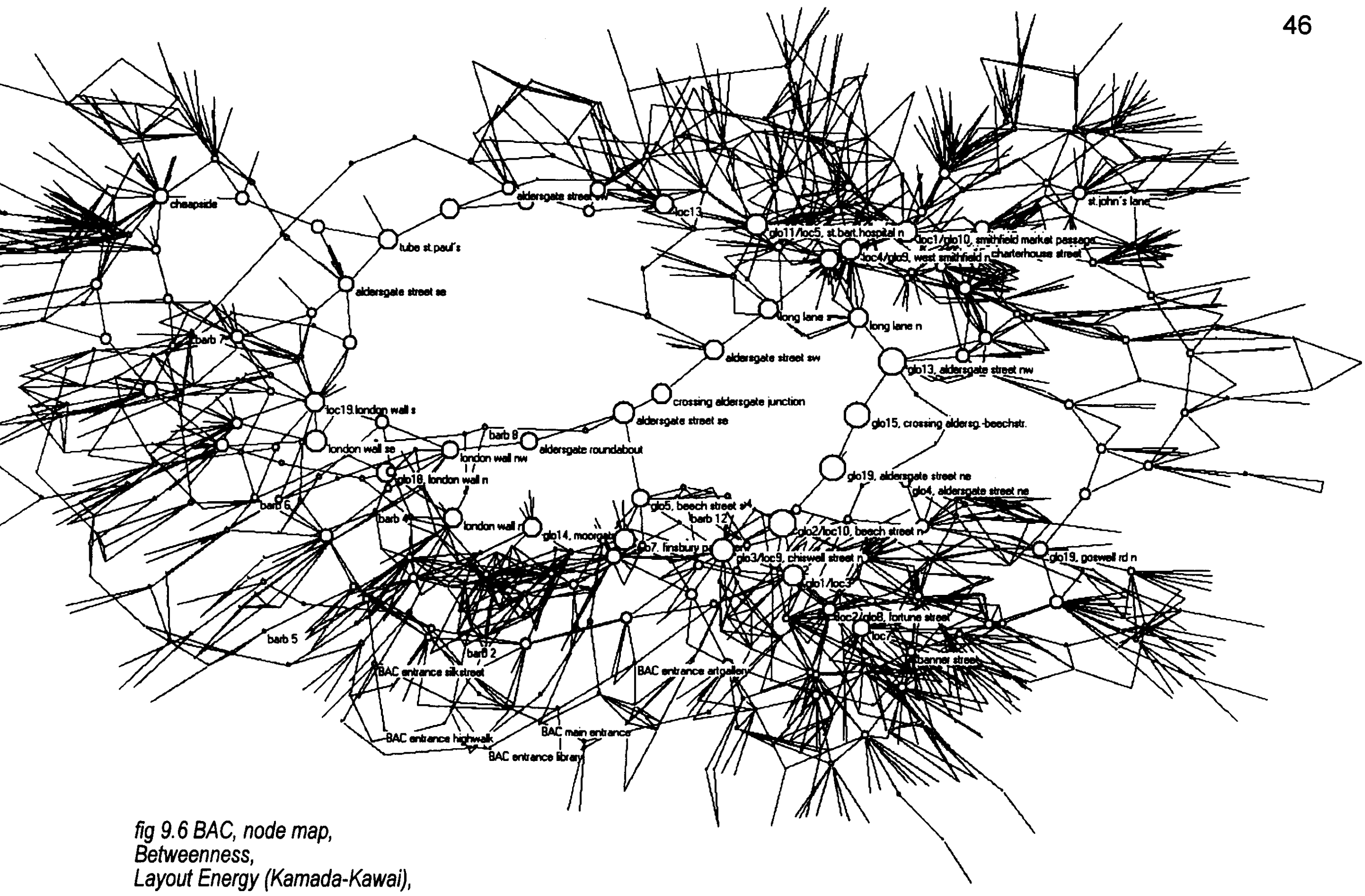

fig 9.6 BAC, node map,
Betweenness,
Layout Energy (Kamada-Kawai),

Inside the Barbican complex, most routes lack diversity of interfaces due to the Barbicans emphasize on residential land use. Five routes, which were supposed to test paths through the Barbican complex, did not pass through but circled the complex. The urban axial lines on these routes are hardly constituted - in combination with lack of through-movement it makes the Barbican act like a negative attractor to its urban context.

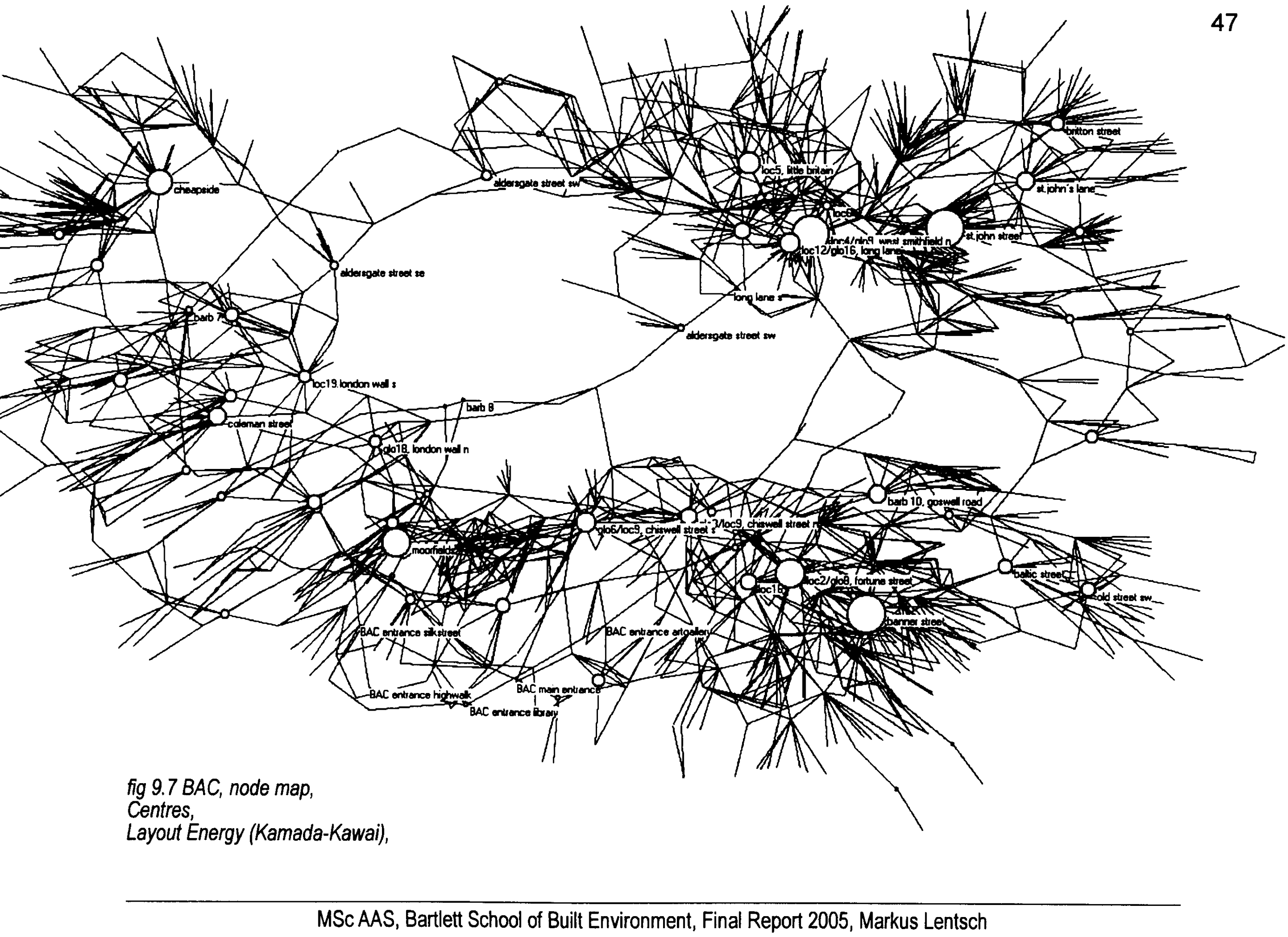

fig 9.7 BAC, node map,
Centres,
Layout Energy (Kamada-Kawai),

Routes from BAC to through-movement lines

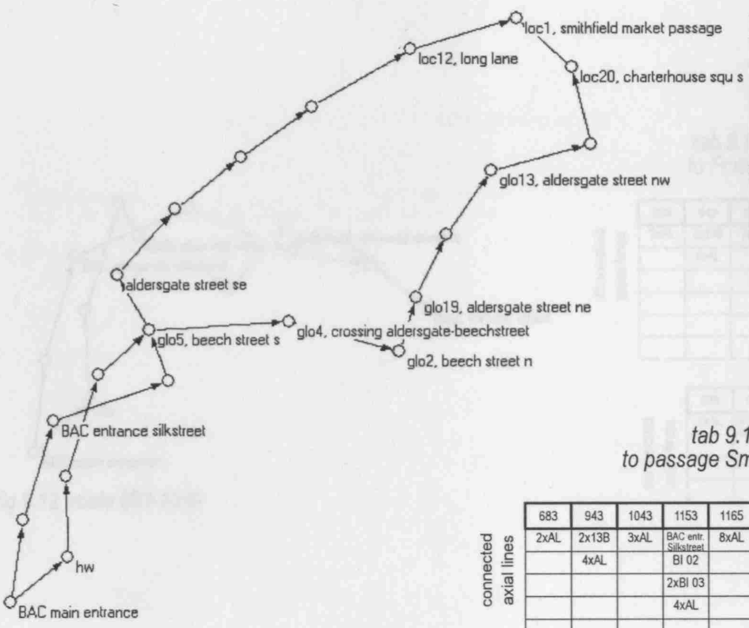

fig 9.9, route 683-776

fig 9.8, BAC entrance Silk Street

tab 9.1 two routes from BAC (683) to passage Smithfield Market (1097); depth: 10/12

	683	943	1043	1153	1165	1138	1163	1158	1146	1160	1121	1094	1097
connected axial lines	2xAL	2x13B	3xAL	BAC entr. Silkstreet	8xAL	2xAL	9xAL	BI 14	2xAL	2xBI 03	2xBI 03	3xBI 03	BI 02
		4xAL		BI 02				3xAL		BI 13	2xBI 13	2xBI 06	3xBI 03
				2xBI 03						BI 14	BI 14	2xBI 14	BI 09
				4xAL						BI 17	BI 15	BI 20	2xBI 13
										5xAL	5xAL	10xAL	BI 14
													14xAL

	683	942	1137	1152	1165	1164	1155	1141	1157	1147	1097
connected axial lines	2xAL	BAC entr. Silkstreet	BI 06	BAC entr. Silkstreet	8xAL	4xAL	2xAL	2xBI 03	BI 03	6xBI 03	BI 02
			7xAL	BI 02				BI 06	BI 10	2xBI 08	3xBI 03
				2xBI 03				3xAL	4xAL	3xBI 13	BI 09
				4xAL						BI 10	2xBI 13
										BI 14	BI 14
										BI 20	14xAL
										8zzxAL	

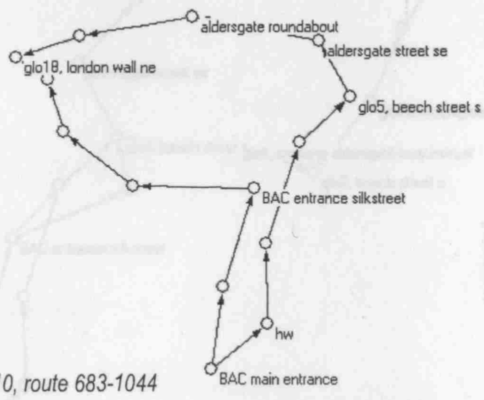

fig 9.10, route 683-1044

tab 9.2 three routes from BAC (683/936) to London Wall north-east (1044); depth: 6/8/5

	683	943	1043	1153	1165	1164	1149	1118	1044
connected axial lines	2xAL	2x13B	3xAL	BAC entr. Silkstreet	8xAL	4xAL	2xAL	7xAL	9xAL
		4xAL		BI 02					
				2xBI 03					
				4xAL					

	683	942	1137	1026	915	983	1044
connected axial lines	2xAL	BAC entr. Silkstreet	BI 06	BI 03	2xBI 03	BI 03	9xAL
			7xAL	6xAL	5xAL	5xAL	

	936	1136	1090	1089	981	1044
connected axial lines	BAC entr. Library	BAC entr. Highwalk	2xBI 13	BI 03	3xAL	9xAL
	AL	BI 13	5xAL	BI 13		
		4xAL		8xAL		

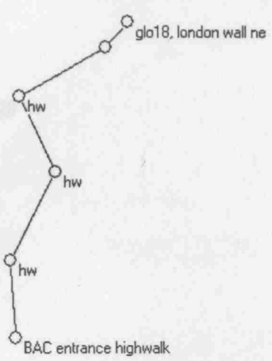

fig 9.11, 936-1044

Routes from BAC to to-movement lines

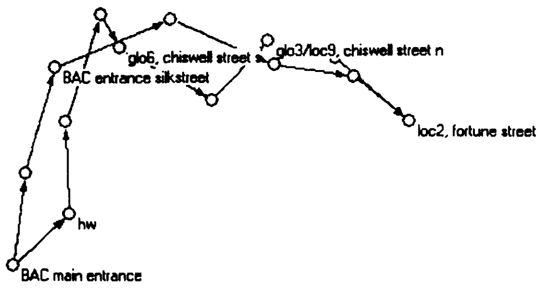

fig 9.12, route 683-1030

tab 9.3 two routes from BAC (683) to Fortune Street (1030); depth: 6/8

	683	943	1043	1153	1154	1069	1140	1125	1030
connected axial lines	2xAL	2x13B	3xAL	BAC entr. Silkstreet	4xBI 03	3xBI 03	4xBI 03	7xAL	2xBI 03
		4xAL		BI 02	BI 06	4xAL	BI 06		8xBI 13
				2xBI 03	BI 09		BI 09		16xAL
					BI 10		BI 10		
					2xBI 18		2xBI 18		
					12xAL		11xAL		

	683	942	1137	1152	1096	1133	1030
connected axial lines	2xAL	BAC entr. Silkstreet	BI 06	BAC entr Silkstreet	2xAL	BI 03	2xBI 03
			7xAL	BI 02		2xBI 13	8xBI 13
				2xBI 03		BI 14	16xAL
				3xAL		10xAL	

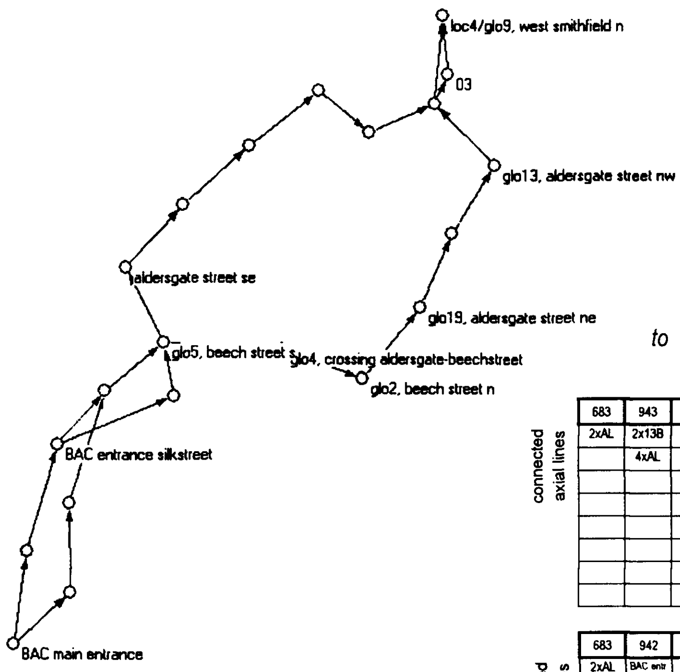

fig 9.13, route 683-1139

tab 9.4 routes from BAC (683) to West Smithfield north (1139); depth: 11/11

	683	943	1043	1153	1165	1164	1155	1141	1157	1171	1145	1139
connected axial lines	2xAL	2x13B	3xAL	BAC entr. Silkstreet	8xAL	4xAL	2xAL	2xBI 03	BI 03	2xAL	5xBI 03	BI 02
		4xAL		BI 02				BI 06	BI 10		2xBI 10	6xBI 03
				2xBI 03				3xAL	4xAL		4xAL	2xBI 08
												3xBI 13
												BI 10
												BI 14
												BI 20
												21xAL

	683	942	1137	1153	1165	1138	1163	1158	1146	1160	1145	1139
connected axial lines	2xAL	BAC entr Silkstreet	BI 06	BAC entr Silkstreet	8xAL	2xAL	9xAL	2xBI 03	2xAL	2xBI 03	5xBI 03	BI 02
			7xAL	BI 02				BI 06		BI 13	2xBI 10	6xBI 03
				2xBI 03				3xAL		BI 14	4xAL	2xBI 08
				4xAL						BI 15		3xBI 13
										5xAL		BI 10
												BI 14
												BI 20
												21xAL

Routes from BAC to local-attractors

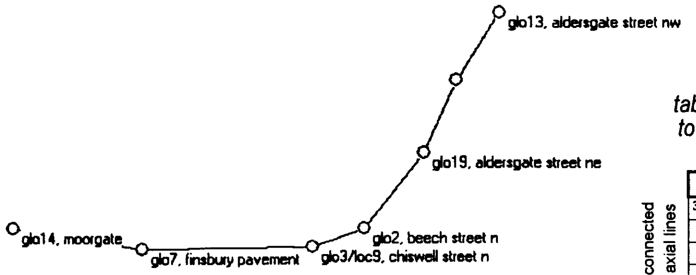

fig 9.14, route 1051-1160

tab 9.5 one route from Moorgate (1051) to Aldersgate Street north-west (1160); depth: 6

	1051	1113	1140	1163	1158	1146	1160
connected axial lines	3xBI 03	4xBI 03	4xBI 03	9xAL	BI 14	2xAL	2xBI 03
	BI 17	4xAL	BI 06		14xAL		BI 13
	2xAL		BI 09				BI 14
			BI 10				BI 17
			2xBI 18				5xAL
			11xAL				

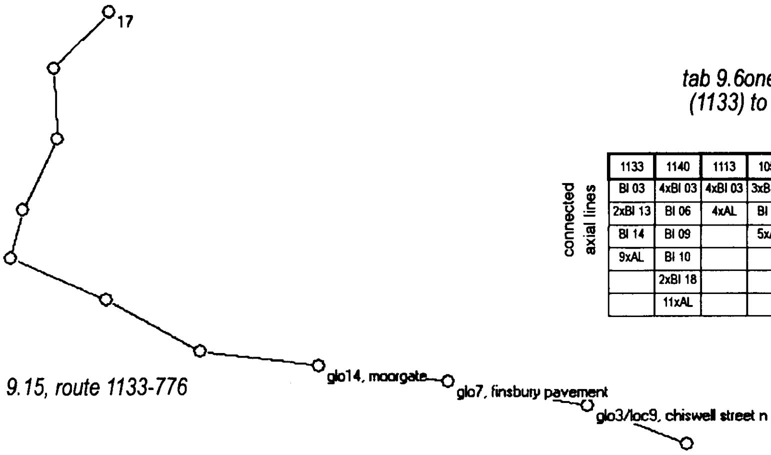

fig 9.15, route 1133-776

tab 9.6one route from Whitecross Street (1133) to tube-station St.Paul´s (1160); depth: 10

	1133	1140	1113	1051	914	777	805	999	889	853	776
connected axial lines	BI 03	4xBI 03	4xBI 03	3xBI 03	6xAL	2xAL	BI 13	BI 03	BI 03	3xBI 03	BI 17
	2xBI 13	BI 06	4xAL	BI 17			BI 18	4xBI 18	3xAL	BI 04	3xAL
	BI 14	BI 09		5xAL			4xAL	9xAL		BI 13	
	9xAL	BI 10								BI 17	
		2xBI 18								4xAL	
		11xAL									

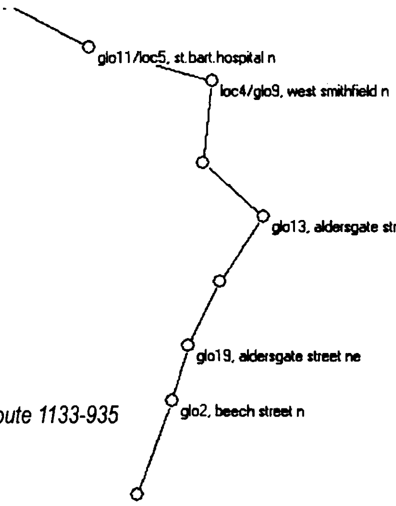

fig 9.16, route 1133-935

tab 9.7 route from Whitecross Street (1133) to St.Bartolomew´s Hospital south (935); depth: 8

	1133	1163	1158	1146	1160	1145	1139	1114	935
connected axial lines	BI 03	9xAL	BI 14	2xAL	2xBI 03	5xBI 03	BI 02	BI 03	BI 03
	2xBI 13		3xAL		BI 13	2xBI 10	6xBI 03	3xBI 11	BI 11
	BI 14				BI 14	4xAL	2xBI 08	2xBI 13	3xAL
	9xAL				BI 17		3xBI 13	10xAL	
					5xAL		BI 10		
							BI 14		
							BI 20		
							21xAL		

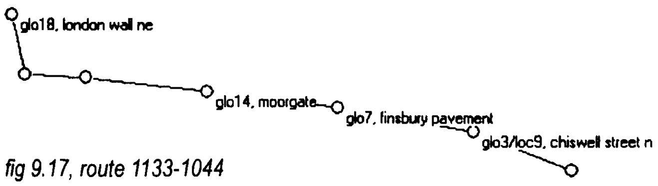

fig 9.17, route 1133-1044

tab 9.8 one route from Whitecross Street (1133) to London Wall north-east (1044); depth: 6

	1133	1140	1113	1051	914	884	1044
connected axial lines	BI 03	4xBI 03	4xBI 03	3xBI 03	6xAL	5xAL	9xAL
	2xBI 13	BI 06	4xAL	BI 17			
	BI 14	BI 09		5xAL			
	9xAL	BI 10					
		2xBI 18					
		11xAL					

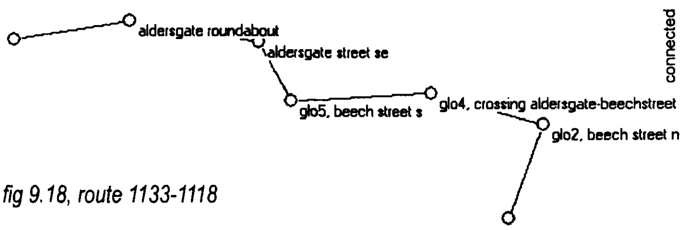

fig 9.18, route 1133-1118

tab 9.9 one route from Whitecross Street (1133) to London Wall north-west (1118); depth: 6

	1133	1163	1138	1165	1164	1149	1118
connected axial lines	BI 03	9xAL	2xAL	8xAL	4xAL	2xAL	7xAL
	2xBI 13						
	BI 14						
	9xAL						

Routes from BAC to transport nodes (tube stations)

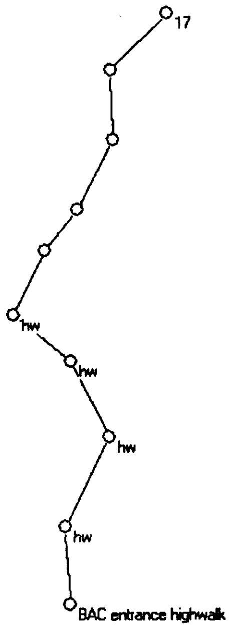

fig 9.19, route 683-776

tab 9.10 three routes from BAC (683) to Tube station St.Paul´s (776); depth: 14/12/9

	683	943	1043	1153	1154	1113	1051	914	777	805	999	889	853	607	776
connected axial lines	2xAL	2x13B	3xAL	BAC entr. Silkstreet	3xBI 03	4xBI 03	3xBI 03	6xAL	2xAL	BI 13	BI 03	3xAL	3xBI 03	BI 17	BI 17
		4xAL		BI 02	BI 06	4xAL	BI 17			BI 18	4xBI 18		BI 04	2xAL	3xAL
				2xBI 03	BI 09		5xAL			4xAL	9xAL		BI 13		
				4xAL	2xBI 18								2xBI 17		
					12xAL								4xAL		

	683	942	1137	1026	915	983	1044	1035	999	795	713	853	776
connected axial lines	2xAL	2xAL	BI 06	BI 03	2xBI 03	BI 03	9xAL	BI 03	BI 03	5xAL	BI 03	3xBI 03	BI 17
			7xAL	6xAL	5xAL	5xAL		3xAL	4xBI 18		4xAL	BI 04	3xAL
									9xAL			BI 13	
												2xBI 17	
												4xAL	

	936	1136	1090	1089	1115	997	999	889	853	776
connected axial lines	BAC entr. Library	BAC entr. Highwalk	2xBI 13	BI 03	BI 04	BI 03	BI 03	3xAL	3xBI 03	BI 17
	1xAL	BI 13	5xAL	BI 13	5xAL	2xAL	4xBI 18		BI 04	3xAL
		4xAL		8xAL			9xAL		BI 13	
									BI 17	
									4xAL	

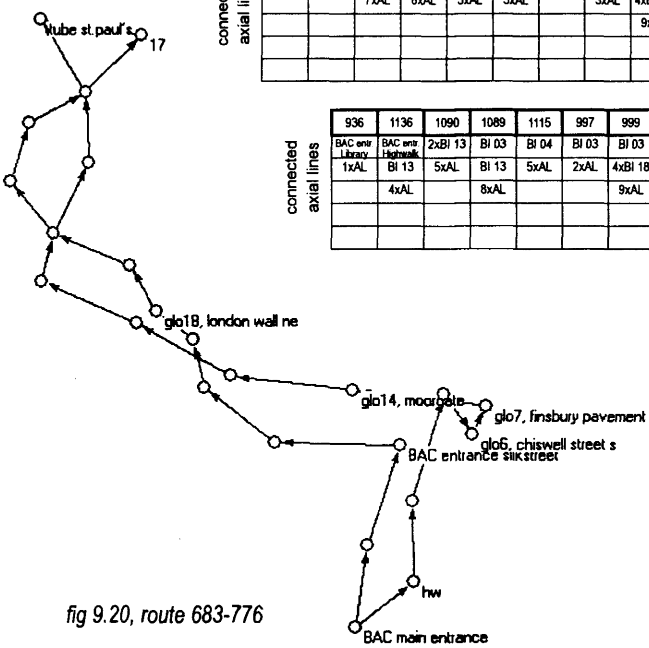

fig 9.20, route 683-776

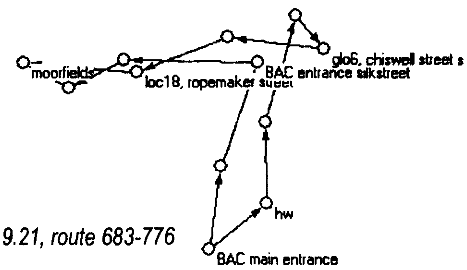

fig 9.21, route 683-776

tab 9.11 three routes from BAC (683/936) to Tube station Moorgate (879); depth: 5/7/7

	683	943	1043	1153	1154	1070	995	879
connected axial lines	2xAL	2x13B	3xAL	BAC entr. Silkstreet	3xBI 03	4xAL	BI 03	BI 01
		4xAL		BI 02	BI 06		16xAL	4xBI 03
				2xBI 03	BI 09			2xBI 13
				4xAL	2xBI 18			BI 14
								2xBI 17
					12xAL			9xAL

	683	942	1137	1026	845	879
connected axial lines	2xAL	BAC entr Silkstreet	BI 06	BAC entr Silkstreet	6xAL	BI 01
			7xAL	BI 03		4xBI 03
				5xAL		2xBI 13
						BI 14
						2xBI 17
						9xAL

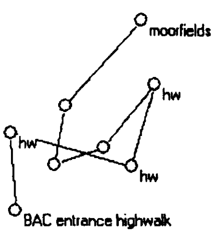

fig 9.22, route 936-776

	936	1136	1027	1077	841	529	543	879
connected axial lines	BAC entr. Library	BAC entr. Highwalk	2xBI 13	BI 13	3xAL	3xAL	BI 01	BI 01
	AL	BI 13	4xAL	5xAL			BI 03	4xBI 03
		4xAL					BI 16	2xBI 13
							3xAL	BI 14
								2xBI 17
								9xAL

The analysis of the RFH´s tables reveals three characteristics for the area around RFH. First, some of the most significant lines of through-movement nearby the RFH feature poor density of building interfaces and low connectivity to other urban axial lines (e.g. Waterloo Bridge, the sunken IMAX-roundabout and its passage to RNT and Queenswalk). Their main purpose is reduced to overcoming space as fast as possible.

Second, the examination of routes from local attractors, including the RFH, to lines of high through-movement were found to be constituted by only one or two interfaces, as well. The transition from urban axial lines to building interfaces is either too fragmented or not existing "in the right places" (e.g. RFH, QPR and Hayward Gallery, IMAX-cinema). Comparing, for example, fig 9.17 to fig 9.19 reveals the poor interfaces of Waterloo Station in comparison to Charing Cross Station.

Analysing how routes touch upon the RFH itself throws light upon the RFH´s interfaces (e.g. fig 9.22 - routes from Waterloo Bridge to London Eye, fig 9.23 - route from Waterloo Station to Embankment). The RFH-approach is the busiest through-movement flow which actually touches the RFH´s south-western facade, where is passes by the most integrated of all RFH´s entrances. Due to its diminishing size and due to lack of convex spaces both inside and outside,

fig 9.23 RFH, node map,
Through-movement and to-movement,
Layout Energy (Kamada-Kawai),

this interface underperforms. Another interface-difficulty concerns the north-west facade, where the large terrace in front of the RFH´s main entrances overlooks - but does not interact with - the river walk below carrying movement due to its connectivity to a number of local attractors on its way (London Eye, NRT, NFT, LTS). The north-eastern facade holds the original main entrance, but its underperforming axial entrance line is not connected to movement flows. Finally, the south-eastern facade simply lacks an interface at all - in spite of considerable movement from Waterloo Station and along the square between the RFH and Belvedere Road.

Third, routes to close lines of to-movement, e.g. Queens Walk at the RNT (see fig. 9.20), split up into three separate paths leading to the same destination. These splits again decreases the ratio of interfaces on routes. Besides, successive nodes on these routes were found to hold very different integration values, which might indicate a lack of continuous flow.

Having exercised the shape of attracted flows between significant lines of through-movement, to-movement and local attractors, the findings altogether reflect a separation of movement-flows as the prevailing impact on the RFH and the South Bank.

fig 9.24 RFH, node map,
Betweenness,
Layout Energy (Kamada-Kawai)

fig 9.25 RFH, node map,
Centres,
Layout Energy (Kamada-Kawai)

Routes from RFH to through-movement lines

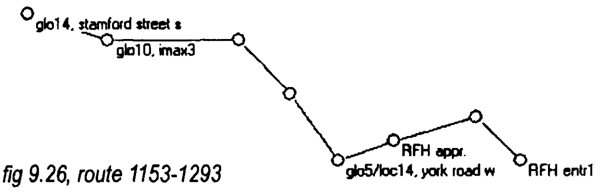

fig 9.26, route 1153-1293

tab 9.12 one route from RFH (1153) to Stamford Street (1293); depth: 7

connected axial lines	1153	1301	1303	1295	1304	1332	1326	1293
	QPR	RFH entrance1	RFH entrance3	Tube Waterl. St.	2xAL	3xAL	3xAL	2xBI 06
	3xAL	RFH entrance2	8xAL	2xBI 03				3xBI 13
		QPR		11xAL				9xAL
		6xAL						

tab 9.13 one route from RFH (1153) to York Road north (1295); depth: 3

connected axial lines	1153	1301	1303	1295
	QPR	RFH entrance1	RFH entrance3	Tube Waterl. St.
	3xAL	RFH entrance2	8xAL	2xBI 03
		QPR		11xAL
		6xAL		

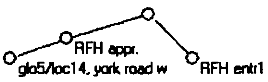

fig 9.27, route 1153-1295

tab 9.14 one route from RFH (1153) to Waterloo Road west (1144); depth: 7

connected axial lines	1153	1301	1303	1295	1304	1332	1326	1305
	QPR	RFH entrance1	RFH entrance3	Tube Waterl. St.	2xAL	IMAX	3xAL	2xBI 03
	3xAL	RFH entrance2	8xAL	2xBI 03		3xAL		BI 04
		QPR		11xAL				BI 08
		6xAL						10xAL

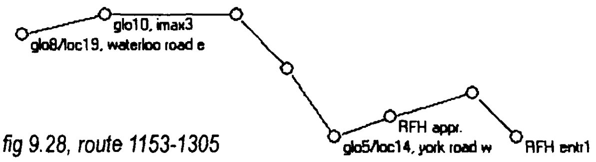

fig 9.28, route 1153-1305

tab 9.15 three routes from RFH (1153) to Waterloo Bridge (1338); depth: 6/5/6

connected axial lines	1153	1301	1328	1259	1258	1310	1338
	QPR	RFH entrance1	RNT	5xAL	6xAL	2xAL	BI 03
	3xAL	RFH entrance2	RFT				7xAL
		QPR	6xAL				
		6xAL					

connected axial lines	1153	1301	1210	1215	1311	1338
	QPR	RFH entrance1	QPR	3xAL	3xAL	BI 03
	3xAL	RFH entrance2	7xAL	AL	AL	7xAL
		QPR		AL	AL	
		6xAL				

connected axial lines	1153	1303	1295	1304	1332	1337	1338
	RFH entrance1	RFH entrance3	Tube Waterl. St.	2xAL	IMAX	IMAX	BI 03
	RFH entrance2	8xAL	2xBI 03		3xAL	4xAL	7xAL
	AL		11xAL				

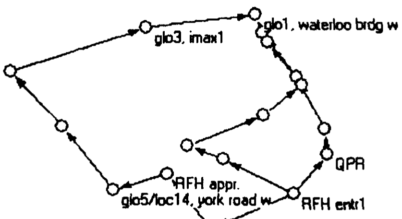

fig 9.29, route 1153-1338

Routes from RFH to transport nodes (tube stations)

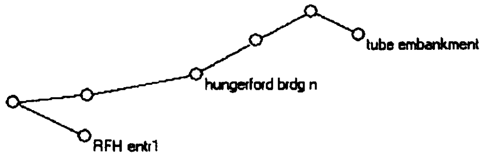

fig 9.30, route 1153-721

tab 9.16 oneroute from RFH (1153)
to Tube Embankment (721); depth: 8

	1144	1301	1279	1237	1026	1041	721
connected axial lines	QPR	RFH entrance1	5xAL	4xAL	2xAL	Tube Embkmnt	RFH entrance1
	3xAL	RFH entrance2				8xAL	RFH entrance2
		QPR					QPR
		6xAL					6xAL

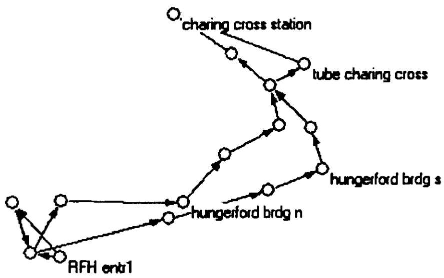

fig 9.31, route 1153-1075

tab 9.17 two routes from RFH (1153)
to Charing Cross Station (1075); depth: 8/8

	1153	1256	1279	1237	1026	1041	1151	1274	1075
connected axial lines	QPR	RFH entrance1	5xAL	4xAL	2xAL	Tube Embnkmnt	Tube Cha.Cross	Charing Cross St.	Tube Cha.Cross
	3xAL	4xAL				8xAL	4xBI 02	5xBI 03	2xAL
							3xBI 03	5xBI 14	
							BI 04	2xBI 17	
							4xBI 14	9xAL	
							2xBI 17		
							5xAL		

	1153	1256	1107	1115	1053	978	1151	898	1075
connected axial lines	QPR	RFH entrance1	2xAL	2xAL	4xAL	4xAL	Tube Cha.Cross	Charing Cross St.	Tube Cha.Cross
	3xAL	4xAL					4xBI 02	5xAL	2xAL
							3xBI 03		
							BI 04		
							4xBI 14		
							2xBI 17		
							5xAL		

fig 9.32, route 1153-1130

tab 9.18 one route from RFH (1153)
to Tube Waterloo Station (1130); depth: 4

	1153	1153	1303	1295	1130
connected axial lines	QPR	Waterloo Station	RFH entrance3	Tube Waterl. St.	AL
	3xAL	8xAL	10xAL	2xBI 03	
				11xAL	

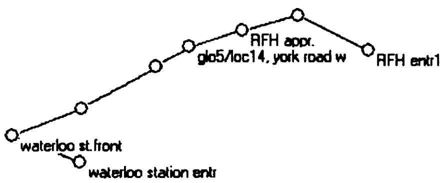

fig 9.33, route 1153-1144

tab 9.19 one route from RFH (1153)
to Waterloo Station (1144); depth: 7

	1153	1301	1303	1295	1163	1106	1247	1144
connected axial lines	QPR	RFH entrance1	RFH entrance3	Tube Waterl. St.	2xAL	3xAL	Waterloo Station	Waterl. St. Hall
	3xAL	RFH entrance2	8xAL	2xBI 03			8xAL	Waterl. St. Front
		QPR		BI 03				4xAL
		6xAL		11xAL				

Routes from RFH to to-movement lines

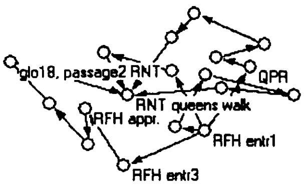

fig 9.34, route 1153-1330

tab 9.20 three routes from RFH (1153)
to Queen´s Walk RNT (1330); depths: 6/3/7/4

	1153	1154	1210	1200	1258	1259	1330
connected axial lines	QPR	RFH entrance1	QPR	HWD Art Gallery	6xAL	Queen's W. RNT	RNT
	3xAL	RFH entrance2	5xAL	4xAL		4xAL	RFT
		2xAL					BI 03
							9xAL

	1153	1301	1328	1330
connected axial lines	QPR	RFH entrance1	RNT	RNT
	3xAL	RFH entrance2	RFT	RFT
		QPR	Queen's W. RNT	BI 03
		6xAL	5xAL	9xAL

	1153	1301	1210	1200	1258	1324	1285	1330
connected axial lines	QPR	RFH entrance1	QPR	HWD Art Gallery	6xAL	7xAL	Queen's W. RNT	RNT
	3xAL	RFH entrance2	5xAL	4xAL			4xAL	RFT
		QPR						BI 03
		6xAL						9xAL

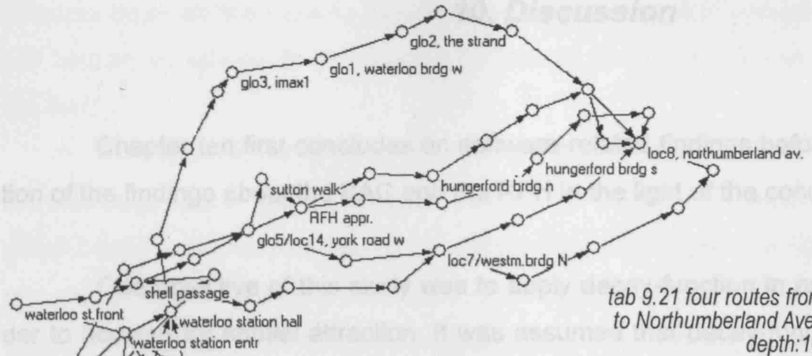

fig 9.35, routes 1144-1024

tab 9.21 four routes from Waterloo Station (1144) to Northumberland Avenue, Westminster (1024); depth:10/13/13/10

	1144	1243	1271	1317	1337	1338	1327	1290	1218	1199	1024
connected axial lines	2xBI 03	Waterl. St. Hall	2xAL	2xAL	IMAX	2xBI 03	5xBI 03	Embank-ment Gar	4xALAL	7xAL	3xBI 03
	7xAL	AL			4xAL		BI 04	7xAL			11xAL
							2xBI 08				
							BI 14				
							9xAL				

	1144	1247	1106	1163	1295	1294	1303	1256	1107	1115	1053	979	858	1024
connected axial lines	2xBI 03	Waterl. Station	3xAL	2xAL	Tube Waterl. St	6xAL	RFH Entrance3	RFH entrance1	2xAL	2xAL	4xAL	4xBI 03	7xAL	3xBI 03
	7xAL	8xAL			2xBI 03		8xAL	4xAL				BI 17		11xAL
					11xAL							10xAL		

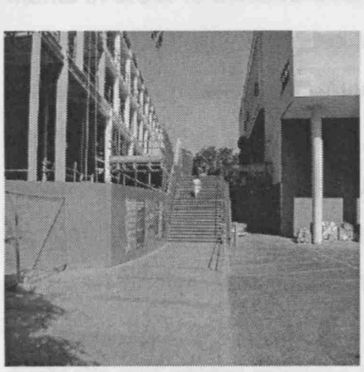

fig 9.36, RFH approach

	1144	1247	1106	1163	1295	1294	1303	1256	1279	1273	1026	1041	1199	1024
connected axial lines	2xBI 03	Waterl Station	3xAL	2xAL	Tube Waterl. St	6xAL	RFH Entrance3	RFH entrance1	5xAL	4xAL	2xAL	Tube Embnkmnt	7xAL	3xBI 03
	7xAL	8xAL			2xBI 03		8xAL	4xAL				7xAL		11xAL
					11xAL									

	1144	1247	1261	1325	1291	1277	1132	1236	1086	1011	1024
connected axial lines	2xBI 03	Waterl. Station	BI 01	4xAL	3xAL	Jubilee Garden	4xAL	BI 01	2xBI 01	8xAL	3xBI 03
	7xAL	8xAL	3xBI 03			5xAL		BI 03	8xAL		11xAL
			BI 07					BI 19			
			7xAL					Tube Westmnstr			
								10xAL			

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Routes between local-attractors

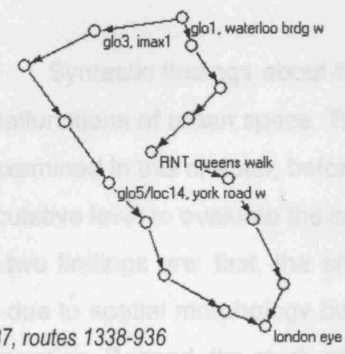

fig 9.37, routes 1338-936

tab 9.22 two routes from Waterloo Bridge (1338) to London Eye (936); depth: 8/8

	1338	1337	1332	1304	1295	1234	1084	983	936
connected axial lines	2xBI 03	IMAX	IMAX	2xAL	Tube Waterl. St	BI 03	BI 10	London Eye	BI 10
	7xAL	4xAL	3xAL		2xBI 03	4xAL	2xAL	BI 10	2xAL
					11xAL			2xAL	

	1338	1310	1258	1259	1330	1296	1262	1190	936
connected axial lines	2xBI 03	2xAL	6xAL	Queen's W. RNT	RNT	Festival Pier	BI 10	London Eye	BI 10
	7xAL			4xAL	RFT	Queen's W. RNT	3xAL	9xAL	2xAL
					BI 03	4xAL			
					9xAL				

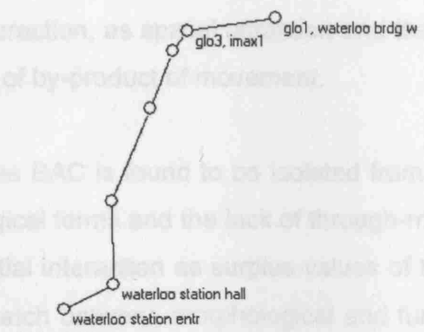

fig 9.38, route 1144-1338

tab 9.22 two routes from Waterloo Bridge (1338) to Waterloo Station (1144); depth: 8/8

	1338	1337	1332	1304	1295	1163	1106	1247	1144
connected axial lines	2xBI 03	IMAX	IMAX	2xAL	Tube Waterl. St.	2xAL	3xAL	Waterloo Station	Waterl. St. Hall
	7xAL	4xAL	3xAL		2xBI 03			8xAL	Waterl. St. Front
					11xAL				4xAL

10. Discussion

Chapter ten first concludes on software-related findings before it switches to an evaluation of the findings about the BAC and the RFH in the light of the concept of the by-product..

One objective of this study was to apply decay-function in processing axial maps in order to account for spatial attraction. It was assumed that decay-function might produce slightly different results than traditional integration-measures due its incorporation of distance-decay in the calculation of the graph. However, the results show a strong correlation between the decay and integration. This thesis would have produced very similar results if it had applied integration-measures instead of decay-measures. A lot of work is needed to produce more precise experiments in order to achieve a refined understanding of distance-decay function.

This thesis was also testing Pajek, a graph-software originally developed in social sciences. Local urban areas have been both visualised and analysed using various functions in Pajek. The overall contribution towards urban studies seems to lie particularly in Pajek's ability to visualise large graphs as clusters. An energy layout, the Kamada-Kawai algorithm, was used to represent attracting and repulsive forces due to the graph-theoretical position of nodes. This allowed an intuitive understanding of spatial attraction of the whole graph. But since this energy layout loses the precise mapping of axial lines onto morphological forms, it becomes difficult to read syntactic and spatial relations in detail. Finally, syntactic measures were found which correspond with Space Syntax measures: betweenness resembles decay-factor 1.001 (through-movement value; choice), centres resembles decay-factor 4 (to-movement value; local integration). Many more functions are available and remain to be explored.

Syntactic findings about the BAC and the RFH have been evaluated so far as evidence of malfunctions of urban space. Two main findings about spatial attraction versus by-product will be examined in this chapter, before chapter eleven shifts the emphasis onto a more abstract and speculative level to evaluate the impact of the findings on the performance of the urban grid itself. The two findings are: first, the analysis of the BAC mainly reveals that spatial attraction is not only due to spatial morphology but also due to transpatial attraction which can overcome spatial segregation. Second, the study of the RFH shows that proximity does not necessarily guarantee spatial interaction, as spatial attraction and the layout of interfaces determine spatial interaction by means of by-product of movement.

The BAC is found to be isolated from any by-product of movement due to segregating morphological forms and the lack of through-movement. Routes from and to the BAC are not offering spatial interaction as surplus-values of trips to the BAC, as shown in chapter 9. Because of a mismatch between morphological and functional layout of both the BAC and the Barbican complex those routes have to be supported by the navigation-system of the yellow line[10] which can be conceptualised of a necessary transpatial component to mentally and physically access the BAC.

Asking, what the BAC contributes to the performance of the urban grid as a machine to communicate space, it can be stated, that it is the residential premises of the Barbican complex which benefit most from having a cultural venue in close spatial proximity. The BAC itself has to rely on transpatial means of promotion, but it can, on the other hand, be speculated that an art venue might benefit from a slightly remote position towards the by-product of urban space, since art in general needs some distance to contemplate. Thus, it is mostly urban space itself which faces a disadvantage: the BAC´s does not offer interfaces to maximise effects of the by-product for surrounding movement flows. To local urban space, the BAC, as a venue of higher cultural interest, remains virtual - almost not existing.

The RFH is embedded in an urban context surrounded by movement-flows which it is to a large degree not interacting with. The findings imply an oversupply of axial lines in combination with an underperformance of building interfaces resulting in a general separation of movement-flows. Both routes to through-movement lines and some significant through-movement lines themselves were found to be poorly constituted. If the activeness of interfaces furthermore depends on specific time slots, like for cultural venues, co-presence on single routes can happen to be largely diminished.

In spite of important local attractors on site, locations on the South Bank and the area in front of Waterloo Station hence remain disconnected from each other and from global through-movement. Their contribution to maximise effects of the by-product of movement is limited. This finding, in reverse, emphasizes on the importance of through-movement to attract co-presence to maximise by-product effects.

10 Continuous lines are drawn on the ground of the Barbican complex as a navigation system to facilitate wayfinding from gates into the Barbican complex to the BAC - see chapter 5.

11. Conclusion

This thesis was investigating the of role spatial attraction as a driver to create surplus-values for trips through urban space. It further asked for its implications on both local attractor buildings and the overall performance of the urban grid as a communicator of space.

The analyses of the BAC and the RFH and its findings imply parallel existence of two distinct kind of attraction in urban space. Spatial attraction, on the one hand, is governed by the configuration of the grid and relies thus on the by-product of movement - it attracts through-movement seeking spaces. Transpatial attraction, on the other hand, is governed by land use activities with their intrinsic social categories to overcome spatial segregation across space. It does not necessarily rely on through-movement and addresses thus less movement-seeking spaces, like the BAC or the RFH for example. However, both mechanisms overlay in real urban space.

Overall, both kinds of attraction seem to have very different implications on the performance of the urban grid as a communicator of space. Spatial attraction arises as through-movement through passages of more integrated spaces which are chosen to move from origin *a* to destination *b* (by-product). These passages were found to have more potential for spatial interaction. Although they are determined to a large degree by the global structure of the grid when taken to the aggregate level, these spaces passed through nevertheless can change with every different destination chosen (Hillier 1996, Space is the Machine). This results in the unique way by which urban space is communicating itself: it is fast (vivid), powerful (economical), reliable (physical) and manifold (new combinations). Coincidence plays a crucial role in possibly generating unplanned encounter. It is speculated that this unique way to communicate space is the surplus-value of trips through urban space.

In opposition, transpatial attraction globally generates movement across space as well. But since it does not rely on through-movement, its locations were found to step back into more or less remote syntactic locations within the configuration of the urban grid. Depending on the ability to attract movement, they can be located even at the end of parts of the graph-structure of urban space, like the BAC does. Consequently, it was found that promoting physical interfaces are not vital - they might be absent to the by-product effects at all. Information to communicate transpatial places seems to depend more on non-spatial means, like promotion or membership of social categories. Spatial interaction becomes more planned and less spontaneous.

Whereas this thesis was originally looking at the BAC´s and the RFH´s malfunctions to research spatial attraction versus the role of by-product, the comparison with transpatial attraction was found impossible to be excluded. Their duality allows to speculate about the urban grid as a unique means to communicate space - this represents the overall finding of this thesis. More work would be needed to explore and describe more carefully how transpatial attraction contributes to the urban grid as a means to communicate space. This thesis can only speculate about its impact, but it can connect here to the whole subject of transpatiality as known in Space Syntax literature.

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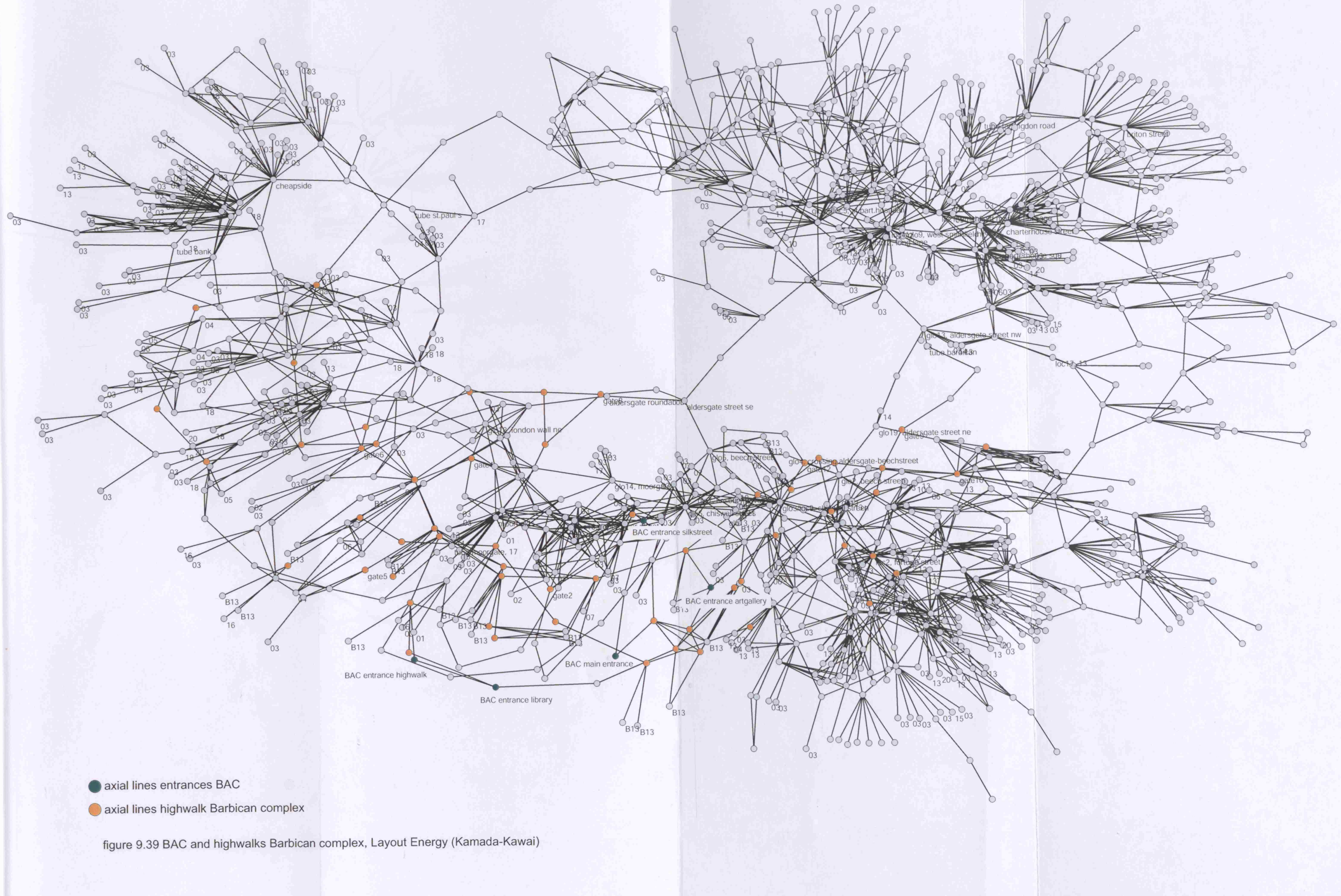

figure 9.39 BAC and highwalks Barbican complex, Layout Energy (Kamada-Kawai)

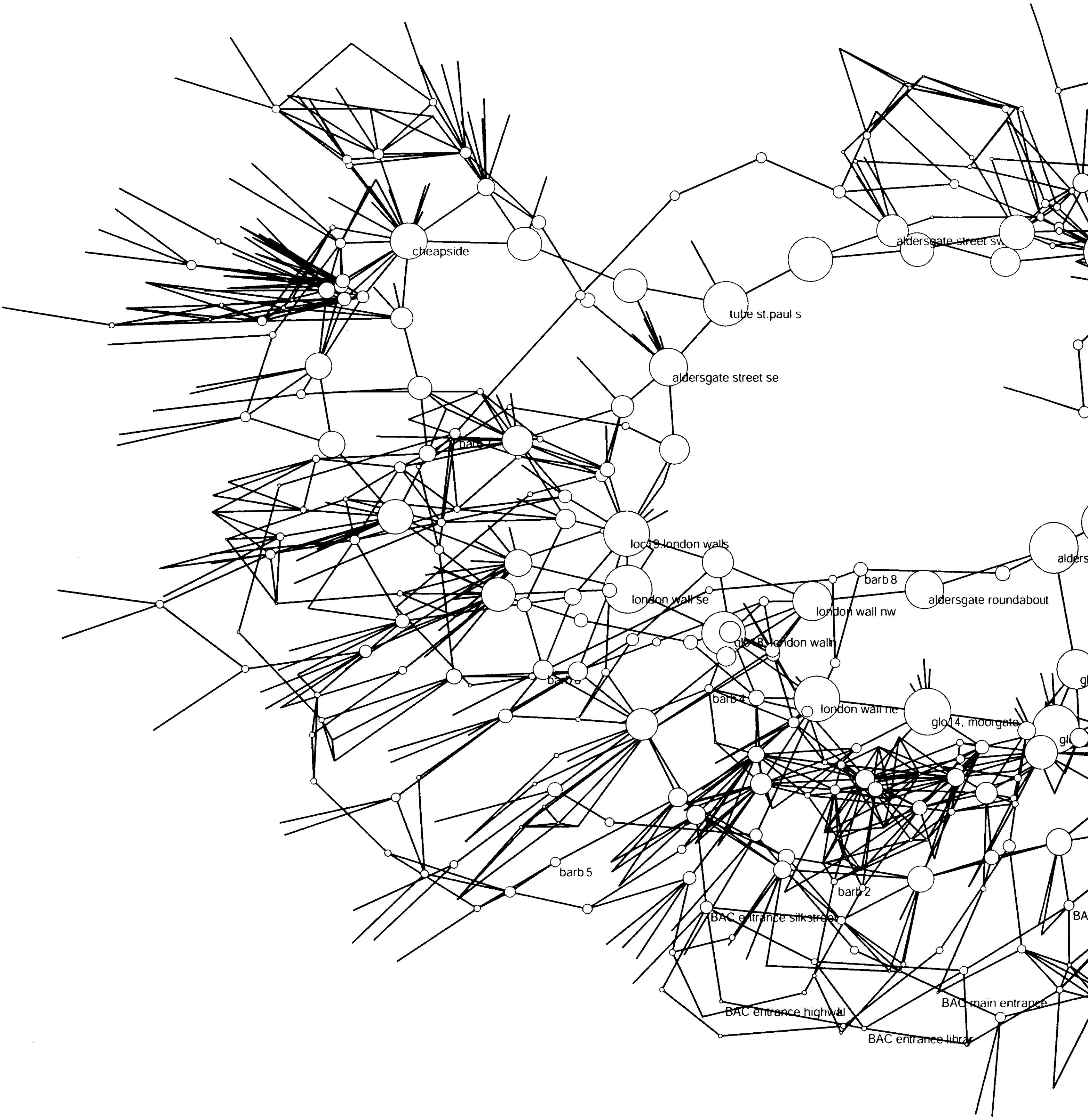

figure 9.40 BAC, Betweenness, Layout Energy (Kamada-Kawai)

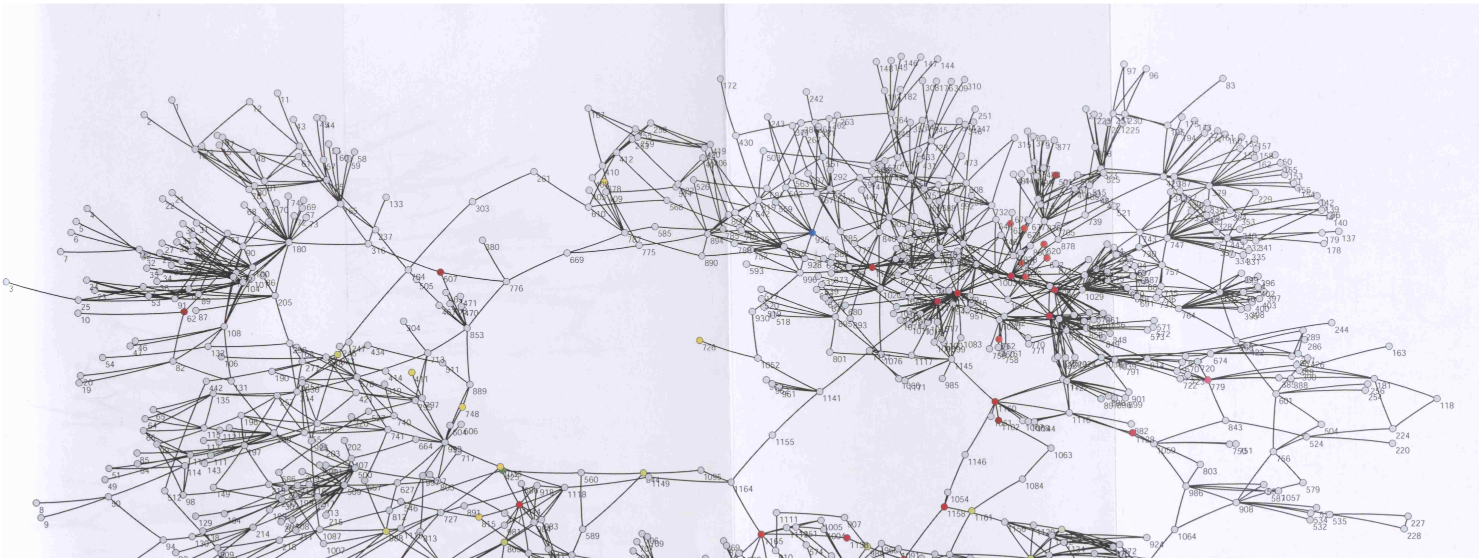

figure 9.41 BAC, ID-numbers od nodes, Layout Energy (Kamada-Kawai)

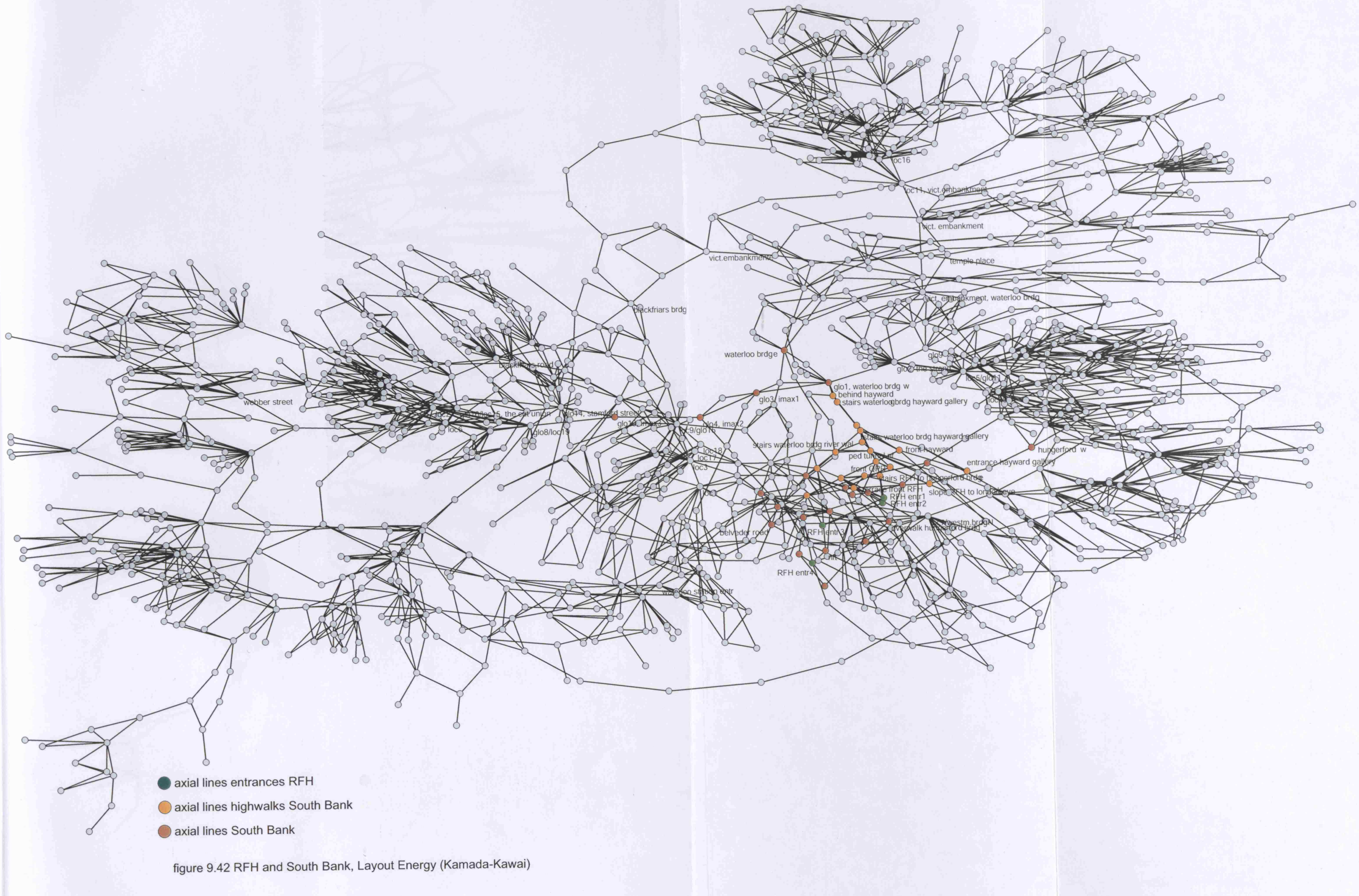

figure 9.42 RFH and South Bank, Layout Energy (Kamada-Kawai)

figure 9.43 RFH, Betweenness, Layout Energy (Kamada-Kawai)

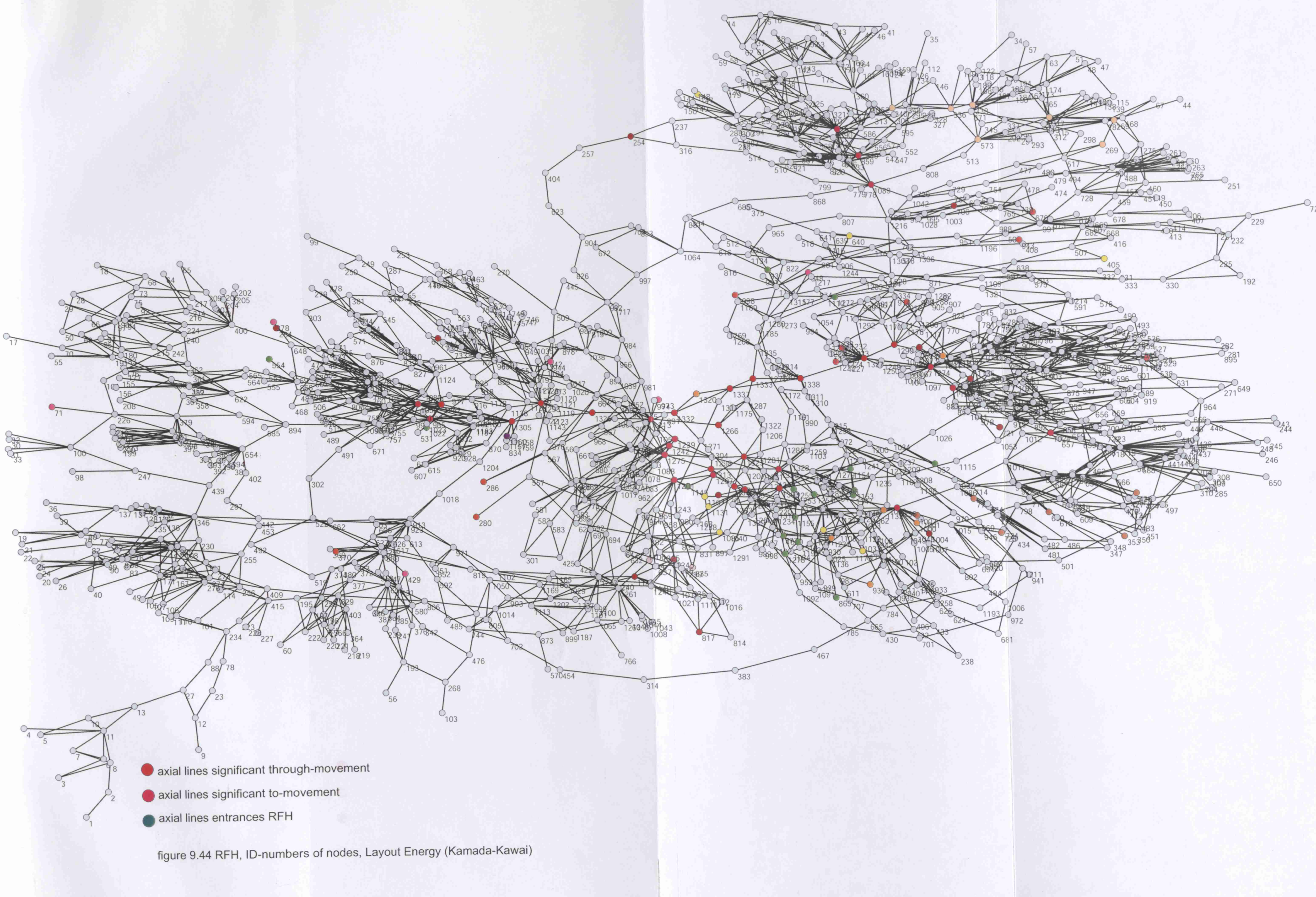

figure 9.44 RFH, ID-numbers of nodes, Layout Energy (Kamada-Kawai)