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## MICRO SCALE SPATIAL RELATIONSHIPS IN URBAN STUDIES:

the relationship between private and public  
space and its impact on street life

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023

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**Abstract**

Research on urban environment by means of space syntax theory and methods tends to focus on macro scale spatial conditions. However, micro scale conditions should not be neglected. In research on street life and dispersal of crime in urban areas, it became inevitable to pay attention to the interdependence between the macro as well as the micro scale spatial conditions. For this purpose, spatial analyses methods were developed and tested in the Dutch towns Alkmaar and Gouda as regards topological relationships between private and public space. In particular inter-visibility of windows and doors and their inter-relationship to street segments were taken into account. Other variables were the density of entrances of private houses connected to streets, the topological depth between various kinds of private and public space, the degree of constitutedness of street segments and the degree of visibility from windows to parking lots. The application of these tools in the analyses on built environments shows clearly that micro scale spatial relationships have impact on street life and street safety in urban areas.

**Spatial Configuration on Various Scale Levels**

As various studies have shown, the spatial configuration of a city's street and road net affects people's natural movement patterns and the distribution of shops and retail (Hillier et. al. 1993, 1998, Hillier 1999, Van Nes 2002). Likewise, the street net's spatial configuration influences the geographic and temporal distribution of crime and anti-social behaviour (Hillier 1996, Shu 2000, Alford 1996, Hillier and Sahbaz 2005). However, the spatial relationships in these studies are mainly calculated on a *macro* spatial level.

Little research is done so far on the *micro* scale spatial level when it comes to the relationship between buildings and streets. The few conducted studies make it clear that micro scale spatial conditions such as a target's degree of exposure to neighbours play a role on where burglaries take place (Shu 2000, p. 33).

## Micro Spatial Relationships

A method describing micro scale spatial variables in urban studies aims at defining the inter-relationship of buildings or private spaces and adjacent street segments. Therefore, a micro scale spatial analysis focuses on how dwellings relate to the street network, the way buildings' entrances constitute streets, the degree of topological depth from private space to public space, and inter-visibility of doors and houses across streets. As Jane Jacobs and Jan Gehl argue, many entrances and windows facing a street is one formula to ensure urban liveliness (Jacobs 2000) and (Gehl 1996). The challenge is to quantify these kinds of spatial relationships. Only then it will be possible to gain a genuine understanding on the spatial conditions for vital street life and urban safety.

Micro scale spatial relationships between private and public space determinate to what extent individualistic life styles can interfere with street life and visa versa. Since up to date no consistent method is available, we wanted to explore the possibilities to improve existing spatial analysis methods on the topological relationship between private and public space.

The aim of this inquiry is to quantify the various topological spatial properties on the relationship between buildings and streets. In this respect, the individual properties had to be observed in particular urban areas and correlated to the other spatial properties on a micro as well as macro scale level. Moreover, the spatial variables had to be correlated with crime distribution and the location of various functions in urban areas. As the results show, a street segment's topological location in relationship with the main route net through urban areas is a factor affecting most of the micro scale spatial variables. The main route net is identified by the angular total depth analyses with a radius 3.

### The Data

In a research project on space and crime in the Dutch towns Alkmaar and Gouda, an opportunity was provided to register various spatial relationships between private and public spaces (López & Van Nes 2007). The variables were observed and registered during the field work and used in statistical analysis.

In each city one local area was chosen and studied in detail. These areas are more or less comparable when it comes to their function (mainly residential), size and the large variation of their social and architectural composition. The social composition of dwellers in both areas is mixed as they house residents of all income classes. Likewise, a large mixture of various housing types and street layouts from different time periods were present in both areas. The local areas contain boroughs with homogeneous building types as well as areas with a mixture of several types. Various examples of design ideologies are present in both areas. In total 1.168 street segments were observed and 25 different spatial features registered on the spot.

### The Method at Issue

For each street segment the street name, the house numbers at issue and the building period is registered. The number of objects located along each street segment is registered by counting the number of dwellings, parking lots, shops, cafés or pubs, and other buildings. In the "others" group, schools, public buildings, offices and retail are included.

With regards to the topological relationship between private and public space the following features are taken into account: topological depth

between private and public space, degree of inter-visibility of entrances and windows, degree of constitutedness, street form, street function, the density of entrances connected to the street, inter-visibility from windows on parking lots and degree of territoriality. Since values of some variables can differ for each side of a street segment, each side was registered separately. Some segments have several buildings with direct connections to public space on one side while there can be high rise flats with several apartments on the other side.

The results of the micro spatial observations were put in a database together with various macro scale variables derived from the computerised axial and segment analyses of the street and road net and the number and characteristics of residential burglaries and thefts from cars in each street segment. Risk band analysis is used to test the relationships of the spatial characteristics of street segments and crime dispersal and to test whether or not the spatial characteristics are inter-related. In the following sections, the operationalisation of the different micro spatial features will be explained in detail.

### ***Topological Depth Between Private and Public Space***

There are several ways of analysing spatial configurative relationships between building entrances and the street network. An easily way is to register the *topological depth* between private and public space (Hillier and Hanson 1984, p. 102). This can be done as follows: one counts the number of semi-private and semi-public spaces one has to walk through to get from a private space to its public street. If an entrance is directly connected to a public street, it has no spaces between private and public space. Then the depth is equivalent to zero. If there is a small front garden between the entrance and the public street, the depth value is one since there is one space between the closed private space and the street. If the entrance is located on the side of the house and it has a front garden or it is covered behind hedges or fences then the topological depth of the entrance has a value of two. Entrances from back alleys covered behind a shed have a value of three. It is the topological steps between the street and the private spaces that are counted.

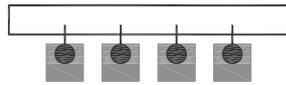
Entrances into flats can be represented in several ways. It all depends on the degree of permeability between the private space and the street. Some flats have upper walkways where the entrances to each apartment are connected. Visitors can walk all the way up to each apartment's front door in order to ring the doorbell. Other flats have a closed main entrance, where visitors have to use a calling system when visiting someone. In for example Manhattan - New York, flats' main entrances are directly connected to a public street. At the main entrance there is a guard or caretaker controlling who is entering the building. How should one count the depth of entrances in these cases? During the registration of the local areas in Alkmaar and Gouda, the degree of permeability was used. Where a flat's front door or main entrance was permanently locked and provided with a doorbell or calling system, it was registered as a private space from thereon. When flats have open main entrances, the number of semi-private spaces was counted up to the apartments.

Each side of a street segment must be registered separately. There are many streets where entrances are directly connected to the street on the one side, while there is a flat with an upper walk gallery on the other side. If a street segment's side has several depth values between private and public spaces, the average value is used.

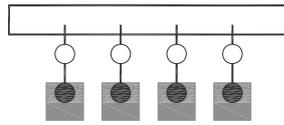
The diagram in figure 1 (top) illustrates various types of relationship between private and public spaces. The black dots represent the

private spaces, while the white dots represent semi-private and semi-public spaces.

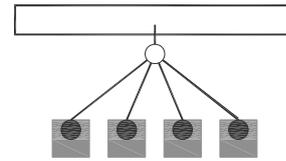
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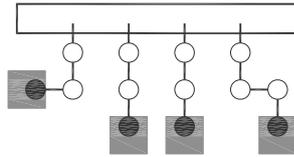
Entrances zero topological step between a street and private spaces



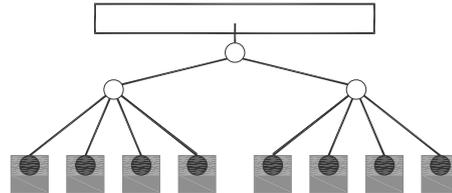
Entrances one topological step between a street and private spaces



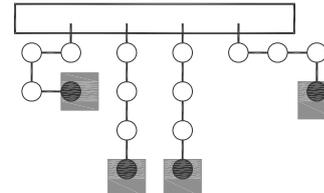
Entrances one topological step between a street and private spaces



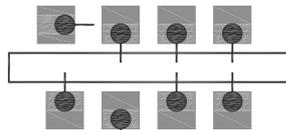
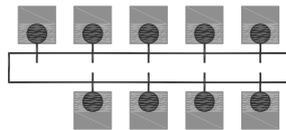
Entrances two topological step between a street and private spaces



Entrances two topological step between a street and private spaces



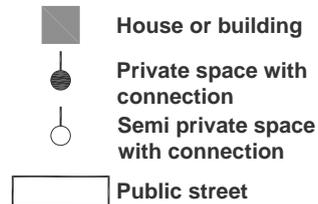
Entrances three topological step between a street and private spaces



Examples on constituted streets



Examples on unconstituted streets



**Figure 1:**  
*How the topological depth from entrances (top) and degree of constitutedness (bottom) is calculated*

In most traditional urban areas, housing entrances often directly face the streets. In most post War urban areas, however, one has to walk through several semi-private or semi-public spaces before private spaces are entered. Moreover, in post War areas with detached houses, entrances are not always directly connected to the street. Many houses have the main entrance on the side facade rather than at the street plinth.

The same topological features can be seen in traditional shopping areas and modern shopping centres. In shopping centres one must walk through a central entrance in order to reach several shops. A characteristic of these shopping centres is that, except from the main entrance, the shop entrances are not oriented towards the street. In many cases the facade is a large wall with "blind" windows, sometimes covered with advertisements. Conversely, a feature of traditional shopping areas is a high density of shop entrances directly connected to the street.

The topological depth from private to public spaces seems to increase in highly segregated urban areas and in areas topologically far away from the main routes. Visitors usually frequent the main routes, while the streets of the topological deep neighbourhoods are predominantly used by its inhabitants. This gives the neighbourhood a desolated atmosphere. Dwellers inside these areas often prefer to protect their private life from insights from neighbours. When the streets are too much occupied by neighbours and there are almost no visitors around, the social control from neighbours can be too present. Therefore curtains and high hedges are used to prevent social control. Entrances are hidden away from streets and visible neighbours.

Urban areas located close or adjoining to main routes tend to have entrances directly connected to public streets. The streets are frequented by visitors as well as by inhabitants. The inhabitant wants to be a part of the urban street life. Often dwellers contribute to street life by sitting outside on a chair or the stair case in front of their homes. From their windows, dwellers keep an eye on what is going on outside. In many topological shallow areas, inhabitants like to contribute to the urban living by displaying their interiors to the view of passers by.

023-05

### **Constitutedness and Un-constitutedness**

A street's degree of constitutedness depends on how building entrances are connected to a street. It is about the degree of adjacency and permeability from buildings to public space (Hillier and Hanson 1984, p. 92). When a building is directly accessible to a street, then it constitutes the street. Conversely, when all buildings are adjacent to a street, but the entrances are not directly accessible, then the street is un-constituted. A street segment is constituted when only one entrance is directly connected to the street. If the entrance is hidden behind high fences or hedges, or located on the side of the buildings, then the street is defined to be un-constituted.

The diagram in figure 1 (below) illustrates the differences between constituted and un-constituted streets. It is thus a difference between a building located *adjacent* to a street and being *permeable* from a street. Spatial relationships of this kind can have impact on vital street life in urban areas.

Figure 2 shows some examples on constituted and un-constituted streets. The two examples on the top represent constituted streets. In both cases the entrances are located only at one side of the street. The example on the left is a street dating from 1600 and the example on the right is a street from the 1970's. Both examples below in figure 2 represent un-constituted streets. No entrances are directly connected to these streets. The example on the left is a street located in a high rise flat area from the 1960's. One has to go into the semi public side streets in order to reach the flats' main entrances. In the example on the right, dating from the 1990's, all the apartments are located adjacent to the street. Even though the street is highly visible from all the apartments' windows, all entrances are located at the buildings' backsides and the underground parking garages.

Street and street segments are not always 100% constituted or un-constituted. In order to measure various degrees of constitutedness, the number of entrances directly facing a street in comparison with the number of adjacent buildings is at issue.

There are several ways of visualising the "urban network - building permeability" relationship. Bill Hillier and Julienne Hanson use the concept "the interface map" to illustrate street links directly connected to adjacent buildings (Hillier & Hanson 1984, p. 104-105). This is done in the following way: one marks all the entrances of the buildings, which are both adjacent and directly connected to the street net. In

this way, one can give a colour code for each street segment, which is directly connected to one or more dwellings. Then the same can be done with street segments where there is one space between the dwelling entrance and the street, where there are two spaces between the entrance and the street etc.

023-06



**Figure 2:**

*Some examples on constituted and un-constituted streets*

Hillier and Hanson also use a method where one makes a *converse interface map* of the street net - building permeability relation. Here street segments are marked only when there are no building entrances connected directly to them. A registration of this kind shows where there is a relation of adjacency and permeability (Hillier & Hanson 1984, p. 105). The purpose of this kind of mapping is to visualise a streets' degree of constitutedness in an urban network.

Chih-Feng Shu applied another variant in order to quantify various degrees of constitutedness in his PhD thesis *Housing Layout and crime vulnerability*. According to Shu, urban space is defined to be constituted when more than 75% of the adjacent dwellings have front doors facing directly to the street. If a street segment consists of four buildings and three of them have their entrances directly connected to the street, the street is considered to be constituted (Shu 2000, p. 119). A street with no entrances connected to it is thus un-constituted (Hillier and Hanson, 1984, p. 92). Clear examples of un-constituted streets are subways and highways.

The number and density of entrances are not at issue. The degree of constitutedness is about the number of entrances connected to a street divided by the number of buildings located along that street.

As research has shown, there is a correlation between the degree of constitutedness and the dispersal of burglaries. In his PhD thesis, Shu used the degree of constitutedness of streets in order to study the spatial characteristics of burglarised streets. As his research shows,

un-constituted streets are affected more by residential burglary than constituted streets. Entrances covered behind high fences and hedges have little visibility from neighbours and burglars seem to prefer spaces of this kind (Shu, 2000, p. 445).

Figure 3 visualises the difference between constituted and un-constituted streets in Gouda. This research focuses on street segments and uses the definition of Shu to differentiate constituted and un-constituted street segments. Un-constituted street segments are marked with a grey colour, while the constituted ones are coloured black. As can be seen from figure 3, most intruded homes (presented as dots) are entered from un-constituted street segments. The points of entry into dwellings are marked with a line from the street or back alley to the dot.

**Figure 3:**

*A visualization of the constituted and un-constituted streets in Gouda*

023-07



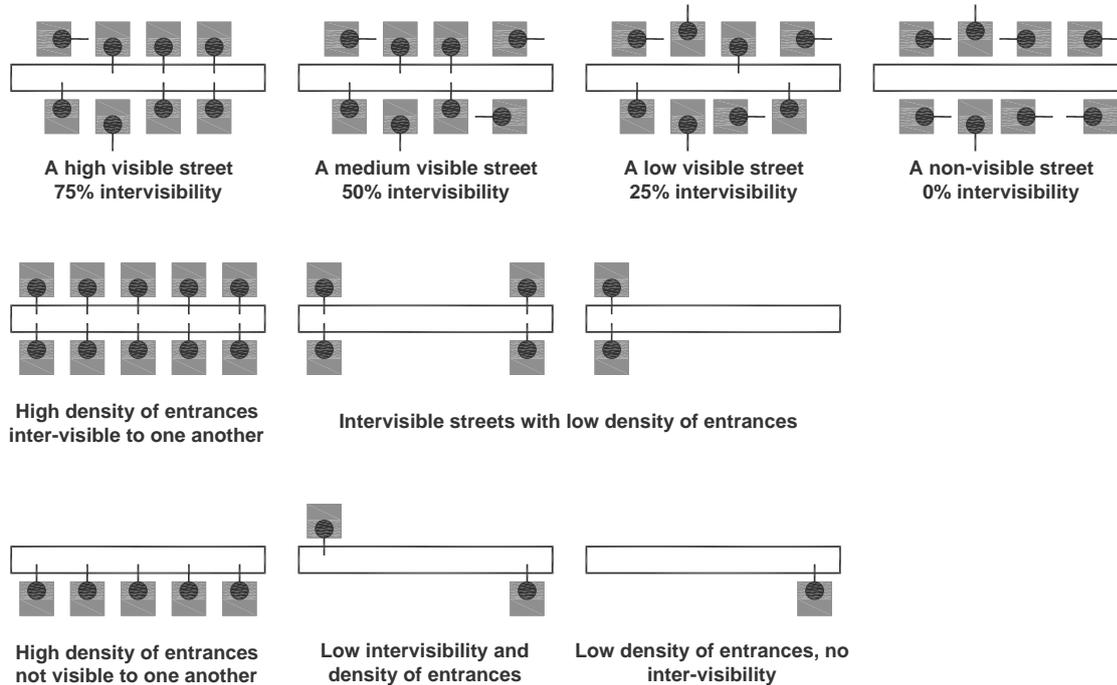
### ***Inter-visibility and Density of Entrances to Streets***

The more entrances connected to a street, the higher the probability that someone can come out from a private space into the public space. However, high density of entrances connected to a street does not always imply high inter-visibility. There is a distinction in the way entrances constitute streets and in the way they are inter-visible to each other. The way entrances and windows are positioned to each other influences the probabilities for social control. Figure 4 shows some diagrammatic principles on the relationship inter-visibility and density of entrances.

There are several ways of measuring various degrees of inter-visibility. In a study on the relationship between burglars' home address and the location of his targets, four different degrees of entrance inter-visibility were used. In this study, a street was considered highly inter-visible if the density of entrances is high and more than 75% of them are inter-visible to one another. An inter-visible street can have a low density of entrances, but more than 75% must be inter-visible to one another. A

street has low inter-visibility if the density of entrances is high and more than 75% of them are located on one side of the street. Likewise, streets with all entrances at one side of the street, with no entrances at all or with entrances covered by high hedges and fences are defined as non-visible (Van Nes 2005, p. 483).

023-08



**Figure 4:**

*Diagrammatic principles on the relationship inter-visibility and density of entrances*

In the local areas of Alkmaar and Gouda, a registration of windows and doors inter-visible to one another and to the street segment were carried out. The number of inter-visible houses was divided by the total number of houses in the street segment. The percentage of inter-visibility from windows and doors from houses to streets and between houses was registered separately. The percentages were grouped in 100%, 80%, 60%, 40%, 20% and 0% inter-visibility for each registration. The density of houses and entrances were not taken into account. This was registered separately. Thus, two buildings with two entrances facing towards each other indicate 100% inter-visibility of doors. Conversely, a street segment with high density of entrances on only one side of the street segment and no entrances on the other side is defined to be 0% inter-visible. High density of entrances directly facing a street segment at only one side can be an indicator for street life, but is not necessarily a sufficient condition for crime prevention. A strong correlation was found between a street segment's inter-visibility and the risk on residential burglary (López & Van Nes 2007).

The calculation inter-visibility between buildings and parking lots was carried out in the same way as between buildings. In every street segment the number of parking lots visible from buildings is divided by the total number of parking lots.

In traditional Dutch urban areas, the density of entrances is generally high. This is in contrast to sub-urban areas with detached houses and post War urban areas with flats. Different cultures have different degrees of entrance densities. In Scandinavian countries for example, the density of entrances in urban areas is low in comparison with central European cities.



023-09

### **Street Form and Street Function**

The street *form* describes the mode of transport suitable for the street as well as the spatial possibilities for a perpetrator's escape. In line with Shu (2000, p. 115-117), street form was categorised as: through carriage ways, cul-de-sac carriage ways, pedestrianised street, cul-de-sac driveways, through footpaths, cul-de-sac front footpaths and cul-de-sac back alleys.

For the definition of the street *function*, the classification of the Dutch Ministry of Housing, Spatial Planning and the Environment was used (VROM 2004). However, this classification turned out to be too rough and not suitable for precise registrations and categorisation of street segments. Some streets fit several categories, while others do not fit any of them. VROM uses the following classification: shopping street, urban traffic road, dwelling (upper floor) and office (ground floor) street, mixed household dwelling street in urban areas, flats in green areas, run down area street, family dwelling street in urban areas, dwelling and offices in low rise buildings street, low rise buildings along footpath, family dwelling street in green areas and detached housing. This kind of classification relates more to the area type where the streets are located, rather than the street function itself. As one might expect, no significant correlations are found between VROM's functional street classification and the topological spatial variables.

### **Degree of Territoriality**

During the observations, the degree of territoriality of the different street segments was taken into account. Although this is a very subjective variable, it was in general easy to identify the degree of territoriality in public streets and semi-private back alleys with a high degree of territoriality. Semi-public back alleys and streets were more difficult to classify. Hence, they are considered to have a medium degree of territoriality.

**Figure 5:**

*Inter-visibility of windows in Gouda with the dispersal of burglaries*

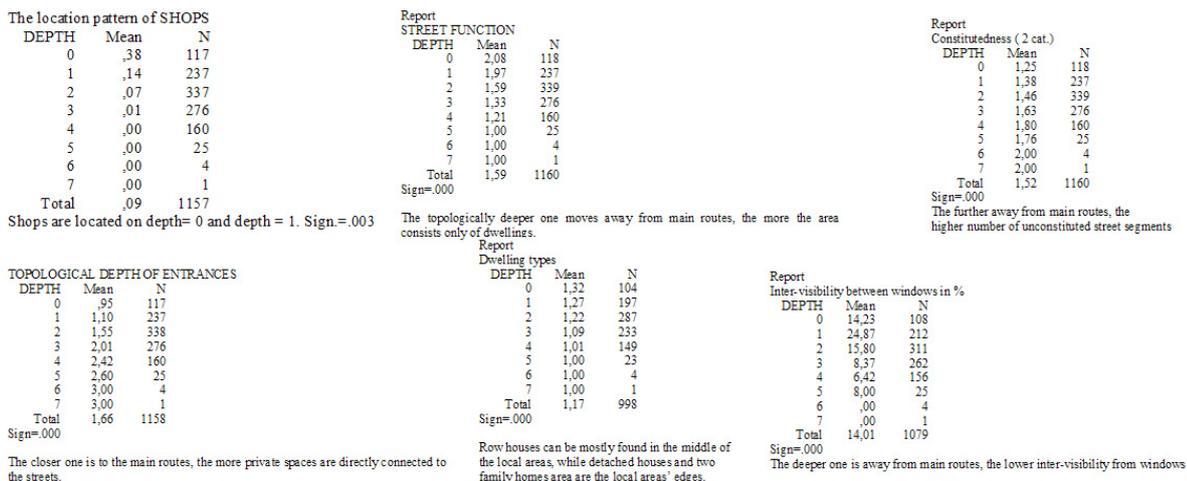
## Combinations of Micro Spatial Measurements

A combination of various micro spatial measurements makes it possible to quantify the micro spatial features of neighbourhoods. These features are, however, not always present in studies focusing on the macro spatial analyses. For example, a street with few connections to its vicinity can still be full of social activities if a high density of entrances constitutes the street and when there is high visibility between public and private spaces. The reverse can be seen in, for example, distributed un-constituted streets with a low number of entrances and low inter-visibility. Independent of cultures and architectural styles, micro spatial measurements make it possible to describe the spatial set up of built environments on a local scale level. Thus, an urban area's degree of liveliness depends on the spatial conditions on a macro level as well as on a micro level. Therefore, both scale levels must be taken into account.

### The Relationship with Macro Spatial Variables

As the results from the spatial analyses in Gouda and Alkmaar show, both micro and macro spatial variables are highly inter-dependent (López & Van Nes 2007). Especially the topological depth of a segment in relationship to its nearest main street gives a detailed description of the spatial set up of the area. In this way, most micro spatial variables turn out to be related to the macro scale variable *angular total depth with radius 3*. This variable identifies the main routes through cities and shows strong correlations with the micro-scale variables. The following results were obtained (figure 6).

**Figure 6:**  
Statistical diagrams



The deeper a segment is situated inside an urban area, the greater the topological depth between private and public space. Along the main routes through urban areas, most entrances are directly connected to the street. When changing direction two times from the main routes, the average topological depth for entrances is 2 while it is 3 in all street segments that are located more than six topological steps from the main routes.

The topologically deeper a street segment is, the more mono-functional the adjacent buildings tend to be. Topological deeply located street segment usually only have a residential function, since offices, shops and public buildings tend to locate themselves along the main routes. The semi-private segments are among the topological deepest and segregated streets. Row houses and flats tend to be located along topological shallow street segments, while maisonettes, vertical separated dwellings and detached and semi-detached houses are located at the areas edges.

The further a street segment is away from the main routes, the lower the values of segment connectivity, global and local integration, control and constitutedness. Homes located along un-constituted streets deeply located inside urban areas with low inter-visibility from windows tend to have a high risk of being burglarised. The unconstituted back alleys tend to be the topological deepest street segments.

## Discussion

As the study in Gouda and Alkmaar shows, micro spatial relationships play a significant role in the socio-economic life of human beings. The micro spatial conditions influence the quantity and quality of street life and the risks on criminal victimisation. This is not only important for urban studies, but also for the design and planning of our cities.

023-11

Micro scale conditions are often neglected in the contemporary planning and design of urban areas. In particular, urban renewal projects, modern housing areas and new large-scale urban development projects often tend to lack adjacency, permeability and inter-visibility between buildings and streets. This has negative effects both on the quality and quantity of the street life and the safety of these urban areas.

Urban project developers nowadays tend to build with high density or high floor-space-index and propose large variations of urban functions (dwellings, offices etc) in these areas. However, the degree of inter-connectivity and the topological shallow public-private interface is often forgotten. All these activities depend on how the spatial configuration is on the plinth or built up street sides. Therefore, there is a need to bring micro scale spatial relationships on the research, policy making as well as the design agenda in the urbanism discipline.

The content of this paper is based on a study of only 1.168 street segments in two local areas in two Dutch cities. As the study clearly shows, the micro spatial conditions of the street segment are inter-related to the macro spatial conditions of the cities street network. The definition and operationalisation of the micro scale conditions is, however, still in a preliminary phase and an area that can be improved upon in the near future. At least, some concept useful in urbanism can be introduced and bring some significant aspects into the urban sustainability and compact city debate.

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