Using Space Syntax to understand multi-layer, high-density urban environments:

What can be done by other means on a syntactic issue using space syntax theories but prior to a full study using the methods

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Abstract
Adopting the empirical attitude of Space Syntax, a set of environments were observed and discussed in the light of the conclusions from Space Syntax theory and literature reviews. Based on this, the author suggests a way to use Space Syntax for analysing Multi Layer High Density Urban Environments (MLHDUE).

Most MLHDUE are considered dismal failures. How may one adapt Space Syntax to provide useful analysis of MLHDUE? How may one create useful design feedback to ameliorate this reality? Case studies show that in multi layer environments the commodity in short supply is the continuity on the pervasive layer, or in other words: Who gets priority on ground and who is exiled to other levels? Projection of the public realm on to auxiliary layers tends to reproduce social structures.

Case studies seem to support the hypothesis proposed. A successful move to expand the public realm into the third dimension may be part of the grid intensification process resulting from the essential urban dynamic suggested by Hillier, therefore governed by similar phenomena. A successful MLHDUE needs one main integrating layer mixing different types of movement. Secondary layers may be relatively more specialised and segregated. The research suggests slight adjustments to contemporary space syntax practice and specific case studies to examine.

Keywords
density urban environments, wayfinding, urban design, skyways

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1. Introduction

Most High Density Multi Layered Urban Environments (MLHDUE) are considered dismal failures. Most spaces in MLHDUE are highly specialised, and lack through-movement. Most people feel they lose their bearings as soon as they set foot in MLHDUE. So far there were difficulties using Space Syntax to predict performance of MLHDUE. How can one create useful design feedback to ameliorate this reality? Space Syntax is a theory and set of tools associating architectural or spatial variables to social behaviour, in a way that can better help research and consequent action.

The purpose of this phase of the research was to refine a research question regarding the incorporation of MLHDUE in the city. Literature that sheds light on existing and theoretical MLHDUE was examined. Most of the literature was based on empirical research.

How may one adapt Space Syntax to useful analysis of MLHDUE? Space Syntax provides a theoretical foundation for empirical analysis of the way urban space is used. Adopting the empirical attitude of Space Syntax, a set of environments were observed and discussed in the light of the conclusions from Space Syntax and the general literature reviewed. Based on the reviews and the case studies, the author suggests a way to use Space Syntax for analysing MLHDUE. The aim of this phase is to prepare the foundation for further syntactic research.

At the outset of the research the author hypothesised that a successful MLHDUE needs one main integrating layer (local and global) that mixes different types of movement. Secondary layers may be relatively more specialised and segregated, depending on their uses. The secondary hypothesis was whether or not there is a role for the essential urban dynamic, relating land use to patters of movement. Following this understanding, MLHDUE can be analysed and movement patterns anticipated by using contemporary Space Syntax practices, mainly regarding the city as 'two dimensional'.

2. Proposed adaptation of Space Syntax practices to MLHDUE

What are the implications of the Space Syntax literature reviewed for MLHDUE? This section sumerises the author’s conclusions derived from extensive study of Space Syntax literature. The conclusions start with overall ideas about the urban process and continue with detailed conclusions concerning the modelling of means of ascent.

2.1 Intelligibility and segregation

So far, no MLHDUE was found to be intelligible. What are the implications of this lack of intelligibility on the MLHDUE and their modelling?

From the problems of the Barbican, the South Bank (Penn and Chung, 1998), and the Peach Centre (Rashid, 1997) it is clear that the issue of intelligibility is crucial in multi-layer environments. It is very difficult to perceive this property in an intuitive way. One of the most reoccurring complaints about MLHDUE is the difficulties in finding one’s way. The MLHDUE that the above authors examined seem to have similar characteristics to British social housing estates examined by Hillier and Hanson (1983) and Hillier (1996); namely a multiplicity of segregated

unintelligible axes, with hardly any through movement, in which one can hardly predict movement patterns. To an extent, lack of intelligibility seems to be more of a problem then excessive segregation.

2.2 'Siksna process' in the third dimension

How do the 'centrality as a process' and 'Siksna process' Hillier (1999b) occur in MLHDUE? How can one use these ideas to deduce the evolution of alternative urban layers?

Beyond a certain density of pedestrian movement, it is argued that the 'Siksna process' moves to a second stage creating additional axes thrusting into the third dimension. One may presume that the densification process suggested by Hillier (1999b) can go on to a certain degree spreading horizontally, until it goes beyond the point where the surface can take any more events without auxiliary systems and layers, such as underground transit, traffic, and parking to name a few.

Space Syntax literature demonstrates how 'production cities' struggle to keep the centre 'shallow' so as to sustain the encounter field. One may assume that a city centre cannot reach the threshold of density needed to expand into the third dimension if it has not been previously using above and mainly underground[1] specialised systems, such as underground trains and stations, underground roads and parking, and other 'technical' facilities. Without specialised additional layers the compact centre is in constant danger of accessibility suffocation due to its own success. However, this does not apply to pedestrian circulation[2]. Space Syntax literature analyses pedestrian movement on a more local level and motorist movement on a more global level. Underground trains and roads provide this 'shallowness' of global integration without fragmenting the local movement economy.

The lesson of 'streets in the air', and British Housing Estates, discussed by Hillier (1996)[3], as well as the experience of Bednar (1989), and Pushkarev and Zupan (1975), lead one to conclude that planners should be very careful when determining which situations justify extra pedestrian levels. It is proposed that the conditions for an off-grade axis to succeed are similar to those suggested in the article (Hillier, 1999b), namely becoming part of the densely integrated centre grid.

2.3 Essential urban dynamic

How does the resolution of analysis influence urban development?

Unfortunately in the last sixty years Modernist ideology led to a shift from the street to the enclave as the ordering rule of the city[4]. These tendencies are accentuated in MLHDUEs. Typical Modernist zoning systems attempt to freeze and

pre-control urban development. Many of the uses cannot/ may not /do not respond to movement patterns. Zoning is seldom done vertically or in an axial mode similar to the way the city zones itself[5]. MLHDUE such as the South Bank mentioned by Hillier (1996) are in particular danger of separating different patterns of use in a way that may be detrimental to the 'essential urban dynamic'.

2.4

What are the implications of Space Syntax literature reviewed for modelling multi-layer urban situations?

Penn et al. (1997) suggest that three dimensional analysis may lead to a better understanding, especially of intelligibility in three dimensional environments. They further suggest that once atria, ramps, sloping floors, and complex circulation strategies are used to overcome barriers between floors the conventional axial analysis will no longer be sufficient. The axial map balances between access and visibility. This balance may be severely outbalanced in such environments. However, it is proposed that on an urban scale, application of such techniques may hinder research and be too complex.

The 'Integrated Multi-Layer Circulation Model' (IMCM Penn & Chang 1998) suggests movement rates decrease as vertical distance from the main integrating level increases. It is proposed that in more intelligible environments, the specific use as well as the ascension means of the destination (attractor) on a remote layer, may be more significant. This can be concluded from the high number of people using vertically remote layers in cinema multiplex and food courts.

The origin-destination simplest route calculation used in the IMCM, may be too specific. When considering configuration of three dimensional areas, let alone a second urban layer such as the underground rail system, it is difficult to use the IMCM, since it is geared to unintelligible segregated environments. Even Chang (1998: 229) believes that the joint effect of configuration of the surrounding urban structures and the transition space" were more significant than any other single factor.

Having said that, it is not clear what happens if levels merge, or more than one layer is well integrated into the context, as happens in the case of Stockholm. Following the success of Ida and Nishibori (1997), the author feels that ways should be developed to use a more or less conventional axial map[6]. The authors considered several solutions to represent extensions of the urban surface into the third dimension in axial models.

2.5

Should every escape stair and service corridor be included in an axial model of MLHDUE?

From observation of numerous examples, the massive use by pedestrians clearly shows that if integrated properly, means of ascent can be regarded as part of the urban grid. However often in MLHDUE, the difference between urban/public/private/technical is blurred. It is the author's conclusion that when modelling MLHDUE, one should be careful not to distort the model by including axes, not perceived as part of the public realm. Often, escalators, stairs, ramps, and lifts are removed from the main axis, and not always visible. They often include several directional changes. Doors, gates, and other signs may exclude them from the 'public' realm. All these change the way people use them and make them more segregated, to the point that one should be discriminate about mapping them in an urban axial map. Often MLHDUE confused designers as to what is private and what is public, and they design means of ascent as they are used to designing them in private projects.

2.6 Proposed multi layered axial analysis

Assuming an axial model of MLHDUE is to be built, how should the different means of ascent be represented? How may one model stairs, ramps, lifts, escalators, and travelators in an urban axial model?

Often aesthetic, formal considerations add unnecessary axial changed in-between layers. When considering means of ascent, one needs to examine direction in relation to the more integrated axes. Stairs and lifts usually have changes in direction and this would normally account for the decreased integration. However, in several cases a stairway continuing an axis may be part of it. This assumption is supported by Chung (1998: 216) who proposes that, as a single factor, grade separation was not the most influential on movement rates. However, when grade separation is combined with other factors, such as integration value of the axis it connects, and the way it relates to it, it becomes more significant.

One can calculate a ramp as a normal axis inspecting the sight line spatially rather than on a plane. For instance, a ramp continuing a street without any horizontal turn may well be considered as part of the same axis. These conclusions relate to Pushkarev and Zupan's (1975) recommendation that stairs connecting grade and underground levels be visible at once from both levels. The same goes for escalators and inclined travelators. However, in the case of escalators, the spatial examination

may lead to the creation of an additional axis. In the case of successive escalators, such as at the Centre Pompidu, one should calculate one continuous axis for all escalators.

3. Case study observation method

The fundamental aim of this research is to establish how one may better understand and assist the design of different types of MLHDUE. What are the main issues to be examined? The following paragraphs present the major issues examined in the various environments. The choice of issues to be examined is based on the research assumptions, the literature review, and the need to support or discharge the hypothesis.

3.1

In recent years, the author has conducted observations of all the case studies[7]. Some of them were visited several times in different seasons and times of the day. The author searched for data that would confirm or refute Space Syntax theories, in an attempt to ascertain which method of representation, and, consequently, analyses, best captures the logic of the way that the environments work. In other words, what are the parameters that best capture the particular case and what is the best way to represent and consequently analyse it?

3.1.1 Use

The most important thing that was looked out for was, whether or not people were there. The authors visited most places several times at different times of the day looking for patterns of use. Chronically unused spaces are usually a sign of a problem[8].

3.1.2 Intelligibility

The property of intelligibility is a quantitative one, trying to represent qualitative property. Following the understanding that intelligibility is crucial, the author tried to evaluate his own sense of orientation in the various environments, assuming it may provide an indication of how others may feel.

3.1.3 Multiplier effect

The author searched for the interface of street level elevations. In many of the environments, well integrated axes are faced with blank walls and uses that do not/ cannot/ may not respond to movement patterns. Central control, tenure, and structure, as well as other problems are known to have prevented the multiplier effect in MLHDUE[9]. Signs of the essential urban dynamic were carefully sought. Hillier suggested (‘Centrality as a Process’, 1999b), that some land uses are more sensitive to movement. The author looked out for signs of the ‘Siksna grid intensification process’ and changes in land uses.

3.1.4 How layers meet

A special effort was made to indicate how layers meet and/or are vertically aligned at points. Experienced colleagues tend to read maps as two-dimensional unless a conspicuous element calls their attention to do otherwise. This lacuna is reinforced by the graphical problem of representing more than one layer aligned. This problem becomes more acute as the area described grows, and, consequently, the scale of the plan shrinks. Discreet moves often slip by unnoticed both in drawings and in reality. This leads to association of only the most obvious multi-level elements with the multi-level city.

3.1.5 Ascending /descending

Special attention is given to axes that ascend or descend and their relation to other axes (particularly the main integrating axis of the area), changes of direction, and, last but not least, means of ascension. Chung (1998: 229) proposes that the joint effect of configuration of the surrounding urban structures and the transition space" was more significant than any other single factor.

3.1.6 Integration axis

Karimi (1997) and Hillier (1999b) found that most 'live centre' elements exist in a local compact grid 2-3 axial steps off the main integrating axis. Hillier [10] believes that a shallow core might be a key to the success of MLHDUE. An attempt was made to search for this assumed integration core. The author searched for an assumed main integration axis and for the way other axes relate to it, both locally and globally. When examining the relationship between the assumed main integrating axis and axes crossing it, the author was particularly interested in similarities with areas and phenomena described in the article 'Centrality as a Process' (Hillier, 1999b). When describing other axes, the number of axial steps off the assumed main integration axis was counted.

Figure 1: Axial map of Central Stockholm. (The red line marks the assumed integration axis, Drottingatan. The orange lines are one step away the yellow lines are two steps and the green line are three steps away. The black dotted lines mark the Tunelban and the grey doted line marks an underground road.)

3.2

The Proposed Multi layered Axial Analyses was referenced in the case studies. However, these proposals were neither tested nor confirmed. Furthermore, all assumptions about intelligibility, integration axes, integration cores, etc' were based on intuition. They should be tested by comparison of axial map analysis with movement rates and other phenomena observed. This was, however, beyond the scope of this phase and may be the subject of further research stages.

In brief most of the research effort was dedicated to case studies using the preliminary research strategy of space syntax. Namely to use the theory ideas and findings flexibly, in a search for structure in spaces investigated. This was done with an eye to the observed function of space, trying to link theory with reality. Following the initial observation, an attempt to find a spatial representation that captures the functional logic of the spatial system was made. This was done with further research in mind.

4. Discussion

What conclusions can be drawn from the case studies and the background literature regarding presented in the previous chapters?

This section offers a comparison of the different case studies using the theoretical background and the framework of the research question. The section begins with an overview of the case studies and their findings on the relative success of MLHDUE. A comparison of concourse and skyway systems was made with a view toward their possible axial analysis vis a vis social performance. This serves as a backdrop for review of the more successful instances of MLHDUE, analysing their common successes and drawbacks. The section ends by posing further research questions.

As one seeks feedback for the design of future MLHDUE, one must ask oneself with regard to each instance considered whether it works. Since this phase of the research depends on qualitative rather than quantitative research, the tools used for assessment were based on observation and impression. The areas were observed under the fundamental assumption that good space is used space. Conversely, chronically unused space may be a sign of a problem.

4.1

How can we use Space Syntax theory and tools to provide feedback for MLHDUE or to predict patterns of use in MLHDUE? In the previous sections, the author has proposed several amendments to traditional axial models, in order to enable the

analysis of multi-layered environments (see section 2.6). However, analysis of the case studies leaves several questions open as to possible implementation and further Space Syntax analysis of MLHDUE.

Most pervasive North American off-grade systems (skyways and/or concourses) are economically successful. Rents on the system are usually higher than the surrounding downtown real-estate. A Space Syntax analysis of the Peach Centre in Atlanta revealed typical problems, (Rashid, 1997). Typically, the more integrated street grid is gradually abandoned, especially by the middle class. A traditional Space Syntax model, or even one using the proposed modification, may not adequately explain the success of the skyway system and the decline of the streets. How can one explain this apparent contradiction of the correlation between integration and movement and land use, usually found in Space Syntax analysis?

There are four main possible explanations to the above paradox:

* The off-grade system is more integrated locally than the street system.
* Streets are lined with 'negative multiplier effect' uses.
* Parking facilities and metro stations need to be calculated in the axial model.
* In unintelligible areas, movement patterns do not necessarily correlate to integration patterns.

4.1.1

Similarly to Rashid's (1997) analysis of Atlanta, the street grid of St. Paul is more integrated globally, and, to a lesser extent, more integrated locally (in some of the cases, it may very well be that the skyway system is more integrated locally R3). Yet there are fewer people on the streets and more people in the skyway system. It is proposed that the intense internal grids, together with the multiplier effect of the intense internal land use, counteract the more integrated streets.

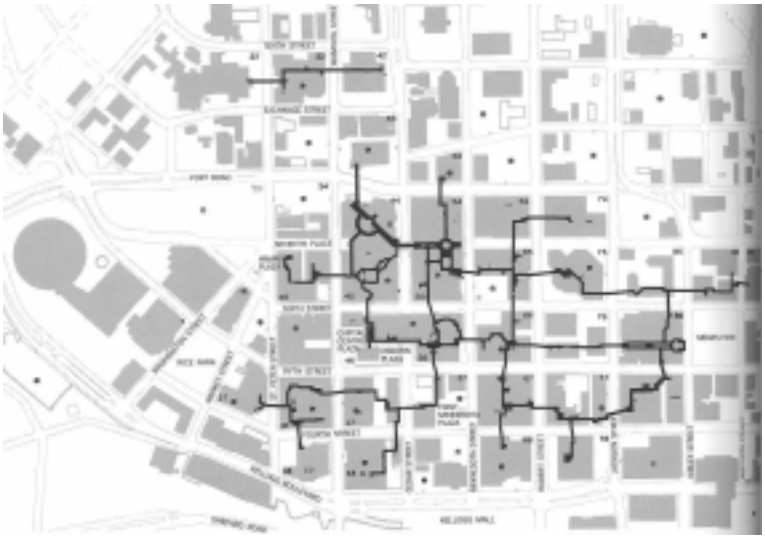

Figure 2: Downtown Saint Paul map. (Source Bednar 1989)

4.1.2 'Negative multiplier effect'

It is proposed here that a 'negative multiplier effect' exists as well as the positive one. The term relates to a process generated by land uses that deter movement (mainly pedestrian). In downtown St. Paul, the more integrated street grid is overcome by the intense internal grid and land use on the skyway system. The match point for the skyway system is the prevention of any assistance to the streets, or rather lining the pavements with 'negative multiplier effect' elements. As demonstrated in the Boston Prudential Centre case study, most 'projects' simply turn their back to the street. They segregate themselves by garage entrances, air handling grills, electric transformer facilities, rubbish containers, etc'. Typically this will be accompanied by a belt of segregated short axes surrounding the projects. Often, this is not a result of malicious intent. It is usually a combination of planning attitude, the sheer size of the projects, and their need for a 'technical' interface with the world.

Figure 3: Negative multiplier effect' uses face pavements of downtown St. Paul (Photo taken by the author)

Figure 4: The multi level Chicago 'Walker Drive' and it's service roads (Photo taken by the author)

4.1.3

How can one explain the success of the skyway system and the decline of the streets in Minneapolis and St. Paul?

Rashid partially explains this by the low intelligibility typical of MLHDUEs. However, this may be explained by the fact that the parking structures are not considered to be part of the urban grid in the axial models. Nevertheless, if most pedestrian movement emerges from the parking structures directly on to the skyway system, a way should be found to express this in a Space Syntax model.

Ida and Nishibori found that they must model the underground transit system, if they want to explain properly movement patterns in metropolitan Tokyo. It is proposed here that a mathematical coefficient that may give the bridges that connect parking structures with the skyway system, the appropriate configurational value

may be calculated [11]. Such a modified model may better explain movement patterns in downtown Minneapolis. The skyway level will become more integrated in relation to the city. This will better explain the larger number of pedestrians observed on the skyways. Configuration is a relative measure; therefore, if the skyways are more integrated the street grid is less integrated. This may explain the declining number of pedestrians on the streets. One may make an additional speculation, that in such a model, intelligibility in the skyway system may be improved.

4.2 'Shallow core'

The internal Space Syntax of multi-level projects seems to reflect the balance of power between the streets and the projects. On the one hand, along Chicago's Michigan Avenue, projects seem to maximise the effect of massive pedestrian traffic along the avenue by arranging themselves around a 'shallow core'. Ascension means are typically one axial step from the avenue and usually visible from the avenue. On the other hand, downtown Minneapolis projects seem to have a deep integration core, typically on the off grade level. Ascension means are located in the centre of the 'projects', several axial steps away from the street. This makes the skyway level more integrated with the centre of the 'project', and more segregated from the streets. Furthermore, ascension means are seldom visible from the streets, and the streets are not visible from the ascension means. Penn & Chung (1998) as well as Arture and Passini (1992) recommend that ascension means be visible from the more integrated axes, so that they may be used.

Figure 5: Plan of the IDS Centre in Minneapolis.
(Source Bednar 1989)

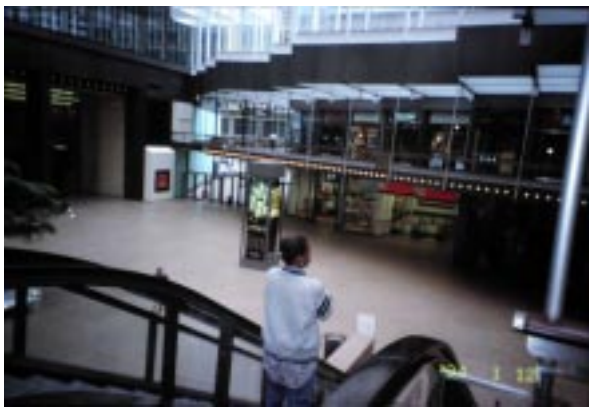

Figure 6: View of the Nicolet Mall entrance to the IDS Centre, as seen from the escalators
(Photo taken by the author)

The design of the Rockefeller Centre is a good example of an enormous effort to attract pedestrian traffic on Fifth Avenue, into the heart of the 'project'. An additional sloping street brings people in to the heart of the 'project' and within view of the lower concourse system. In these cases, it is not clear which is the chicken and which is the egg.

Figure 7: View of Fifth Avenue from Rockefeller Plaza (Photo taken by the author)

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It is proposed here that direct links between the pavements and the skyways, depending on their location and type, may bring them within one axial step from each other. As demonstrated in Stockholm and in the Dizengoff Centre, the off-grade level may even be on the same axis. This may improve the relative local integration value of the streets. Together with current policy encouraging street-facing retail and street improvements, this may eventually improve the balance between streets and skyway in favour of the street. The possible configurational change that may be brought by direct links from the pavement to the off grade system will be further discussed below.

4.3

How does the performance of cases studies with skyway systems compare with the second type in which underground transit feeds a pervasive concourse system?

It seems that transit/concourse systems lend themselves to a better balance between the street and the off-grade system. In many of the cases, the transit stations are under the street. Often, station entrances are accessed by an escalator or a stairway directly from the street. Even in stations that connect to the street through the concourses, planners usually make sure that passengers have alternatives of more direct and clear exits. Stairs descending to a lower level are much less intrusive,

spatially, then stairs connecting to a higher viaduct or bridge. Consequently, there are more of them. The combined effect of these reasons may also explain the better balance between street and concourse compared with the balance between streets and skyways.

Obviously, this is not the only difference, as several other explanations come to mind. Most people do not feel confortable spending too much time underground with no view to the outside world. In comparison with the skyway system that offers generous views from the bridges on to the street, concourse systems are by far less generous when it comes to views outside. This gives people an incentive to go outside, and thus keeps a better balance between the off-grade system and the street.

Figure 8: St. Paul streetscape as seen from a skyway. In the background the Minnesota Capitol building. (Photo taken by the author)

On the other hand, in cities with skyway systems, excessive bridges or viaducts crossing over, casting shade, and limiting the space compromise the streetscape. This gives an advantage to the people on the bridge, offering them a good view point at the expense of pedestrians on the street. Hillier (1996) suggests that one of the most common informal uses of space is observation of other people walking by. In comparison to cities with a concourse system, the balance in cities with skyways between the street and the off-grade level tends to favour the off-grade level.

It is suggested that a second pedestrian level works only in a very dense areas, in which most people arrive on the second level. In cities in which the majority of people arrive by car and park in above-ground parking structures (Los Angeles, Minneapolis, St. Paul, Atlanta), a skyway system works well. On the other hand, in cities in which the majority of the people arrive underground, using transit, concourse systems work well (Montreal, Toronto, midtown Manhattan). All the case studies

serve as a warning against a third pedestrian level, even in very dense areas such as midtown Manhattan[12]. All the case studies demonstrate that special care should be taken to maintain the balance between the street and off-grade systems.

4.4

How do the case studies' skyway/parking systems compare in their social performance to concourse/metro systems?

Contrary to skyways and shopping malls, streets carry many more forms of movement. Streets are more likely to effectively relate global and local patterns of movement. This puts them in a much better position to function as an 'encounter field' or a locus for the latent community. An attempt to compare the social stratification[13] of a city with a skyway system with a city with a concourse system, may further help to explain the way they are put together. In cities dependant on underground metro trains, one is constantly in direct visual contact with 'others'. Furthermore, since often the concourse system connects directly to the metro system, chances for social stratification between the urban levels are lower.

In a skyway system connected to parking structures, fewer, yet more affluent people generate the economic power to ignite the multiplier effect. This may increase the conflict between the more globally integrated streets (weakened by negative multiplier effects) and the more locally integrated skyways (strengthened by the multiplier effect of fewer affluent people). This process strengthens social stratification in a city with a skyway system by creating a physical stratification that reproduces the social one. Thus, the concourse system connecting directly to the transit system is more integrated socially compared with a skyway system connected to parking structures.

4.5

The question is asked whether there is a need for a pervasive off-grade system? Midtown Manhattan has different types of concourses, mainly around underground transit stations. These concourses are not pervasive, in the sense that they do not connect to a whole system that covers the central area. They are limited to local areas, usually enhancing transit station access. In Manhattan, streets connect different underground and over-ground intensive nodes, rather than a pervasive off-grade system. Pedestrian traffic is generated between these nodes as it is generated between anchors in a shopping mall. Furthermore Bednar (1989) suggests that it may be better not to let 'projects' interconnect, over or underground, thus keeping the street as the main integration axis between them. Pushkarev and Zupan (1975) propose not to systematically and indiscriminately connect 'mezzanines', so as not to create a parallel pedestrian circulation system competing with the streets above[14] .

4.6

Chicago mixes the two models. Chicago has an underground highway connected to a relatively pervasive second (and some times third) underground road system. This frees the street level for a mix of pedestrian-compatible uses. The urban continuity needed for pedestrian movement is less broken by major roads or streets lined with technical facilities. Double level Michigan Avenue/Walker Drive let centrality cross over the Chicago River, while commercial traffic and shipments remain underground. Many pedestrians emerge from massive over-ground parking facilities. Many others emerge from the subway stations along the parallel State Street. Mixed dense pedestrian traffic is generated between major MLHDUE, along north Michigan Avenue. Michigan Avenue merges local and global motorised traffic as well as local and global pedestrian traffic. Pedestrians that frequent any of the very dense projects along the avenue must use the pavements to walk to the following ones, to the benefit of all.

4.7

Stockholm is probably the best example of a successful MLHDUE. Most of the off-grade axes are hardly noticeable. It is difficult to say which is the ground since most of the axes are so well integrated. Most of the successful moves into the third dimension on an urban scale are more discreet and less obvious, such as the streets perpendicular to the Central Station in Stockholm. Systems that harm other forms of movement are exiled to the underground, leaving mere entrance and exit points observable. The elaborate underground infrastructure enables the centre to thrive. For local movement dense nodes are connected by the street system and not by bridges or concourses.

4.8

When discussing MLHDUE, it may very well be that the essential question is where does the vital massive infrastructure go? In all the cases it is clear that secondary non-pedestrian, technical levels are essential. As density increases, more and more services are needed. If they are not provided underground they become an obstacle on the ground, as demonstrated in the Prudential Centre case.

Problems start when density generates demand for a scale of movement that cannot be reconciled with other forms of street use. Case studies show that in MLHDUE, the commodity in short supply is the continuity on the pervasive layer. One of the most common problems with MLHDUE is that planners think that they can exile pedestrians to a local second level, and thus feel free to dedicate street level to technical facilities and roads. This is the problem with the Municipal Building/ Gan HaIr development, the Atarim Square, Dizengoff Square in Tel Aviv; and the Prudential Centre in Boston.

73.16 **Figurs 9 & 10: Tow alternative future cities. In the early 1920s, W.H. Corbett.** (Source: Avery Library)

5. Refined research question

As stated in the introduction, one of the main purposes of the qualitative research conducted was to refine a research question for a more detailed quantitative research, using Space Syntax theory and tools. As to further research of MLHDUE, a quantitative examination using Space Syntax is hindered by the fact that Space Syntax models of unintelligible MLHDUE have generally failed to anticipate movement patterns. The general research questions for further investigation of MLHDUE are therefore:

1. Can intelligible MLHDUE be successfully modelled using slightly amended traditional Space Syntax practices, suggested in section 2, to anticipate movement patterns? This may lead to further investigation of the relative social performance of intelligible MLHDUE to non-intelligible ones?
2. Another line of research that emerges from the discussion of the case studies may be what conclusions may be drawn about the relative local vs. global integration of MLHDUE with the city, when connected by different types of off-grade systems or when they are connected by the street? What is the relative performance of the streets in both cases?

Considering the case studies, it is clear to the author that, as implied by the hypothesis, intelligible axes mixing both global and local integration that give place for a positive multiplier effect are well frequented by pedestrians. Unintelligible segregated axes, which cause a negative multiplier effect, are sparsely frequented by pedestrians. The way to further expand knowledge of MLHDUE may be to

examine the cases that somehow appear to conflict with the hypothesis. One of the products of the case studies was a discussion of several possibilities that emerge as quantitative empirical research paths[15].

6. Conclusions

An analysis of the projects makes it clear that, while some MLHDUE make an effort to blend in with the city around them, others are clearly hostile and turn their back to their immediate surroundings. The move to multiple urban layers is associated with privatisation of urban space. Subsequently the structure of the society and the extent of social solidarity is expressed by the extent the authorities protect the needs of all segments of society. Projection of the public realm on to auxiliary layers tends to reproduce social structures. Case studies show that in multi layer environments the commodity in shortage is the continuity on the pervasive layer. In cities such as Stockholm social solidarity is expressed by allocation priority on the ground to pedestrians while massive infrastructure is exiled to the underground. In cities such as Houston lack of social solidarity is expressed by allocation of ground level to motorists, while pedestrians are exiled to skyways and underground concourses.

Case studies seem to support the hypothesis proposed. The way to further expand knowledge of MLHDUE may be to examine the cases that somehow appear to conflict with the hypothesis.

Notes

1 Upper technical systems such as viaducts and elevated trains can be harmful to urban continuity since they tend to limit growth of the centre and restrict interface between different types of movement such as local and global through the centre. For further discussion of examples see Gabay (2003).

2 Pushparev and Zupan (1975) conclude that the limit imposed by a theoretical pedestrian only circulation surface is FAR 60.

3 See Also Hillier, 1992, “Look Back to London” in which he demonstrates how the configuration of Milton Keynes breaks and separates all components of the movement economy thus depriving the city of the synergy they may have generated.

4 For further discussion about the social and political meaning of this please see Hillier and Hanson, 1983, ‘Postscript’, pp. 262

5 “The fundamental land use element is not the zone or even the urban block but the line…” Hillier 1996 : 166

6 Ida and Nishibori made an axial map of metropolitan Tokyo, combining the ground level system with the mostly underground rail system. This enabled the axial model to account more accurately for the observed city functioning. Major et al.1997 (SS V. III 42.03) This is strengthened by Chang’s suggestion that the “first priority in rout choice and decision behaviour is not minimising level changes but minimising spatial depth as far as movements on the global interaction routs were concerned” (1998 :229).

7 Case studies include: Embarcadero Centre, San Francisco; Prudential Centre Boston; Central Minneapolis & Saint Paul, Michigan Avenue, Chicago; Midtown Manhattan; Normalm, Stockholm; Central Tel Aviv.

[8] For a discussion social problems resulting from chronically unused space see Hillier 1996, pp. 184-204

[9] Chang 1998, pp. 22

[10] Hillier suggested the idea of Shallow core should be used. Supervision July 2000

[11] The coefficient should probably take into account the size in relation to location. One possibility of modelling such parking structures would be to calculate their ramps as urban axes, thus making the entrances more integrated.

[12] See also Pushkarev and Zupan, 1973, pp. 173

[13] The word stratification here comes from the social sciences referring to strata of society. However it's original meaning comes from geology, referring to the way rocks are composed of layers.

[14] They recommended that the Manhattan underground 'mezzanines' connected by concourses (totalling 6.5km in length) should be extended and improved only according to the needs to harmonise

[15] For further discussion please see Gabay, 2003.

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