Using space syntax to regenerate the historic centre of Jeddah

or why we need architectural models of whole cities

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• My presentation today is about how we can use a new architectural technique called space syntax, invented at University College London and exploited by its spin-out company, Space Syntax Limited, to masterplan the regeneration of the declining historic city centre of Jeddah in Saudi Arabia.

• The technique integrates architecture, urban design, planning and transport planning in a unique and powerful way.

• I have two core arguments.

• The first is that you cannot separate the problem of the historic city centre from its much larger context, and even from the structure of the whole city. The centre is a multi-scale.

• The second is that we need architectural techniques – that is, spatial and physical design techniques - at the larger urban scale we normally associate with planning, if we are to solve problems like these.
The form of the presentation will be that we will:

- first explain the space syntax technique, and how it has given rise to

- a new theory of the city as a **self-organising** system, which we call the **city creating process**

- and a new conception of the **good city**

- then explain how the technique can be used to resolve a **multi-scale problem** such as the historic city centre of Jeddah.
Space syntax is about going from this... to this...

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What is space syntax? It starts with the **spatial architecture** of the city.

Cities are large collections of buildings held together by a **network of space**: the street network. The network is the largest thing in the city. It is what holds it together. It has an **architecture**, that is a certain **geometry** and **topology**, that is, a certain pattern of connections.
Urban models were planning based and **back-grounded** the network.

In the past, little attention has been paid to this network by theory or research, because nobody knew how. Urban models, for example, have taken a planning view and divided the city up into areas to analyse it.

Such models have their uses but they are **insensitive to the architectural level** at which decisions are taken in real projects.

And they led traffic engineers to believe, and us to be persuaded, that **movement was independent of place** – perhaps the cardinal C20 error.
Space syntax is an *architectural* approach to modelling cities.

Space syntax is a new *architectural* way of modelling cities, for both research and design, by looking *first* at the architecture of the street network.

It starts at the level of the *segment of the street* between junctions and uses some simple mathematics to analyse its *geometry* and *topology* and to establish what *movement* each segment would carry if people moved from all parts of the grid to all others.

It measures these *movement potentials* for different *scales of movement*, from local to global, and makes different assumptions about how people judge *distances* in selecting routes and destinations. So it gives us a rich matrix of network measures to *structure* explore and *function* in cities.
The analysis identifies **structures**, global and local, in the space network.

The analysis identifies different kinds of **structures**, global and local, in the network, and makes them visible by colouring segments **red** for high movement potentials through to **blue** for low.

On the left we see the movement potentials of each of the 285,000 segments of London within the M25 for **large scale movement**. It predicts the real main movement arteries.

On the right we see a much finer-scale structure for **local movement** potentials up to 750m. The red pattern you see is essentially London’s ‘urban villages’ and the links between them.
A new discovery: the architecture of the network shapes movement

This ‘network first’ approach has led to a key discovery about cities: that in and of itself the architecture of the network shapes movement flows. Research shows that between 60% and 80% of the movement flows on streets are due to the structure of the network, that is to the potential flows identified mathematically.

This does not mean that space determines individual movement. It means that if people go under their own volition from everywhere to everywhere else, some spaces get more used than others.

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The grid-movement relation is the key to *self-organisation* in cities

- But by examining real movement patterns in cities, we have shown that people move by reading the *angular geometry* of the network, not actual metric distances.

- This means we can approximate movement potentials from the *architecture of the network* and of course for *new designs* inserted into the network.

- But, more importantly, once the influence of the grid on movement is understood it opens then way for a new theoretical understanding of the city as a self-organising system through what we call the *city-creating process*. 
Self-organisation works through a generic *city-creating process*

It works like this. Because the network structure shapes flows, it also shapes land use patterns, in that *movement-seeking* land uses seek locations that the grid has already made *movement-rich*, while others, often including residences, migrate to less-movement rich parts of the network. Economic values follow this process. With *feedback* and *multiplier effects* – once one shop appears, others follow – this is the fundamental ‘*city creating process*’ by which cities evolves from collections of buildings to living cities, with busy and quiet zones, often in close juxtaposition, and with differentiation of areas according to the detail of how they are embedded in the larger scale grid.
A new definition of the good city: the city of pervasive centrality

This leads us to a new definition of the spatial form of cities. Cities in general – and not just ‘organic’ cities – self-evolve into a foreground network of linked centres at all scales, from a couple of shops and a café through to whole sub-cities, set into a background network of largely residential space.

Good cities, we suggest, have pervasive centrality in that centrality functions diffuse throughout the network. The pattern is far more complex than envisaged in theories of polycentrality. Pervasive centrality is spatially sustainable because it means that wherever you are you are close to a small centre and not far from a much larger one.
So, what can a space syntax model do?

A space syntax model of a city gives you:

- a way of **researching site and context** to establish existing dynamics
- a means of approximating **movement** patterns at the **design** stage
- a theory capable of building the **city-creating process** into design.

And above all perhaps:

- a way of **working across scales** from local to global with the same tool
- a way of **integrating data** of all kinds into a functionally intelligent model for the city.

**FURTHER READING**
Hillier & Iida 2005
*Network and psychological effects in urban movement* (.pdf version 1.2 MB)
The **city-creating process** in action

So let me persuade you that this all makes sense and that we are identifying **meaningful structures** in the urban grid by looking at Jeddah.

Above left we see one of the unplanned areas of Jeddah with all the **shops** marked in **red**, clearly the result of the kind of process we have described. On the right we see one of our spatial measures of **movement potential** – essentially it measures **passing trade** potentials using **least angle change** routes – calculated up to a radius or 2.5 kilometres, so only allowing for trips up to this length.

The agreement between the two patterns is not quite perfect, but it is **remarkable**.
Applying the method and theory in design

So this is the method and the theory. How can we apply all this in design?

Essentially, the procedure is this:

- we build a model of the site and its context, usually the whole city these days

- we test the model against existing movement flows and land use patterns

- we can then use the verified model to test out designs by inserted them into the model and re-running the analysis,

- and suggest new design ideas from the analysis.
The case study  **Reversing the decline of Jeddah’s historic centre**

So now let us look at our case study: how to reverse the decline of the historic centre of Jeddah.

Our aim is to show how we can use space syntax modelling

- to **clarify design** and planning problems

- to make design intuitions into **testable propositions**

- to show how different aspects of the city – building conditions, densities and so on **inter-relate** to each other and to space

- to show how critical the **interdependence of scales** is in this case.
Solving spatial problems first

We cannot do justice to this large and complex study in a few minutes, so my aim is to show how the syntax method can be used:

- to solve the spatial connection problems that contribute much to the current decline of the historic centre

- to show how other hard factors (land uses and densities) and soft factors (surface treatments, addition of markers to spaces) can be related to the spatial issues

and so generate an overall, more synthetic and evidence-based approach to design.
The Historic Core is the oldest part of the City of Jeddah and represents the nucleus of development for the entire city.

Jeddah thrived as an important crossroads of major sea and land routes, including routes linking the port to Madinah and the Holy City of Makkah.
In addition to its remarkable historic and cultural assets, the modern day historic core is surrounded by a combination of prime developable land and dense, unplanned settlements — so a classic problem for design and planning to combine sensitivity to history with future needs and pressing social problems.
60 years ago the centre was a kilometre across.
Since then, rapid urban expansion means the city is now 51 kilometres from north to south.

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As the city expanded over time it was driven by two competing forces, **radial growth** around the historic core and **linear growth** along the Makkah and Madinah Roads.
In the 1960s and 1970s, car driven growth along the Makkah and Madinah corridors outstripped radial growth around the centre. The first Jeddah International Airport acted as an **barrier to growth** in the north eastern direction.

Major ring roads were introduced during this period that pierced the increasingly dense unplanned areas to the east and south of the historic core. As these settlements grew denser and more impoverished, they began to act as a **barrier to growth** and investment, which only increased the incentive to develop to the north and east.
Unplanned settlements are mixed-use and have an internal structure.

At the same time, the unplanned areas around the historic centre have a remarkable blend of mixed land uses, including some of the highest residential densities in Jeddah - nearly 500 people per hectare - and as we will see, each has a strong internal structure.
Progressive spatial isolation of the centre with growth

The historic core is close to the key routes, the Makkah Road & Madinah Road. But they bypass it and leave it as a relatively isolated area in the centre of Jeddah. This level of isolation in the centre is quite unusual for such a central area in the city.
The current spatial isolation of the centre

Zooming in, the figure to the left clearly demonstrates the structural segregation of the historic core from its surroundings.

This can be seen in the dense concentration of green and blue lines in the area, which represent streets that are more difficult to get to and less likely to be passed through, and so less integrated into the network than those coloured in red or orange.

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Effects of growth on the centre show former plans are unsustainable

We can show the structural isolation of the historic centre in two more ways. First we analyse the whole structure of Jeddah as it has evolved. We see the ‘integration core’ of Jeddah has moved to the north and east of the old centre, which is now a green patch rather than a focus of red and orange lines.

We then expand the analysis to include all current plans for extending the city. And re-run the analysis. We see that the structure of the city has moved even more decisively north and east and the old centre has become blue as well as green. In other word, current plans will exacerbate the structural problems of the city.
We can show this dramatically by colouring up all the street segments in Jeddah according to how much urban integration each gains by the planned new developments.

Red means high. We see that all the gains are away from the old centre, and none are in the centre itself. The plans would make the structural problems of the city worse rather than better.
The centre becomes weaker as the scale of context increases.

At 400m we see a pattern of centres and sub-centres.

At 2000m the centre appears but not the sub-centres.

We can see how the structure of the core changes with increasing radius.

At 10,000m east-west links fade.

At 400m a complex of centres and sub-centres.

At 2,000m only the main centre.

At 10,000m the east-west links fade and, for the whole of Jeddah, even the north-south line fades.
So the problems of the centre are **glocal** not local.

So the problems of the centre are rooted in history, but they are **structural**—and space syntax enables us to see how they are so. We have also seen that the old centre has a structure, but it has become **over-localised** and disconnected from the city. The task then is not so much to re-design the old centre as to **reconnect** it.

So the problem of the old centre is linked to two other key planning aims of the Jeddah authority: - to **re-integrate the unplanned settlements** into the urban and social structure of the city; and - the **development of key adjacent sites**, such as the harbour, the waterfront area and the old airport.
The unplanned settlements have good internal, but not external, structures

So what might we mean by aiming to re-integrate the unplanned settlements into the urban structure?

If we analyse them syntactically, we find that although at the global scale each forms a relatively isolated patch in the urban structure, if we analyse them locally, we find in all cases that the settlements have strong internal structures which relate well to patterns of public activity and land use— as we saw in the example we showed.

This can provide our starting point.
Using syntax to re-integrate settlements while preserving internal structures

We start with the existing local structures in each settlement and first improve their connection to the links to the larger scale network. We then relate these links to the larger scale network. We use space syntax simulation at every stage to check the effects of each step.

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Linking space to other factors

We can also use the space syntax model to relate non-spatial factors, such as **building condition**, which we call the ‘Transformability Index’, the provision and quality of **public space**, which we call the Public Realm Index, and the availability of **utilities and services**, which we call the Utilities Index.

By building these into the syntax model, all these factors can be **integrated** into the design process. For example, there is often a choice between two alternative reconnection or road widenings, and this allows us to take the option with the **least economic and social cost**.

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Adapting the network

We can then transform selected local alignments to form a network of larger scale streets, which both connect to the main entry points of the old city but also form a secondary network to link the unplanned settlements to each other.

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Linking space structure to land use patterns

And we can use our knowledge, including the local knowledge we acquired during the analysis phase, of the interdependence of land uses and space structure to assign land uses to the new network. Much of this will happen, of course, after the initial changes are made to the network though the city creating process..

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The syntactic values which approximate likely movement rates and establish the relative importance of each alignment at different scales can also be used to govern **building heights and densities**. This will establish a relation between building heights and public activity in each space, and this in turn will enhance public activity.

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Adding a new transport structure to the adapted network

We can also support this with a new public transport network, designed to enhance the new street network.

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Redevelopment of the old airport site

We must also take the old city into account in developing the 1200 hectare old airport site as a new central business district. How to develop the old and new cities so they work symbiotically?

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The syntax analysis suggests a key new linkage

Again the space syntax analysis suggests an opportunity in the form of an existing alignment potentially linking the heart of the new Central Business District (CBD) with a major public space on the edge of the historic core.

Spatial Accessibility
- high (1.00)
- medium (0.50)
- low (0.00)
The new ‘Jeddah Boulevard’

This concept then became the guiding idea for the whole new CBD development: Jeddah Boulevard

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Spatial Accessibility
- high (1.00)
- medium (0.50)
- low (0.00)
The plan for the new CBD was then developed around this core idea.

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Again scaling architecture to the syntactic importance of alignments

With architecture that reflects the syntactic power of the new alignments.

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Similarly, the relation to the historic city defined to approach to the development of the Waterfront Area of 500 hectares.
Syntax identifies key new linkages to the historic centre and other adjacent areas.

Critical were new bridges, including a pedestrian bridge, in locations which the syntax analysis suggested would optimise their use and so form key linkages between the areas.
Adapting the historic centre for the new structure: new public space around the edges

With these redesigns of the contextual areas, the historic core could then be adapted spatially to optimise their effect. This involves relatively minor physical and spatial interventions.

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Adapting the historic centre for the new structure transition to shared space roads within the core

There are important opportunities to enhance the quality of life in the historic centre through creation of new public space around the historic centre. Again, syntactic techniques allows us to diagnose where this will be most successful, and exactly how it should be done.

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Adapting the historic centre for the new structure: re-integrating Al Bay’ah Square

And it includes the redesign of a major public space, the Al-Bayiah square on the northern fringe of the historic core, using the syntactic principles that were used in the UK for the re-design of Trafalgar Square and Nottingham Market Square—both immensely successful spatial redesigns of major public spaces.

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The historic centre in its new context: the glocal view

Existing

Space syntax analysis shows that the entire central area of Jeddah will be strongly re-integrated, if the development of the unplanned settlements and the development sites are implemented along the strategic guidelines proposed by this study.

New plan

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The analysis also shows that if the transformation of the central area is combined with careful planning of the wider area of Jeddah, the whole **structure of the city** will be drawn back from the east and north towards the historic centre. At the same time, the patches of unplanned settlement will become more **integrated** into the urban fabric.
Summary

- Space syntax is then a new space-based and evidence-based way of bringing architecture, urban design, planning and transport planning together in what people are beginning to call strategic urban design, meaning urban design that works across scales, from the micro to the macro.

- We have also shown how the modelling technique can be used to integrate different factors into spatial design in a rigorous way.

- But most of all it allows us to design in such a way as to go with the flow of the city creating processes which are the real sources of the life of cities.

- This is because the model is based on a theory of the city which can be tested against the hard evidence of observable urban functioning.

- So let evidence-based design also be theory-based design – and let our theories in future be testable theories.