SPACE SYNTAX AND THE DUTCH CITY
The supergrid

36

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0 Abstract
Space syntax, as developed at the Unit for Architectural Studies, University College London, proposes a fundamental relationship between the configuration of space in a city and the way that it functions. The analysis of space in terms of its configurational properties - or syntax - may, according to the theory, allow us to determine some aspects of the functioning of cities.

This paper aims to extend the process begun in the first paper of this series (Read, 1997) of testing this proposition in five Dutch cities, and exploring the nature of any fundamental space/function relations in the Dutch city as reflected by space syntax.

Whereas the first paper of this series concerned itself with the local scale in the Dutch city and the relation between activity levels in the Dutch neighbourhood or local area and the configuration of its public space, this paper attempts to begin to address the part played by the configuration of public space on global patterns of movement in the Dutch city. The results include a basic confirmation of the ability of the space syntax instrument to identify those spaces which are prioritised for global movement and discusses aspects of the nature and geometry of the global movement network in Dutch cities as they are revealed by space syntax ideas and public space occupation data surveyed in a sample of Dutch cities.

The paper introduces a method for the identification of spaces prioritised by global movement and shows how the particular nature of the global movement pattern in Dutch cities may arise out of certain historical and practical conditions affecting the expansion and development of the Dutch city.

1 Introduction
This article is the second of a series about the Dutch city and in particular about the way that the configuration of space in the Dutch city, as revealed by the descriptive theory of space known as space syntax and developed at the Unit for Architectural Studies, University College London, contributes to the functioning of Dutch cities. Space syntax (Hillier & Hanson, 1984) proposes that the key to urban function, at the level of the movement of people through the city and the distribution of people within the spaces of the city, is the way in which each space is accessible from every other space in the city, not in terms of metric distance, but rather in terms of topological distance, or the number of changes of direction needed to move from one space to another. The space syntax model is the product of the computation of topological distances (number of steps or number of changes of direction) of axes from other axes in the axial map - that set of longest and fewest straight lines that completely and

continuously covers the public open space of a city or part of a city. This paper presents further results of a research programme which began at the Delft University of Technology and continued at the Unit for Architectural Studies (1). It is intended to stand alongside similar studies conducted in other cities in other parts of the world, and to take account of some of the particularities of the Dutch city and of Dutch planning.

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Figure 1. Amsterdam; axial map

The first article in this series (Read, 1997) proposed that it was at the scale and level of the local area in Dutch cities that spatial configuration determined most strongly the rates of occupation of public space and that it was therefore at this scale that much of the underlying impetus for their social vitality and even safety originated. Attention in that article was given to that large majority of more typical spaces in the local area or neighbourhood, while those spaces which appeared to be more important to global movement and to the orientation and distribution of people within the configuration with respect to the configuration of the city as a global entity were ignored. This article will attempt to fill the gap deliberately left by the first one by addressing the issue of that set of spaces which have a more global significance within the Dutch city. It is a thesis of these two articles that there appear in fact to be two quite separate scales in the configuration of Dutch cities that have a clear impact on their function; that of the grid of the local area, and that of a more global scale grid that appears to carry city and regional scale movement through a set of spaces that are far better used than the typical local area spaces often directly connected to them. It is proposed that there is a relative disjoint in the movement and space occupancy pattern between these two scales in the Dutch city, as compared to London for example where space syntax has for the most part been developed and tested, and that this may be due to some particular practical and historical conditions of the development of the Dutch city.

2.1. The Dutch city - the local scale

It was proposed in the first article that the Dutch city is, as a configuration of space, fundamentally different to many other cities. It was suggested there that practical constraints on the development of land due to the need to claim land back from the water and to make often very difficult soil conditions suitable for building and development have led to a process that has constrained outward expansion at the edges of cities through history and resulted in cities that are compact, dense and in the main composed of local areas that have been developed all at once within clearly defined borders rather than having developed by the incremental infilling of interstices between major movement routes. It was suggested that these practical and historical conditions affecting the growth of the Dutch city have resulted in a spatial configuration which has a quite different relationship between the global and the local scales than has London for example.

In particular it was shown that the space syntax measure of global integration (the global version of the property of the mean topological distance - or number of changes of direction - of a space from the rest of the spaces of the system being considered) was not a uniformly good predictor of the rates of occupation in individual public spaces in areas, and that in 30 of the 36 areas for which public space occupation and movement data was collected, a much more local version of the measure of integration was a better predictor. It was also shown that whereas Hillier has reported good correlations in London between the space syntax measure of intelligibility (the correlation between local and global measures of integration) and the predictability of public space occupancy rates (represented by the correlation coefficients between the rates of occupation of public space as surveyed in the real world, and space syntax integration measures)(Hillier et al., 1987), the relationship between these two factors in Dutch cities was not nearly as consistent. Those Dutch cities tested showed that a better correlation between intelligibility and predictability were also those that had relatively higher mean connectivities (connectivity being simply the number of other spaces that a linear space connects with) and it was suggested that one of the reasons for the generally poor correlation between these factors may be that the Dutch city has in general fewer high connectivity long linear spaces - or rather that its axial map has fewer high connectivity long axes.

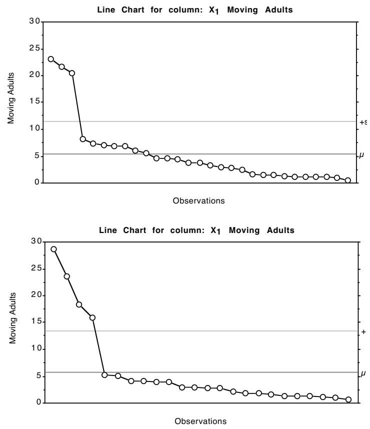

Figure 2. Observations of moving adults/100m for the areas Amsterdam Jordaan (top) and Amsterdam Southern Grachten (below). Each observation is for one particular space and all the spaces together represent the sample of spaces surveyed in each area.

The spaces considered in the first article were those that carried the relatively low rates of movement and public space occupancy - represented by the lower values to the right of the line graphs of observed movement rates within areas (see figure 2) - in the majority of spaces in the local area which, it was suggested, approximated to what Hillier calls natural movement - that part of the occupancy of urban space determined by the grid configuration itself (Hillier et al., 1993) - and relatively uninfluenced by the 'multiplier effect' due to the attraction of shops and other functions. The higher values - to the left of the line graphs in figure 2 - would then represent the effect of the same local level natural movement, possibly topped up with an effect due to the attraction of shops and other functions and probably also a global, city scale movement pattern - which may itself conform to the definition of natural movement - through a set of spaces that are more globally significant throughout the whole city.

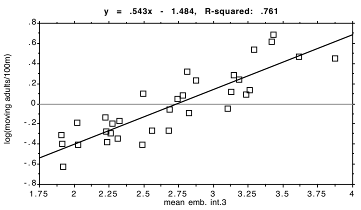

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Figure 3. Natural movement means of whole areas plotted against means of local integration.

Data on the rates of occupation of public spaces was compared with space syntax integration measures based on computations carried out on the axial map of each city. The strength of the correlation between the general overall public space occupancy rate through the local area (discounting those few spaces showing the markedly higher rates of occupation) and the mean rate of the space syntax measure of local integration (the local version of the property of the mean topological distance - or number of steps - of a space from the rest of the spaces of the system being considered) for the area, suggests that the rate of occupation of the more typical public spaces of the local area may for practical purposes be considered separately from the total movement pattern of the city - that in fact, in the Dutch city, the general rate of occupation of the public space of local areas as far as the large majority of their more typical spaces are concerned becomes predictable on the basis of purely local configurational measures. This result may suggest that the Dutch city is like an agglomerate of areas which, while often being packed tightly together, rather like balls of wool in a basket, remain essentially quite separate in the way that they function.

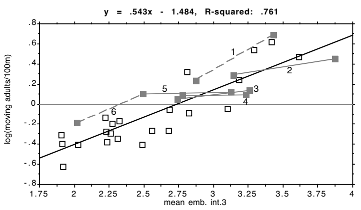

Figure 4. Natural movement means of whole areas plotted against means of local integration - picking out pairs of adjacent areas. 1; Amsterdam, Old Indischebuurt - New Indischebuurt pair. 2; Den Haag, Schilderswijk 1 - Schilderswijk 2 pair. 3; Amsterdam, Old Watergraafsmeer - New Watergraafsmeer pair. 4; Haarlem, Botermarkt - Florapark pair. 5; Den Haag, Bezuidenhout - Mariahoeve pair. 6; Den Haag, Mariahoeve - Essesteijn pair.

The first clue that this may not be the whole story is evident in the scattergram in figure 4. There are 13 cases amongst the 36 areas tested where two areas tested lie immediately adjacent to each other. Many of these pairs of areas have quite similar mean local integration measures and correspondingly quite similar mean occupation rates within their public space, but there are six pairs of areas where there is a difference in the mean local integration measure of about 0.5 or more.

It is immediately evident in the scattergram that four of these pairs lie in a horizontal relationship to each other. That is, they show differences in their mean local integration values while at the same time showing quite similar values for their mean background space occupancy rates. If we look for a factor which links these four cases it can be seen that in all cases the pair share a long - on the face of it probably globally significant - axis that passes through or immediately past the pair, 'skewering' them together - rather like a knitting needle skewering the balls of wool in the basket. The suggestion is that there may be a more global factor which tends to smooth out the local area differences in public space occupation and that this may have something to do with the issue of long linear globally significant spaces.

2.2. *The Dutch city - the global scale*

It is clear that there is a simple reason connected with the system of the axial map itself why the space syntax measure of intelligibility should tend to become weaker in conditions where the mean connectivity is low. The topological distance (number of changes of direction) considered in computing local integration is 3 while the topological distance considered in computing global integration is dependent on the 'topological diameter' of the system which is strongly affected by the length of the axes relative to the total size of the system and is especially dependent on the length and distribution of the longest axes. The lower this topological diameter - the closer it is to 3 - the more local and global integration measures are going to tend to be alike and the stronger the space syntax measure of intelligibility is likely to be. The measure of intelligibility is likely - in a very simple way related to the properties of the axial map itself - to tend to reflect the presence or absence of a well distributed set of long and especially very long axes in an axial map.

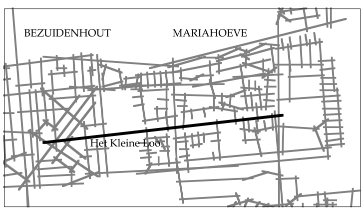

Figure 5. Den Haag; Bezuidenhout and Mariahoeve 'skewered' by the long highly trafficked space, Het Kleine Loo.

Figure 6.

Figure 7.

Figure 8.

Figure 9.

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Figure 6. Amsterdam; Typical figure/ ground map, 2.5 km square.

Figure 7. Amsterdam; Corresponding axial map. Axes with connectivities over 12 picked out.

Figure 8. London; Typical figure/ ground map, 2.5 km square.

Figure 9. London; Corresponding axial map. Axes with connectivities over 12 picked out.

The distribution of long linear spaces also appears to be different throughout the configuration of Dutch cities than they are in London - perhaps again due to the more 'organic' development of the spatial pattern in London through history. In fact the clear geometries in the plan of Amsterdam and the relatively less geometrically ordered plan of London obscure the fact that long spaces in London are organised in a very subtle manner - tending to form strings of long spaces - whereas in Amsterdam long spaces often end by connecting with short spaces or ending abruptly at a crossing with another space. The way that long spaces are organised is likely to be highly relevant - long axes that are strung together are going to tend to reduce the 'topological diameter' of the system much more effectively than if those same long axes are simply distributed evenly or randomly over the whole configuration. It is interesting to consider the effect of this set of long and very long spaces in a city on the intelligibility (in its more general sense) of an urban spatial configuration. It is certain that Oxford Street and its extensions in London and the major boulevards in Paris contribute powerfully to the intelligibility of the spatial layouts of these two cities by providing people with a strong directional and locational reference across great distances of what could otherwise be a very confusing spatial pattern. It is also clear that there are fewer strongly orientating and locating spaces in Amsterdam - and that those long spaces that there are tend not to be organised in the way described above. It may indeed be that part of Amsterdam's close intense urban character and its reputation as an enjoyable place in which to get lost may be a result of this factor.

In fact it could be the strongly orthogonal ordering of the spatial network of areas in Amsterdam which tends to disturb and inhibit the kind of long space geometries that one finds in London. Similar patches of grid can be seen at other scales in the Dutch landscape - the result of a practical management of land that would disappear under water if it were not crossed and divided by drainage ditches. An unintended but characteristic consequence of this straight-forward geometric ordering are the collisions where two or more of these patterns meet - the more strict and grid-like the order, the less the geometries are inclined to merge into one another and the landscape often seems, when viewed from above, to be as much fragmented as it is ordered by its geometry. Similar local geometries can be found in the space of the city - often generated in the first instance from pre-existing patterns in agricultural land. Here the patterns are often not simply traces of a pre-urban past - they remain as a working part of the global drainage pattern in the landscape.

Collisions of geometries in the space of the city will tend to cause disjunctions within the configuration, by breaking up continuities in spaces. Often the break in a spatial continuity is a simple one - simply a change of direction - but in many cases, at the point of grid collisions, a major route through the city will be forced into a dog-leg. This not only breaks long spaces but also tends to introduce short - sometimes very short - spaces into the strings of spaces that constitute major routes. The consequences for the space syntax concept of intelligibility as well as for the efficacy of spaces as orientating and locating references in the spatial configuration of the city are clear.

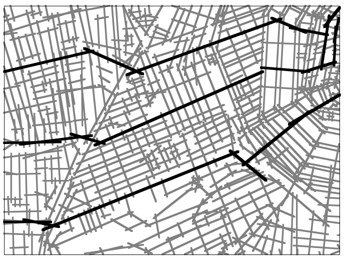

Figure 10. Three routes through west Amsterdam showing continuity breaks and dog-legs.

There are other ways that the continuities of space are broken in the Dutch city, like the green strips or areas that are left separating urban expansion areas in more recent developments - but the point is that they all tend to arise from a process that involves the conscious and deliberate design and making of complete arrangements of urban space as opposed to having the shape of urban space emerge bit by bit over a period of time by a more or less 'organic' process of development and growth.

While it may be, as was suggested in the first article, that the strongest and most defining relationship in Dutch cities between people and the configuration of the space of the city occurs at the level of the local area, the city is quite obviously experienced and used at the global scale by people moving through it and this scale may be as interesting and as particular to the Dutch city as is its local scale.

3 The sample

This article is concerned with the same material as the first - the Dutch city and the configuration of its spatial network - and uses the same set of data as that used previously. The Dutch city is considered through a sample of five cities of different sizes from the largest in the Netherlands and the capital, Amsterdam, through the administrative capital, Den Haag, and two smaller centres, Haarlem and Alkmaar, to a semi-autonomous peripheral district of Amsterdam, Zaanstad. 36 areas within these cities were chosen as a sample on a number of bases. They were first required to form a reasonably representative cross-section of the neighbourhood areas within each city; secondly, they each had to show some internal consistency to visual analysis in the geometrical properties or texture of their grids; thirdly, they had to constitute commonly understood local areas or neighbourhoods with fairly clearly demarcated and commonly understood edges. Nine areas were chosen in Amsterdam, eight in Den Haag, six in Haarlem, seven in Alkmaar and six in Zaanstad. Samples of the spaces in these areas were surveyed for the density of their occupation by adults on

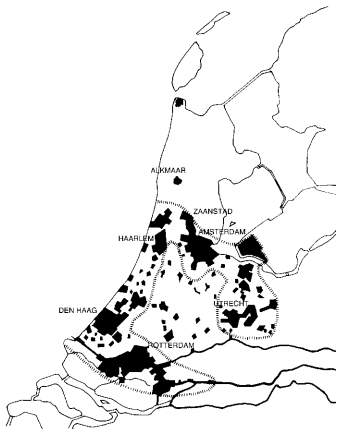

Figure 11. Map of the Netherlands.

foot and bicycle. 180 spaces in the nine areas of Amsterdam were surveyed, 144 spaces in the eight areas of Den Haag, 133 spaces in the six areas of Haarlem, 131 spaces in the seven areas of Alkmaar and 119 spaces in the six areas of Zaanstad.

4 The supergrid

It is useful to consider what possible components might comprise the movement and space occupancy represented by the points in the graphs in figure 2. Hillier has proposed that the configuration of space itself determines a part of the movement and space occupancy pattern to be found in the spatial grid of the city. He calls this component natural movement and proposes in addition that the pattern of movement and space occupancy thus established influences the choice of locations for shops and other facilities. These facilities would then tend to attract still more people to those spaces that the configuration itself prioritises anyway. In this way shops and other facilities act as attractors which tend to amplify the effect of the configuration on the occupation of those prioritised spaces (Hillier et al., 1993). Hillier makes no distinction in principle between that minority of more intensely used spaces and the large majority of more typical spaces in the configuration, all of which are subject to natural movement. However, it seems likely that the higher value points to the left of the graphs in figure 2 would represent a more complex situation than those low value points to the right. It was proposed in the first article of this series that the occupation rates in these low value spaces approximate to pure natural movement, uncomplicated by effects due to attractors and uncomplicated by any possible role in global movement patterns, and it was shown that the general rate of occupation in these low movement, low space occupancy spaces was strongly related to very local configurational properties - namely local integration at the level of the area.

In contrast, as far as the high value spaces to the left of the graphs are concerned, on the one hand these spaces are likely to display the effects of the amplification of natural movement rates due to the attraction of shops and other facilities. On the other hand, while the movement and space occupation in the large majority of spaces in the Dutch city may be primarily determined by local configurational properties, there obviously is movement at a more global and even regional scale within the Dutch city and it is likely that this global and regional scale movement will tend to prioritise a particular set of spaces within the city and that rates of movement and space occupancy in this set of spaces - defined here as the supergrid - are far more likely to be affected by global configurational properties. While it seems likely that these two effects will often co-exist in the same spaces, the possibility must be considered that some spaces may show the one effect more than the other. There are well used spaces in cities that seem to be predominantly global scale movement routes and others which are strong shopping streets serving a very local area, and not appearing to carry any significant level of global through movement.

It is possible also to argue that the movement and space occupancies of better used spaces in the city comprise three components because, in addition to the movement and space occupancy due purely to the relationship of these spaces to the global and regional configuration and the movement and space occupancy due purely to the attraction of shops and other facilities, these spaces must also have a component of purely local movement determined by local configurational properties, like the other

There are two aspects of the supergrid of the Dutch city that this article intends to try to address. First there is the question of a practical method for the identification of that set of spaces in the Dutch city which constitute the supergrid - not simply on the basis of the observation of the level of activity within those spaces, but rather on the basis of purely configurational properties of the spatial network. Second is the question of the prediction, to some degree of accuracy, of the rates of movement in those spaces. The question of the relationship between the local and global properties of these spaces and between local and global effects in the configurations of areas will be left for a further paper or papers.

Figure 12. Amsterdam; 10% highest global integration values (compare with figure 1).

Figure 13. Amsterdam; 10% highest connectivity values.

Figure 14. Amsterdam; 10% highest local integration values.

4.1 The identification of the supergrid

The supergrid has been defined as that set of spaces prioritised by global and regional scale movement within the city, and it is argued that they are likely to be found within the set of spaces picked out by the graphs in figure 2 as showing markedly higher levels of activity than the rest of the spaces local to them. That set of spaces showing markedly higher levels of activity than the rest of the spaces local to them are clearly not that set of spaces that have the highest global integration measures in the configuration as a whole, even if global integration might eventually prove to be a good predictor of activity levels in supergrid spaces. High global integration spaces tend to cluster close to the centre of the global configuration and do not distribute themselves through the local areas of the Dutch city in the way implied by the graphs in figure 2. Supergrid spaces are not simply the most heavily used spaces in the global configuration, but are rather those spaces involved in global movement patterns throughout the urban spatial network and are distributed through the configuration as a whole. In fact the pattern of supergrid spaces, constituting as it must do a pattern of routes used to access all corners of the global spatial network, is probably the most familiar and recognisable to regular users of an urban spatial network - more familiar and recognisable than that cluster of most heavily used spaces at the centre - and correlates with a global understanding of the layout of the city. It would approximate to that pattern of highlighted important streets found in any way-finder map.

High connectivity and high local integration spaces do distribute themselves more evenly throughout the local areas of the Dutch city and as a rough rule spaces which have high connectivity and local integration values correspond with those spaces which are candidates for the supergrid according to the survey data. In Amsterdam for example, of the 23 possible supergrid spaces picked out in the nine areas surveyed, 20 of them also belong to the set of 10% highest connectivity value spaces in the city as a whole and the same 20 also belong to the set of 10% highest local integration value spaces. Two of the other three cases, the Gerontalostraat in the Indischebuurt and the Helmholzstraat in Watergraafsmeer, are spaces whose rates of occupation put them only marginally within the set chosen as possible supergrid spaces and they are strongly affected by the attraction of a supermarket in the one case and schools and a community centre in the other. The other case, the 1e van Swindenstraat in the Dapperbuurt, is a major neighbourhood shopping street, which in spite of being in metric terms relatively long, and linking at both ends with other spaces identified as probably belonging to the supergrid, has a connectivity value of only 6, making it a relatively short line in topological terms. This case highlights the point that a set of supergrid spaces - if it is to be a set of global movement routes through the city -

cannot simply be randomly or evenly scattered over the configuration of the city, but must form continuous strings of spaces or routes through the configuration. The set of 10% highest local integration spaces in Amsterdam is almost identical with the set of 10% highest connectivity spaces and it would appear that connectivity - or local integration - on their own are not going to identify the whole set of supergrid spaces but will tend to pick out longer and more locally integrated supergrid spaces and may miss those that are shorter and less locally integrated, but are nonetheless clearly part of a global movement network in the city.

There is another space syntax measure which could on the face of it begin to address this issue of the continuity of routes and pathways. The measure of choice of a space is simply the number of times that space is traversed when topologically shortest pathways between each space and each other space in the system are computed. There is clearly more continuity in the map of the 10% highest choice value spaces of Amsterdam (see figure 15), but only 15 of the 23 possible supergrid spaces picked out in Amsterdam also belong to the set of 10% highest choice value spaces in the areas surveyed. Of the eight other cases, besides those two already mentioned, the Westerstraat in the Jordaan and the eastern end of the Javastraat in the Indischebuurt are not obviously major through routes and seem to be more important for local movement and shopping. The four remaining cases, the Weteringschans and the Utrechtsestraat in the Grachten, Staalstraat in Nieuwmarkt, and the western end of the Javastraat in the Indishebuurt have an obvious global function as well as local importance and would be expected to be part of a set of supergrid spaces for Amsterdam as a whole.

Another set of configurational measures considered as means to identify the supergrid derives from the idea that although people may be thinking globally when they traverse global or regional scale distances through the city, they act locally. As has already been suggested, long spaces may tend to orientate and locate people with respect to the configuration of the city as a whole. They may very simply make a configuration comprehensible which might otherwise need a map and local knowledge of landmarks to traverse effectively. It is easy to imagine that a person may tend to use these long orientating and locating spaces to construct the simplest possible pathway through the configuration - especially if his or her knowledge of the configuration is not complete. As has already been mentioned, strings of long axes are likely to be extremely effective at reducing the topological diameter of the whole configuration and they are therefore also likely to be effective at increasing the effective range of small numbers of long spaces strung together - they make quite distant parts of the configuration, in terms of metric distance, relatively near in terms of topological distance. Another way of saying this is that they make long journeys simple in terms of the number of changes of direction involved. So it seems plausible to say that it is not simply the presence of long linear spaces within a configuration that will tend to make an otherwise complicated configuration comprehensible, but also the relationship of those long spaces to other long spaces within the configuration. In these terms, the space syntax measure of integration would seem to begin to quantify the effectiveness of spaces as elements of pathways through the system. Integration defines the nearness in terms of topological distance of a space from the rest of the

Figure 15. Amsterdam; 10% highest choice values.

system - this means that it accounts not only for the length of a space (indirectly - higher connectivity tends to correlate to higher local and global integration) but also for the relationships of spaces to other spaces. A relatively short space that happens to connect at each end to long spaces will be relatively near in terms of topological distance to the rest of the system as a result of its relationship with the long spaces. If people are going to tend to use globally integrated spaces in order to make journeys at the scale of the whole city, then logically, they are going to seek out the most suitable globally integrated spaces to be found locally at every stage of that journey. Another way of saying this is that people are going to tend to move locally from 'deeper' to 'shallower' spaces in terms of their topological 'depth' with respect to the rest of the system.

It is proposed therefore that a possible indicator of supergrid spaces is the integration gradient which is defined as being the ratio of the global integration value of that space with the mean of the global integration values of all the other spaces that connect with it. This concept can be extended by considering the connecting spaces to a radius of 1, 2, or 3 (respectively, those spaces that connect directly to the space being considered, all those spaces within 2 changes of direction of the space being considered, and all those spaces within 3 changes of direction of the space being considered). Integration gradients are calculated by dividing the global integration value of the space in question by the average of the global integration values of the spaces connected to it, so that spaces with an integration gradient over 1 will be the locally 'shallower' spaces that people may tend to move towards and spaces with an integration gradient less than 1 will be the locally 'deeper' spaces that people may tend to move away from.

A feature of integration gradient maps is the way they appear to pick up the continuities of routes through the configuration. In this regard they are similar to choice maps and at first sight the map of the 10% highest integration gradient value spaces is similar to the map of the 10% highest choice value spaces for Amsterdam. 18 of the 23 possible supergrid spaces picked out in Amsterdam also belong to the set of 10% highest integration gradient value spaces in the areas surveyed. The 1e van Swindenstraat is picked out and in addition to the 15 supergrid spaces picked out by the map of the 10% highest choice value map, the Weteringschans, Staalstraat and the western end of the Javastraat, spaces mentioned before as having a fairly obvious global function are also included. The spaces not picked out by the map of the 10% highest integration gradient spaces are the Westerstaat in the Jordaan, the Utrechtsestraat in the Grachten, the Gerontalostraat and the eastern end of the Javastraat in the Indischebuurt and the Helmholzstraat in Watergraafsmeer. Of these the Gerontalostraat and the Helmholzstraat are clearly neither part of a global movement system nor important shopping streets and their high space occupancy can be accounted for by their relationships to locally important attractors. The Westerstraat and the eastern end of the Javastraat are important local streets without any obvious significant through-route function. The Utrechtsestraat is part of a busy inner city area and is important as being the focus of a lively local area. It also clearly carries a significant amount of through movement, and its relatively low integration gradient value does not reflect an intuitive evaluation of its importance in the supergrid of Amsterdam. It was discovered that a mistake had been made in the axial

Figure 16. Amsterdam; 10% highest integration gradient values.

map, which once corrected boosted the integration gradient vale for the Utrechtsestraat to well within the range of the 10% highest values.

A similar process of comparison of connectivity, local integration, choice and integration gradient maps with spaces identified as possible candidates for the supergrid was carried out in the other four cities studied. In Alkmaar, connectivity and local integration pick out 12 and 13 respectively of the 21 obvious supergrid spaces in the survey data, choice picks out 15 and integration gradient picks out 20. The one space that is arguably a supergrid space which is not picked out by the integration gradient - or by any of the other measures for that matter - is Marestraat a short street linking Oudorp and Oudorperpolder and the main connection to Oudorp from the west. It should be noted that Oudorp, originally a tiny hamlet appearing in 16th century maps, was accessed historically from the south and that the connection from the west is new and dates from the building of Oudorperpolder in the 1980s.

In Haarlem, connectivity and local integration pick out 17 and 16 respectively of the 20 obvious supergrid spaces in the survey data, choice picks out 14 and integration gradient picks out 19. The Bartel Jorisstraat in the historical centre is the one anomaly, seeming to carry a significant amount of through movement but not being picked up by the 10% highest integration gradient values. In Zaanstad connectivity and local integration each pick out 11 of the 12 obvious supergrid spaces in the survey data, choice and integration gradient each pick out all 12.

In Den Haag connectivity and local integration each pick out 22 of the 25 obvious supergrid spaces in the survey data, choice picks out 19 and integration gradient picks out 23. The Hoogstraat in the historical centre and the Vaillantlaan in Schilderswijk are the anomalies, failing to be picked up by the 10% highest integration gradient values. The results of this process are summarised in the following table;

City	high use spaces	s/grid spaces	conn.	local int.	choice	int. grad.
Amsterdam	23	19	18	18	15	19
Den Haag	39	25	22	22	19	23
Haarlem	24	20	17	16	14	19
Alkmaar	23	21	12	13	15	20
Zaanstad	24	12	11	11	12	12
TOTALS	97	80	80	75	93	

Connectivity and local integration are shown to be good rough and ready indicators of supergrid spaces but as has been explained they fail on the count of not picking out continuous routes through the configuration and not distinguishing between local high-street type spaces and genuine supergrid spaces. Choice maps give continuous routes but tend to miss some important supergrid spaces. These results have shown that the best indicator of supergrid spaces is the integration gradient map. However the most remarkable thing about the integration gradient map is its recognisability as a map of a particular city. It is effortlessly and intuitively familiar to anyone who knows these cities well, highlighting not the best used spaces in the city as a whole, but rather those spaces that people will regularly use in finding their way to all its corners - those same spaces that are highlighted in a city way-finder map. Much more than other space syntax maps - which may be better at predicting absolute rates of movement in spaces within the city - the integration gradient map picks out

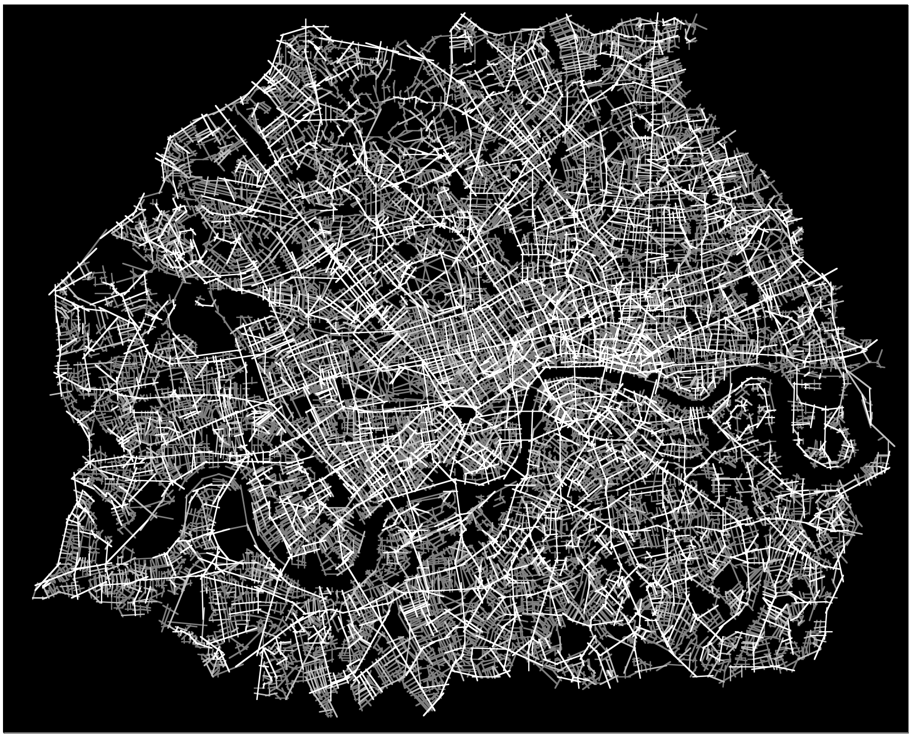

Figure 17. London; Integration gradient map. White represents the highest 10% integration gradient values; light grey and white, the highest 25% integration gradient values (roughly all those integration gradient values over 1).

those spaces which are important to the global shape and structure of the city, and to a global understanding of the city. In addition, insofar as the model is based simply on a representation of the spatial network of the city, the integration gradient map is a powerful demonstration of the extent to which the structure of space and of movement within the city is determined by configuration.

The space syntax measure of choice begins with a principle which strings spaces together across the global configuration. It is therefore not particularly surprising that choice maps show up continuities of spaces within the configuration which begin to look like routes. There seems to be no similar intrinsic reason why measures based on the topological distance of spaces from the rest of the system will show such clear routes - unless of course such routes are indeed part of a 'topological distance structure' already designed into the geometry of the spatial configuration! It has been suggested that the geometry of long spaces in London sets up certain favoured pathways through the configuration which topological distance measures like integration may then begin to highlight - and which the integration gradient may make even clearer. What the integration gradient shows in Amsterdam and other Dutch cities is that although the special geometry of long spaces is compromised here by misalignments between the geometries of area spatial configurations, there is nevertheless still a set of spaces organised - or designed in one way or another - such that they establish strong global routes through the city. The fact that this set of global movement spaces are not as clearly organised as those in London may be reflected in the relative difficulty of access and way-finding in Amsterdam - and the relative weakness of the supergrid probably reinforces the dominance of the local area in the functioning of Dutch cities.

4.1.1 The history and geometry of the supergrid: some elaborations and limitations of the model

The familiarity of the integration gradient map makes those anomalies highlighted above very obvious and makes the integration gradient map a powerful tool for the

Figure 18. Amsterdam; Integration gradient map. White represents the highest 10% integration gradient values; light grey and white, the highest 25% integration gradient values (roughly all those integration gradient values over 1).

understanding of the space syntax model itself. The case of the Utrechtsestraat in Amsterdam demonstrated that one could begin to use it to spot errors in the axial map - which had not been picked up previously by looking at global or local integration maps.

Two of the four anomalies in the results above appear to be of a similar type - these are the Hoogstraat in the historical centre of Den Haag and the Bartel Jorisstraat in the historical centre of Haarlem. Both of these streets are elements in strings of spaces that can be visually identified as routes through the area configuration and both are parts of routes that were important in the histories of these two cities. The Bartel Jorisstraat was part of one of two main routes connecting north and south gates of 16th and 17th century Haarlem and the Hoogstraat was similarly part of the main route linking a gate in the north west with one in the south east of Den Haag.

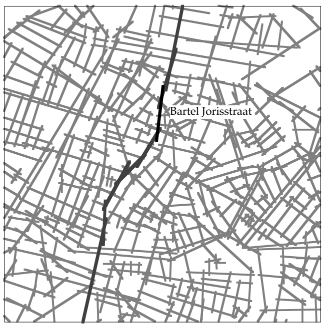

Figure 19. Historical centre of Haarlem showing the Bartel Jorisstraat as part of an historically important route through the centre.

These routes consist of strings of spaces reminiscent of the strings of long spaces one finds in the supergrid of London. But the spaces are not long - or rather they are not long when compared with long spaces one finds in the supergrids of modern cities. However, cutting the axial maps of Haarlem and Den Haag down to the extent of these cities in the 17th century and recalculating integration gradients, both these routes show up clearly as parts of the supergrids of the historical configuration. The historical centres of these cities clearly retain within their spatial networks much of the supergrids of their various historical states and extents, and it seems likely that these historical supergrids would have a continuing impact on the use of the spatial network close to the centre. The historical centres of many Dutch cities contain their main concentrations of retail facilities and it is easy to imagine these historical supergrids influencing the patterns of activity of shoppers who drive or take public transport to the centre and then use the centre on foot quite independently of the rest of the city - as if the historical centre was a complete city in its own right. This spatial structuring of the historical city as a city within a city - combined with the fact that all later additions to the city grow up around the centre, orientated towards a spatial network whose focus was the centre - so that the historical centre is almost by necessity the focus of the spatial arrangement of the rest of the city - means that patterns of activity in and close to the historical centre may be reinforced in complex ways. The reduced and concentrated scale of this historical supergrid within the whole city supergrid in most Dutch cities seems likely to suit them to pedestrian movement and Dutch historical centres have in general been turned very successfully into pedestrianised shopping precincts.

Of the remaining two anomalies, Marestraat - the main connection built between Oudorp and Oudorperpolder when Oudorperpolder was laid out - is the easiest to account for; there is simply no other convenient route between the centres of these two neighbourhoods. Marestraat gives few clues as to its relative importance - appearing from Oudorperpolder to be just another suburban side street - and a stranger would not comfortably find his or her way between these two areas, or perhaps even suspect that the other area existed, without a map. Most of the people using this street are likely to be local residents who can compensate for any configurational deficiencies with local knowledge. This case - where accessibility is very clearly the issue - seems to highlight the fact that space syntax does not measure simple accessibility, and suggests that in general it is not accessibility that determines the intensity with which public space is used, but some other factor related to lines of sight and to complexity within the configuration. In general there are many ways to get from one point to another within the spatial network of Dutch cities and cases like this one are rare. This case and the generally good performance of space syntax in predicting patterns and rates of movement within the spatial network of the city suggest that pure accessibility is seldom going to be the limiting or determining factor when it comes to rates of activity within spatial networks.

Another important aspect of this case is that whereas most spaces within the more traditional city are used in a variety of different ways and are elements of numbers of different routes, the function of Marestraat is very specialised in that it serves almost exclusively as a link for people moving between some point in Oudorp and another in Oudorperpolder, and that for origins and destinations anywhere else in Alkmaar, Marestraat would probably not feature as part of any route. It is really quite questionable therefore whether Marestraat should be seen as part of a global movement network or supergrid in the context of the whole of Alkmaar. In the context of the pair of areas Oudorp/Oudorperpolder taken on their own, Marestraat does fall within that set of spaces which have the 10% highest integration gradient values. It is argued in the next section that this part of Alkmaar has an extremely weak supergrid and that its parts function even more independently of each other than the parts of other Dutch cities.

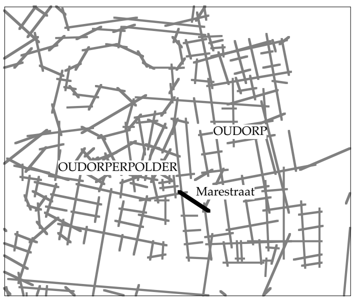

Figure 20. Oudorp and Oudorperpolder showing the connection via Marestraat between the centres of these two areas.

The last and most spectacular anomaly is that of Vaillantlaan in the Schilderswijk, Den Haag. It does not show up in the set of 10% highest integration gradient lines although it quite clearly carries a great deal of through traffic and would certainly be included in most people's lists of the globally most important streets in Den Haag. The integration gradient value of Vaillantlaan is in fact less than 1, which means that in the terms in which the integration gradient was initially set up it would belong to the set of locally 'deeper' spaces that people should tend to move away from. In fact the Vaillantlaan seems to be part of a global movement pattern between the crossing of the railway line to the south - 'A' in figure 21 - and the north of the city. From the survey data it appears that movement from the direction of the crossing splits where the Vaillantlaan meets the van der Vennestraat with the van der Vennestraat taking the major share and the Vaillantlaan a very significant smaller share of the total. Figure 21 highlights those spaces in the district with integration gradient values higher than 1 - roughly the set of spaces with the 25% highest integration gradient values. It is a simple matter to trace global routes to the north via the van der Vennestraat using only this set of spaces. However the major global route to the north from the western part of the centre begins at the road crossing marked 'B' - originally the western gate to the city - and anyone beginning at 'A' and wanting to join this route at 'B' would have to either take a rather indirect route via the van der Vennestraat or use the Vaillantlaan.

Space syntax considers neither distance nor direction directly in the way it models and describes the spatial network of the city. However that doesn't necessarily mean that distance and direction play no part in the mechanism that is being modelled here. It is quite possible that the sorts of geometries one ordinarily finds in the spatial networks of cities have as a property that - when they are translated into axial maps - have a 'topological distance structure' which correlates with functional patterns in the city. It is possible that the way that this connection comes about has as much to do with the 'sorts of geometries one ordinarily finds in the spatial networks of cities' as it has to do with the topological description. Global and local integration values under-predict the level of activity one finds in reality in the Vaillantlaan, which also shows non-typical geometries in its relation to those spaces with which it seems to relate as elements of a global route. It is clear that the shortest simple route between points 'A' and 'B' in figure 21 includes the Vaillantlaan, but also includes two dog-legs which were partly the result of misalignments between the old city wall of the historical centre - whose south west corner is at the northern end of the Vaillantlaan in figure 21 - and the area immediately to the south, including the Vaillantlaan, which was laid out at the end of the nineteenth century. A map drawn in 1896 (see Hoefnagels, 1991; p. 8) shows the eastern side of the Vaillantlaan already built up but shows no van der Vennestraat and no crossing of the railway line at 'A'. Another map drawn in 1989 shows the crossing now extant and the Vaillantlaan clearly now intended as the connection to the western edge of the historical centre. The Vaillantlaan was close to alignment with the road skirting the outside edge of the old wall (the light grey line just to the north of the Vaillantlaan). The modern route however is now on the inside of the old wall and it is this shift which has caused the misalignment to be as pronounced as it is today.

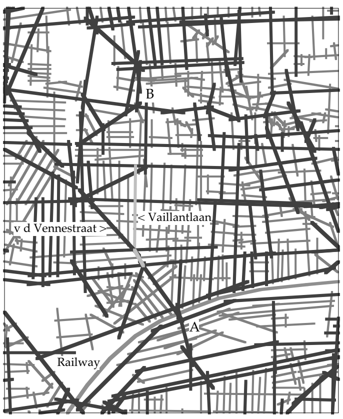

Figure 21. The Vaillantlaan as part of a major movement route through the Schilderswijk neighbourhood of Den Haag.

The supergrids of Amsterdam and other Dutch cities contain more of these 'non-typical' dog-leg geometries than does London for example. This factor would appear to tend to compromise the establishment of a configurationally dependent supergrid structure by breaking up the long spaces on which such a structure depends. But there seems still, on the basis of these results, to be enough that is 'typical' of supergrid geometries in the supergrids of Dutch cities that they can be fairly reliably identified on the basis of configurational attributes alone. Out of a sample of 97 supergrid spaces in five Dutch cities, there was only one case whose configurational attributes unequivocally failed to identify it as part of a supergrid. A great deal more research needs to be done on the relationship between public space configurations in cities and the geometries of their spatial networks.

4.2 The prediction of occupancy of space in the supergrid

It has already been established (Read, 1997) that the rates of occupation of non-supergrid spaces in local areas are strongly determined by local configurational measures. Supergrid spaces are the most global spaces in the way they function and one might expect therefore that their rates of occupation would be likely to be determined by global configurational measures. In fact the situation is not as simple as this - as the example of Alkmaar will show.

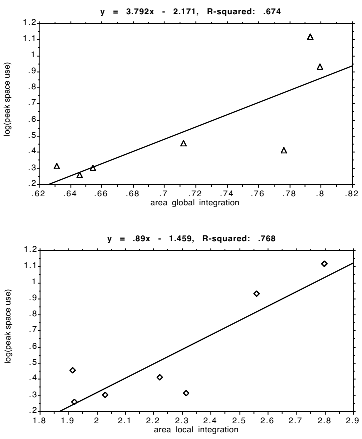

Figure 22. Alkmaar; log(combined moving adults in each area) compared with area mean global integration (top; R = 0.821) and with area mean local integration (bottom; R = 0.876).

In the first place, a simple comparison between the rates of occupation of spaces picked out from the survey data as being better used than the other spaces local to them - those higher value spaces to the left of the graphs in figure 2 - and integration values gave generally poor results. This is perhaps to be expected given how widely separated in the configuration of the city some of these spaces are. Nevertheless the comparison of rates of occupation of these spaces with global integration values gave marginally better results than with local integration values in all cities.

When all the rates of movement of the supergrid spaces for each area in each city are combined (as one mean value for each area) and compared with their corresponding local and global integration values (again as a mean value for each set of high occupation rate spaces) one gets a better result - but, perhaps surprisingly, in Alkmaar the correlation between these combined rates and their corresponding local integration values is better than that between the combined rates and their corresponding global integration values. The results are in most cases better still when one combines the supergrid rates for each area and compares them with the integration values for the areas as a whole (area mean integration values - calculated by averaging the integration values for all the spaces in the local area). Again in Alkmaar, somewhat surprisingly, the combined high occupancy rates correlate better with area mean local integration than with area mean global integration.

The results of comparisons between combined supergrid occupancy rates in areas and area mean integration values are summarised in the following table;

	Correlation coefficients for log(combined moving adults in each area) against;	
	area mean global integration	area mean local integration
Amsterdam	0.845	0.685
Den Haag	0.665	0.652
Haarlem	0.797	0.729
Alkmaar	0.821	0.876
Zaanstad	0.960	0.374

It is interesting to note that area level integration measures are better post-dictors of the finer than area level public space movement rates being measured in almost all cases, than are the integration measures which strictly correspond with the combination of spaces involved. This tends to reinforce the suggestion made in the first article that public space occupation is to some very significant extent determined at the area level - that the configurational properties of the area will tend to influence the occupation of space by people at the finer scale - even up to the level of the supergrid. Zaandam is the exception, and has an almost perfect correlation (correlation coefficient of 0.989) between combined supergrid spaces for each area and their corresponding mean global integration values.

Of the five cities tested Zaanstad seems to be most strongly structured by its global movement routes. It also has a very high level of pure through movement. This is primarily a result of it having grown along major regional routes connecting Amsterdam and Alkmaar. Zaanstad shows extremely strong correlations between its combined high value occupancy rates and both their corresponding mean global integration values and area mean global integration values, so of all the cities, supergrid movement in Zaanstad would appear to be most strongly determined by the global configuration.

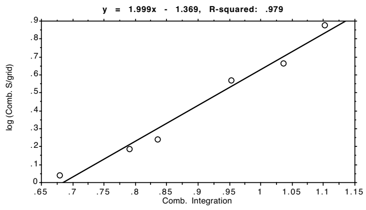

Figure 23. Zaanstad; log(combined moving adults in each area) compared with corresponding mean global integration (R = 0.989)

Alkmaar at the other end of the scale is a city divided into two distinct halves - the southern half including the historical centre being structured by what appears to be a reasonably strong supergrid while the northern half is strongly suburban with what appears to be an extremely weak supergrid as one moves north of the historical centre. Many of these areas in the north of Alkmaar (which include some of the areas taken as cases in this study) have been designed in such a way that the supergrid, such as it is, not only by-passes the areas themselves, but becomes extremely convoluted. Supergrid movement in Alkmaar appears on the basis of the study described at the beginning of this section to be more strongly determined by the local configuration than by the global configuration. It must also be noted here that the convolutions in the supergrid in the northern part of Alkmaar appear to have less to do with geometries in the landscape than with a way of designing suburban areas which was popular in the 1970s.

Supergrid movement in the other three cities appears to be determined more by the global configuration than by the local configuration although the correlations are nowhere near as strong or as unequivocally biased towards the global as is Zaanstad.

Picking out the areas tested in Zaanstad - the city with what appears to be by far the strongest supergrid - in the graph of natural movement means plotted against means of local integration (figure 3), all lie in a horizontal relationship to each other. This ties in with the effect highlighted in figure 4 and supports the suggestion that rates of public space occupation within areas connected by a strong supergrid are going to tend to be evened out by the influence of that supergrid.

5 The supergrid and the local area

The image drawn of the Dutch city in the first article of this series - as a set of relatively independently functioning local areas - needs to be modified to account for an often very significant global effect due to the supergrid. In fact it is easy to suggest how the supergrid may affect rates of occupation in the public space of local areas. Areas whose points in figure 3 lie below the regression line appear almost all to be areas whose spaces are topologically relatively ‘shallow’ with respect to the supergrid - that is their spaces are relatively few changes of direction away from the supergrid. If people are going to tend to move from ‘deeper’ to ‘shallower’ spaces

36.18

Figure 24. Zaanstad; Integration gradient map. White represents the highest 10% integration gradient values; light grey and white, the highest 25% integration gradient values (roughly all those integration gradient values over 1).

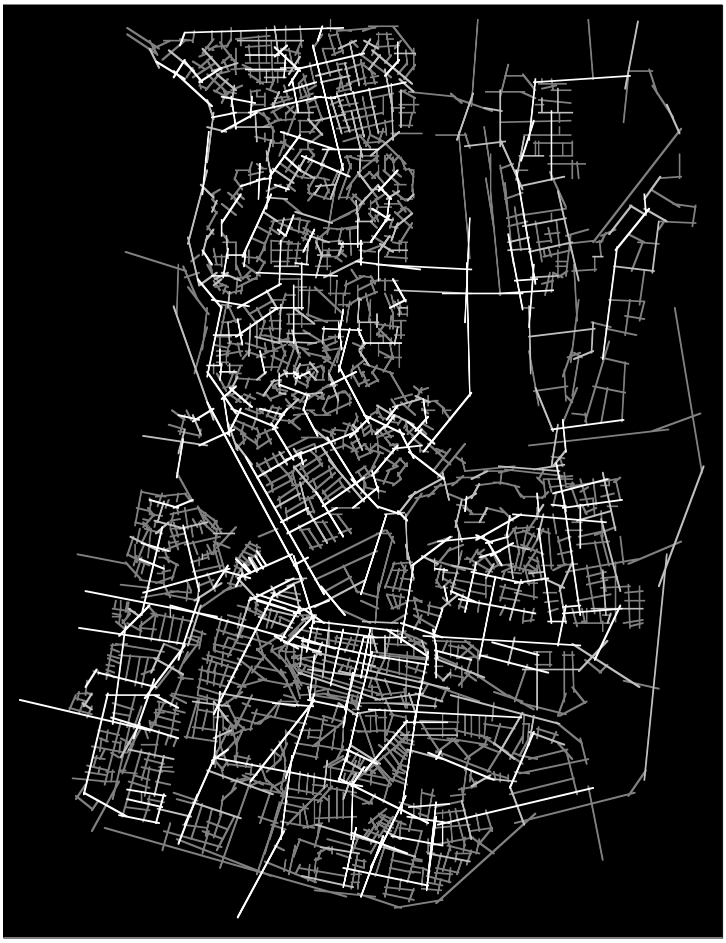

Figure 25. Alkmaar; Integration gradient map. White represents the highest 10% integration gradient values; light grey and white, the highest 25% integration gradient values (roughly all those integration gradient values over 10.

36.19

Figure 27. Haarlem; Integration gradient map. White represents the highest 10% integration gradient values; light grey and white, the highest 25% integration gradient values (roughly all those integration gradient values over 1).

Figure 26. Den Haag; Integration gradient map. White represents the highest 10% integration gradient values; light grey and white, the highest 25% integration gradient values (roughly all those integration gradient values over 1).

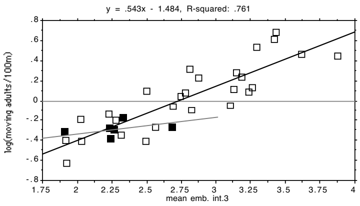

Figure 28. Natural movement means of whole areas plotted against means of local integration - picking out the areas of Zaanstad.

locally in the configuration, it would not be surprising if a large proportion of the people in an area that was shallow with respect to the supergrid ended up moving to the supergrid itself - and leaving that set of spaces which are the more typical spaces in the area. In this way the supergrid 'sweeps' topologically shallow areas of many of the people in their public space. Because shallow areas are going to have - by definition - higher area mean local integration values than their deeper neighbours, this 'sweeping' effect is likely to reduce the population of a shallow area to something approaching that of its deeper neighbour and the effect highlighted in figures 4 and 28 would be the result. An important point is that the population and character of the supergrid space itself would be likely to be significantly affected by the presence of shallow areas alongside it. In fact, an area that is shallow with respect to a supergrid space would tend to use it as a locally important space and it would be likely to already be a local shopping street.

The special balance and interaction between the supergrid and the local area in Dutch cities must be a primary source of the functional balance and character of Dutch cities - especially in their older areas where local areas tend to be shallower with respect to the supergrid. The continuing vitality of the inter-relationship between dwelling, shopping and employment in Dutch urban areas is a thing to be valued and maintained and an understanding of the nature of this relationship and the part that space plays in it can be a lesson for the planning and design of new urban areas. It is hoped that as these issues become better understood, this understanding can be fed back into improving the social and living quality of urban redevelopment and urban expansion schemes.

Notes

1. The first part of this research was carried out within the Department of Urban Renewal and Social Housing at the Faculty of Architecture, Delft University of Technology and was published as a doctoral dissertation (Read, 1996). The research was continued at the Unit for Architectural Studies, University College London, under a Human Capital Mobility Fellowship funded by the European Union.

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