Spatial tools for diagnosing the degree of safety and liveability, and to regenerate urban areas in the Netherlands

AKKELIES VAN NES, MANUEL LÓPEZ, LAURA DE BONTH, DIRK VERHAGEN, SIMONE WAAYER

Nes, A., López, M., de Bonth, L., Verhagen, D., & Waaijer, S. (2016). Spatial tools for diagnosing the degree of safety and liveability, and to regenerate urban areas in the Netherlands. *Research In Urbanism Series*, 4(1), 139–156. doi:10.7480/rius.4.853

Abstract

This contribution describes the tool Social Safe Urban Design (SSUD), seen together with socio-spatial and linguistic challenges when applying space syntax in the regenerating of problem urban areas. The Space Syntax jargon is technical and needs to be translated into a language understandable and acceptable to stakeholders who are responsible for the implementation of improvement strategies acceptable for the users of a neighbourhood. Moreover, the degree of public-private interface between buildings and streets needs to be incorporated in the Space Syntax analyses. As it turns out from spatial analyses and crime registrations, there is a correlation between crime and anti-social behaviour and the spatial layout of built environments in the investigated eight pilot cases. Simultaneously, there is also a challenge to come up with locally and globally functioning spatial solutions for reducing opportunities for crime and anti-social behaviour for the neighbourhoods. Proposed solutions for three of these neighbourhoods are presented in this contribution.

KEYWORDS

Space syntax; Urban regeneration; Network configuration; Crime; Communicative planning

1. INTRODUCTION

The past five years, several deprived neighbourhoods in the Netherlands have received special attention for improving their liveability, safety and socio-economic position. The main focus is on improving the social and economic position of the neighbourhood's inhabitants, the quality of the built environment itself and formal surveillance. As far as the built environment is concerned, the emphasis is primarily on the physical properties (such as renovating buildings and playgrounds) of the neighbourhoods, while the spatial properties are largely overlooked.

In this context, the project Social Safe Urban Design (SSUD) was conducted. This project resulted in a new tool for the (re)vitalization of new and existing residential neighbourhoods. The basis of this tool lies in a national survey, which was carried out in 43 neighbourhoods and in eight pilot neighbourhoods the approach was further refined and applied. In the Dutch municipalities of Alkmaar, Deventer, Eindhoven, Maastricht and Utrecht consultancy projects were carried out in which the researchers and local stakeholders worked together to draft recommendations and interventions for possible improvement of the liveability, safety and economic potential of the pilot areas. This contribution presents the SSUD project as an example of how space syntax can be applied in consultancy practices: how to make space syntax understandable and acceptable to the laymen and what challenges do we need to overcome to translate scientific knowledge into practical and feasible interventions.

2. INVOLVING THE STAKEHOLDERS

The specific agendas of the local stakeholders and policymakers need to be recognised for identifying what they consider as key issues for the neighbourhood. Mutual understanding and consensus need to be established and interactive workshops are a good way to achieve this (Forester, 1989; Arnstein, 1969). The challenge is to translate the space syntax jargon into a terminology understandable for the involved stakeholders who have a practical rather than a scientific interest in the problems at hand. This rhetorical approach implies in this case that the pathos (the words used) and logos (the correlation between safety, vitality and spatial configuration) in re-design proposals have to be understandable for all involved parties. Likewise, the ethos of the approach is to propose solutions that are both understandable for the users and that can reduce the opportunities for crime and ant-social behaviour (Asmervik, 1998). In this way, the local stakeholders feel an ownership to the plans as well as the feeling to have participated in a plan contributing to increase the safety and vitality of the neighbourhoods. The communicative approach is the project's button-up approach.

The analytical approach is a top-down approach, consisting of correlating crime data provided by the police with the space syntax analyses. The re-

sults were presented to the various policymakers and (other) stakeholders. In addition, fieldwork was carried out consisting of a registration of the quality of buildings, public spaces, location of shops and services, and parks in the area, the liveliness of the streets and implemented crime prevention measurements (such as the Dutch Police Label Safe Housing).

The results from the analytical approach were used to construct several improvement scenarios for the neighbourhoods. They were presented to the local stakeholders and discussed at redesign workshops. Various models for redesign were developed and tested both on their spatial properties, forecasted effects on criminal opportunity and feasibility. Together with the stakeholders it was then decided whether these models are in the neighbourhoods best interest and how they can best be translated into measures effective and feasible to implement.

3. THE CONCEPTUAL FRAMEWORK

The term accessibility is used to describe global as well as local angular integration with a topological radius. As space syntax research has shown, the higher the degree of accessibility of the street system on various scale levels, the higher the number of people in the streets (Hillier, Penn, Hanson, Grajewski, & Xu, 1998). Conversely, a lower degree of accessibility reduces the number of people in streets, resulting in less natural surveillance. Streets with a low degree of accessibility on a local level in particular tend to be affected by burglaries (Van Nes, & López, 2010; Hillier, & Sabaz, 2005).

With the evidence from various space syntax studies, the following two principles are used in the improvement strategies for the eight neighbourhoods. The higher the degree of street accessibility on the local as well as on the city level, the more it generates a mixture of visitors and locals on the streets. A balanced mixture of different user groups on the streets increases the degree of informal social control, which in turn reduces the opportunities for crime and anti-social behaviour and increases the feeling of safety.

The term connectedness is used in this project to describe how the main route system that is going through and between neighbourhoods is connected to all the local streets. The angular step depth analysis from space syntax provides insight in how a main route is connected to the local streets. When most dwelling streets are more than two direction changes, or more than one direction change with sharp angles from the main route network, the area scores low. When a main route is located outside the neighbourhood, the local streets tend to get extremely low values in the angular step depth analyses. Conversely, when a main route goes through the area, the local streets get high values. In these cases most streets of a neighbourhood can often be reached within two direction changes.

Research has shown that the higher the number of direction changes

from the main route network, the higher the risks on burglary (Van Nes, & López, 2010) and anti-social behaviour (Rueb, & Van Nes, 2009). Therefore, the following principle is used in this project: the lower the number of direction changes from the main routes, the lower the burglary risk.

Vitality refers to the spatial potential for vital street life and successful local businesses. When a main route goes through the neighbourhood combined with high integration values, it contributes to the location of small businesses inside the neighbourhood (Hausleitner, 2010; Van Nes, Berghauser Pont, & Mashhoodi, 2012). When a main route is located around the neighbourhood, the neighbourhood tends to lack small businesses and the area consists of only dwellings (Yu ye, &, Van Nes, 2014). Especially the overlap between the angular analyses with high and low metrical radii appears to be important. When these two analyses do not correspond, the neighbourhood lacks the spatial framework supporting urban vitality. These neighbourhoods tend to lack street life and various facilities.

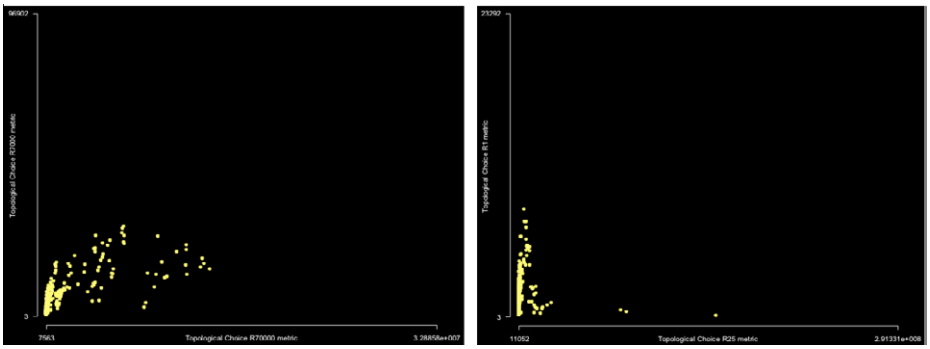

Figure 1. Two different scatterplots showing the correlation between the angular analyses with a high and a low metrical radius. The scatterplot to the left is from a vital neighbourhood where the scatterplot to the right is from a mono-functional problem neighbourhood.

Figure 1 shows a scatterplot of two different neighbourhoods. In the scatterplot to the right, the plots have an L-shape. In this case, streets with high values on the metrical high radius have low values on the metrical low radius and vice-versa. These neighbourhoods tend to lack street life due to the fact that the main routes are located outside the neighbourhood. Often these neighbourhoods tend to be very mono-functional, consisting of mostly dwellings. In the scatterplot to the left, the values correspond. Streets with high values on the metrical high analyses have also high values on the metrical low analyses. These neighbourhoods tend to have the main routes going through the area and to have micro-businesses located along these main streets.

It is important to explain to the local stakeholders and involved parties that a smart lay-out of the street network does not only limit the opportu-

nities for crime and incivilities. It also shapes opportunities to improve the economic potential of the area and vital street life.

Visibility is about how visible the streets are from dwellings on ground floor level and how well dwellings are visible from streets (Van Nes, & López, 2010). The position of entrances and windows are plotted on maps, providing insight in the extent to which public spaces are directly visible to visitors and residents, and the location of visual barriers. The degree of visibility can be combined with the space syntax maps. Separate maps are made, providing insight in the extent to which public spaces are directly visible to visitors and residents, and the location of visual barriers. Regarding visibility, the following principle is used in this project. Both windows and doors located on ground floor level contribute to informal social control between people in streets and people inside buildings.

The identity of a neighbourhood – its character and atmosphere – is largely determined by the attractiveness of the neighbourhood, the aesthetic quality of the buildings and public spaces, the diversity of buildings, the clarity of the functions of the public spaces, the orientability of the route system for visitors, and attractive well maintained public facilities. The use of semi-public spaces almost always generates problems when the function or management of these areas is unclear (Luten, 2008). In determining the identity of a neighbourhood, data are collected on the quality and diversity of the buildings, the facilities provided, the amount and use of public parks and the level of maintenance and management. The following principles are used in this project: clarity of functions, an intelligible routing system and attractive well maintained public facilities contribute positively to the character and atmosphere of the neighbourhood.

4. GENERAL FINDINGS

The first phase of the Social Safe Urban Design (SSUD) project consisted of a national inquiry in which spatial, crime and social data of 43 deprived Dutch neighbourhoods were collected and analysed on the neighbourhood level (Van Nes, & López, 2013) and data of four neighbourhoods were studied in detail on the level of the street segment. This resulted in the model Social Safe Urban Design with various insights regarding the accessibility, connectedness, vitality, visibility and identity of neighbourhoods and their relation to the spatial distribution of crime and social parameters.

As it turns out, there are strong correlations between spatial accessibility and connectedness and crime dispersal inside the neighbourhoods. Street segments with poor values on accessibility, connectivity, vitality, visibility and identity are more often affected by crime and anti-social behaviour than streets with good spatial values. There are, however, examples of neighbourhoods (e.g. Oudegoedstraat in Deventer) where the technical standards of the

dwellings are at such a high level that it overruns the poor spatial properties of the neighbourhood, keeping the number of residential burglaries low. With regards to the social composition of dwellers, it turns out that low-skilled non-European immigrants and low-income people tend to be clustered in neighbourhoods that score low on the spatial analyses concerning accessibility and connectivity (Rueb, & Van Nes, 2009)). How and in which way accessibility and connectedness relate to criminal dispersal depends on the type of crime. As Valerie Alford already concluded: 'Different types of crime occur in different types of space' (Alford, 1996, p. 64).

The national inquiry resulted in several statements that have been taken into account during the in-depth study of the eight pilot cases and in the definition of the urban renewal scenario's and measures proposed to revitalize these areas:

- An integrated main route through the neighbourhood contributes to a natural mixture of visitors and inhabitants and to a mutual social control between them.
- Dwelling streets that can be reached within one to two times direction changes from main routes tend to have a lower burglary risk than dwelling streets with more than two times direction changes.
- Street with blind walls adjacent to services and local shopping centres contribute to a clustering of youngsters making noise and disturbances.
- Neighbourhoods with streets with low values on the local angular integration analyses with a topological radius tend to lack street life and location of small local businesses.
- Neighbourhoods with streets that have high values on the local angular analyses with both high and low metrical radii have lower incidents of vandalism and anti-social behaviour of youngsters than neighbourhoods where these aspects do not overlap.
- Streets with high spatial integration contribute to more people in streets and to the location of small businesses. These streets are perceived to be vital and social safe streets.

The studied eight pilot cases yielded the following findings in relation to criminal dispersal:

- Residential burglary mainly takes place in the streets furthest away from the main routes, most commonly in places with low degrees of intervisibility.
- Theft from cars is most common in streets close to the main routes, in particular on large parking lots.
- Threats and fighting are especially common in segregated streets with poor intervisibility.

- Physical abuse and threats generally take place in streets that are poorly connected to the main route network.
- Anti-social behaviour of youngsters generally take place close to service and shopping functions on streets adjacent to the main routes, and spots with poor intervisibility.
- Vandalism is most common along the main routes, at schools, youth centres and public transport stops/stations.

5. EIGHT PILOT CASES

The SSUD model and the findings of the national inquiry have been used to analyse eight neighbourhoods in five different Dutch municipalities, to develop scenarios and models for revitalisation, and measures to improve the safety and vitality of these neighbourhoods. The eight cases cannot all be described as deprived areas. They all have challenges with regards to vitality and some of them have social or criminal problems. During local workshops, a wide range of both radical and minor interventions were explored and discussed with the stakeholders. In this contribution only the final proposals are presented, which are the ones that according to all parties involved are both feasible and effective. The coming years will show which interventions are actually implemented and how effective they turned out to be.

The eight cases vary a lot in terms of the social composition of dwellers, building typology, building period and planning ideologies. Two of the neighbourhoods are yet to be built. The cases can be classified as: pre-war working class neighbourhoods (Rode Dorp in Deventer and Mariaberg in Maastricht), post-war housing neighbourhoods (Kanaleneiland in Utrecht, Pottenberg in Maastricht and Vaartbroek-Eckart in Eindhoven), and post-modern/new urbanism neighbourhoods (Hoge Weide in Utrecht and Vroonermeer-Noord and -Zuid). In this section, three of these neighbourhoods are described as an example of each category.

6. PRE-WAR NEIGHBOURHOODS

Rode Dorp in Deventer is a typical pre-war working class neighbourhood, housing a relative high number of poor immigrant and youngsters. In the spatial analyses, the area scores quite well. The area has gentrification potentials, due to its proximity to Deventer centre and provision of relatively integrated main routes running through the neighbourhood. Figure 2 shows the space and crime analyses of the Rode Dorp area. The most integrated streets have high values in the angular analyses with both high and low metrical radii. The accessibility of the main route Boxbergerweg is high. The main route Enkstraat and many residential streets are however not so well connected and therefore more vulnerable to crimes such as burglary, assault and vandalism. Many public functions such as playgrounds and squares are located at segre-

gated streets poorly connected with the rest of the neighbourhood. Rode Dorp has several streets with blind walls and several unclear routings. The area has a strong place identity in the vernacular architecture of the buildings. Most of the buildings are small-scale row houses. In the south-western part, the area is disconnected to the surrounding neighbourhood due to the barrier formed by the rail track.

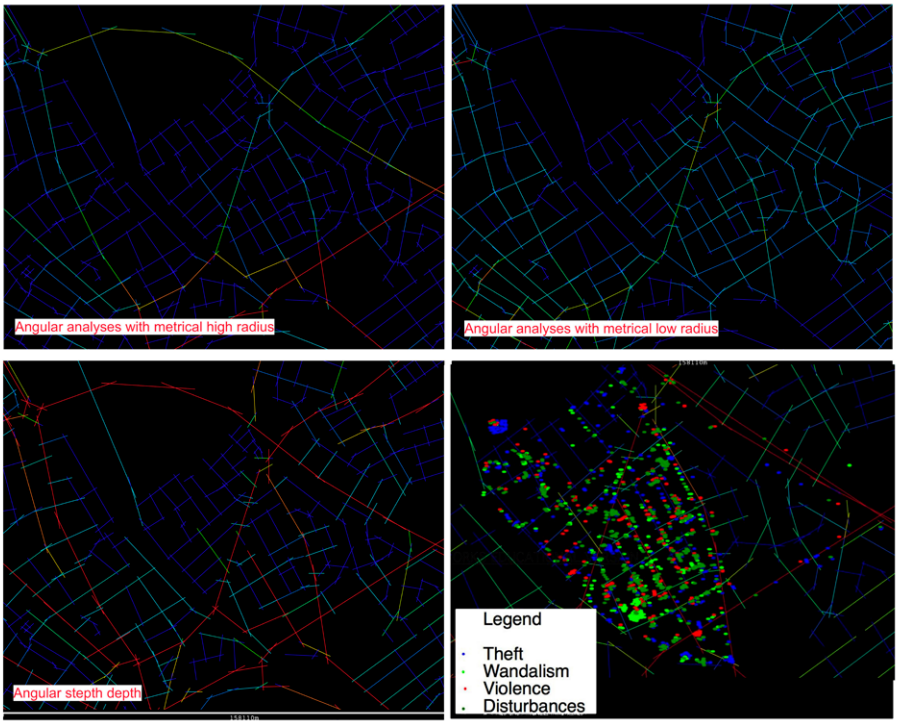

Figure 2. Space and crime analyses for Rode Dorp in Deventer.

To improve the safety situation in Rode Dorp and to create spatial potential for vital street life and small businesses, various design and urban renewal measures have been proposed. These measures focus on improving the vitality of the neighbourhoods' main route Boxbergerweg and the creation of a continuous cycle route along the rail track. Four different models have been proposed to increase the accessibility and connectivity of the three boroughs by linking several streets. On a micro-scale level, proposals are made to improve the visibility around the school, the youth centre and some of the squares and parks as well as the accessibility and visibility of the small playgrounds. As can be seen in Figure 3, the proposed changes increase the integration in the most segregated streets in Rode Dorp area.

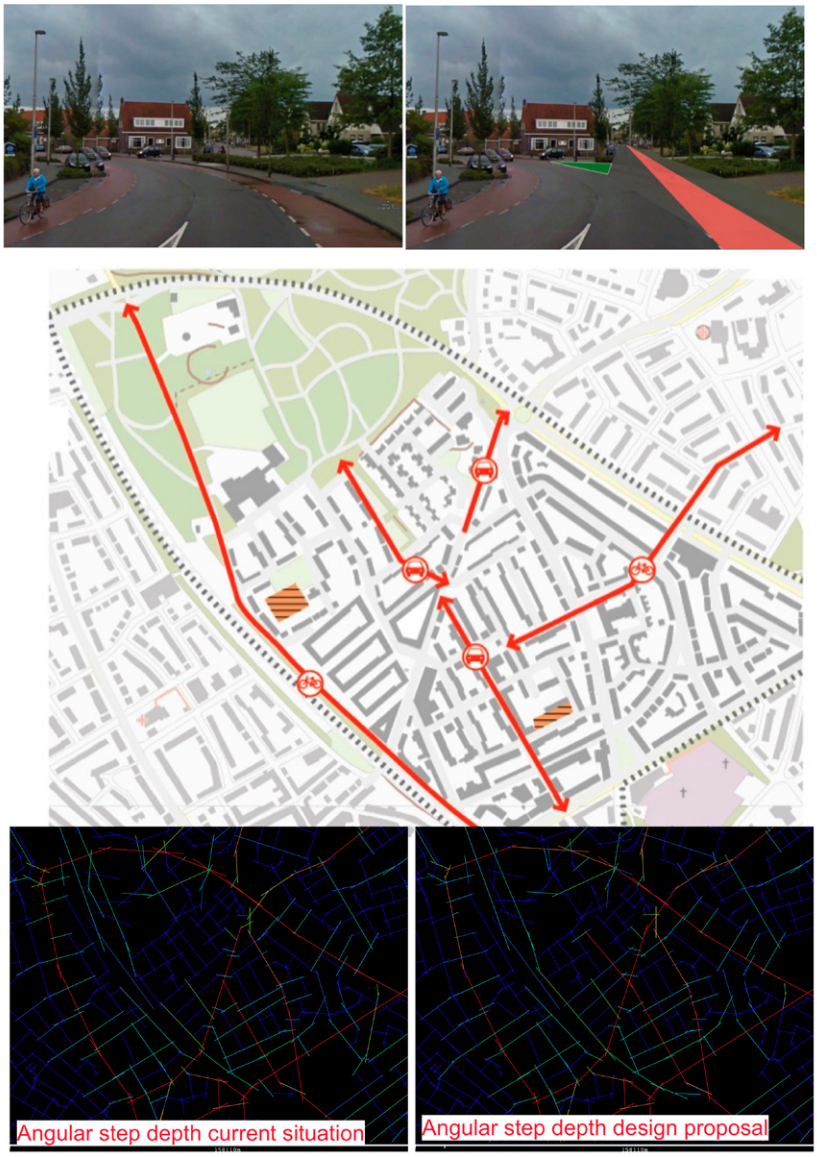

Figure 3. Improvement proposal for Rode Dorp in Deventer.

7. POST-WAR HOUSING NEIGHBOURHOODS

Kanaleneiland (Utrecht) is a good example of a Dutch post-war modernist urban area. Its socio-demographic and economic position is weak and the spatial characteristics are poor on almost all investigated variables. The neighbourhood consists of two areas divided by a road.

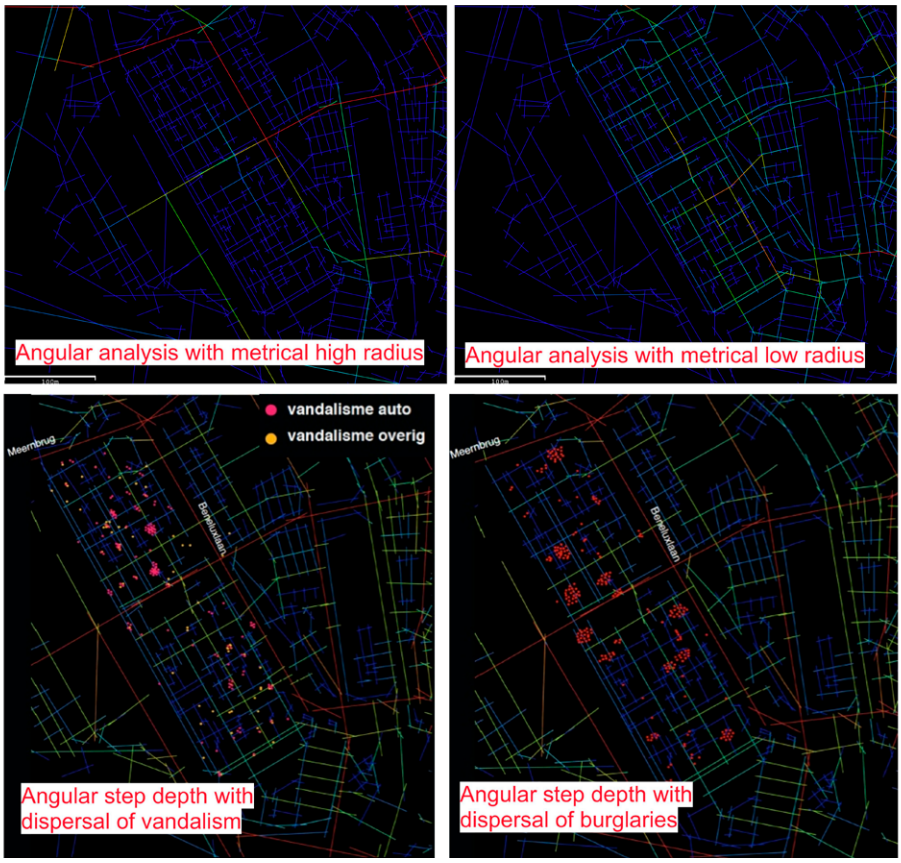

Figure 4. Space and crime analyses for Kanaleneiland in Utrecht.

Figure 4 shows the space and crime analyses of the Kanaleneiland area. The main routes in Kanaleneiland are mainly located around this neighbourhood. The main route between Kanaleneiland-North and -South has high integration values. The area has a grid structured street pattern which is broken up, due to a high number of T-junctions inside the area. Therefore, the various residential streets have low values in the angular step depth analysis. The local shopping centre in the area's southern part is located along streets with high values in the angular analysis with a low metrical radius, whereas the large inward oriented shopping centre for the northern part is located along the main route with high values in the angular analyses with high metrical radius. The dwellings in Kanaleneiland have their entrances on the most segregated streets in the area. The area has several playgrounds, but these are mostly located in segregated streets with little or no intervisibility. Several of the playgrounds and the parking garages look deteriorated.

The key to improve the spatial conditions of Kanaleneiland is to reconstruct the neighbourhoods' broken up orthogonal grid structure. This grid structure has been broken up at several points over the last few decades,

mainly at the hand of traffic engineers who reasoned it would be safer for pedestrians and bicycle riders when some streets were no longer fully accessible for motorized vehicles. The proposal for improving the spatial conditions in Kanaleneiland consists, therefore, in strengthening the main routes through the area. First of all, there is a need to make an internal main route in a north-south direction through the area, linking the northern and southern part of the area together. This route has to be well connected to the east-west oriented main route, which currently divides the area. The connection to surrounding neighbourhoods must also be enhanced and the same goes for the connection between local dwelling streets and the main routes. Figure 5 shows the spatial analyses of the design proposal. On a lower scale, the pedestrian accessibility between the northern and the southern part needs improvements. There are some new buildings adjacent to the east-west main route, but they lack active frontages towards this main route.

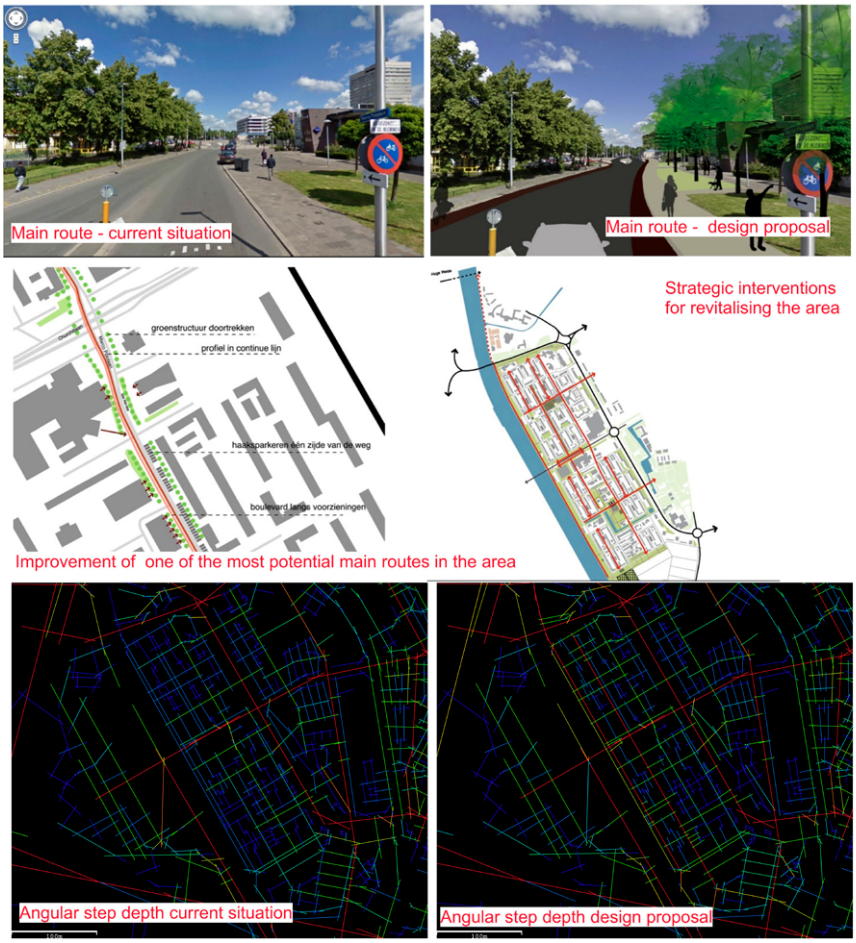

Figure 5. Improvement proposals for Kanaleneiland in Utrecht.

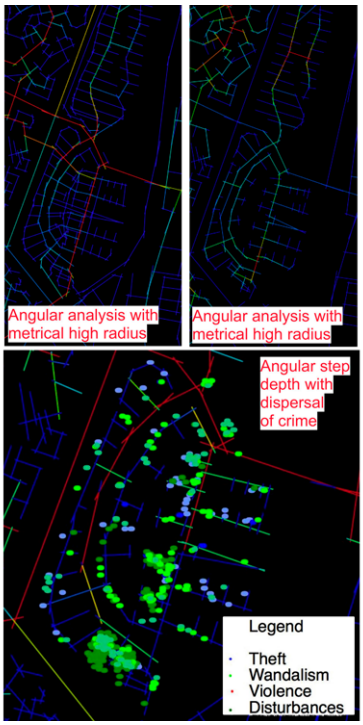

Figure 6. Space and crime analyses for Vroonermeer-Zuid in Alkmaar.

8. THE POST-MODERN/NEW URBANISM NEIGHBOURHOODS

Vroonermeer in Alkmaar is an example of contemporary urban design practice in the Netherlands. The first part of this neighbourhood – Vroonermeer-South – was completed in 2005 and consists of 1,230 homes. Vroonermeer-North is yet to be built. Like many other post-modern neighbourhoods, Vroonermeer is designed as a low-traffic residential area. The existing housing area and the new plans of the Vroonermeer-North consist almost entirely of residential houses. Vroonermeer-South only has one side access point for motorized traffic. The routes for cars, bicycles and pedestrians are largely separated and the streets accessible for motorized vehicles are blocked at two places leading to a highly segregated street pattern, offering poor accessibility between the neighbourhoods and its surroundings. As the spatial analyses of Vroonermeer-South shows in Figure 6, there are several spatial issues on various scale levels. The spatial characteristics of the proposed plan for Vroonermeer-North are much better than Vroonermeer-South. There is no separation between fast and slow traffic. The borough is accessible from both the north and south and vehicles can move through this area. In general, Vroonermeer-North's street pattern is better connected with the urban network than Vroonermeer-South. The main route running through the centre of this borough is fully accessible and well connected (Figure 7).

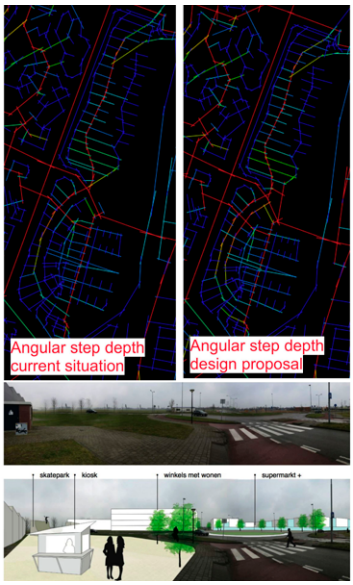

Figure 7. Improvement proposals for Vroonermeer-South in Alkmaar.

There are several issues concerning visibility. Several houses both in North as South turn themselves away from the main routes and green spaces. The orientation of the buildings, the lack of meeting places and the low accessibility do not provide spatial qualities that strengthen the bond between the residents. The streets are relatively quiet. There are almost no visitors from outside the neighbourhood and the residents themselves have no reason to stroll the streets. The level of crime is still relatively low in Vroonermeer, probably due to the social composition of dwellers. Many of the residents are hardworking commuters. There are many children in the neighbourhood, but still few teenagers. In ten years' time this may of course all be different. The most pressing challenges at this moment are lack of street life inside the area and scarcity of commercial and service functions.

To improve this situation various strategies and measures have been proposed (Figure 8). These strategies focus on making some routes accessible for vehicles, improving the accessibility of Vroonermeer-South, making spatial and physical changes for improving the vitality of the neighbourhood, and creating a new local centre connecting the two boroughs together instead of separating them.

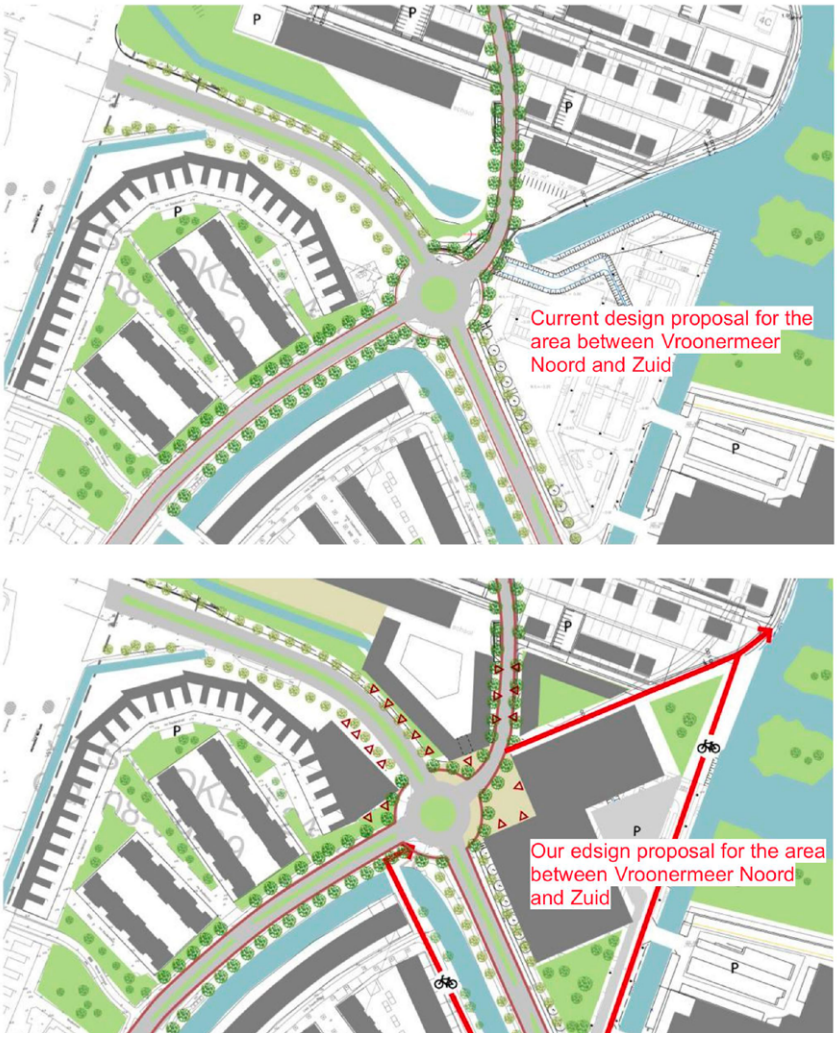

Figure 8. Plan for a new local centre between Vroonermeer-North and -South.

9. CONCLUSIONS – NEW CHALLENGES FOR URBAN REGENERATION PRACTICES

How to improve the use of space syntax in urban regeneration, urban planning and design practice? During the last few decades, space syntax has grown and been accepted by many scholars worldwide as a method not only suited for describing the spatial properties of the street network, but also as a tool for predicting the effects of possible changes. As such, space syntax is well suited as a tool for consultants and policymakers who want to make positive changes to the built environment and forecast the effects of those changes.

Before using space syntax as a consultancy tool, there is a need to translate the technical vocabulary currently used in the space syntax community into terms understandable to practitioners and urban planners who have no

knowledge of space syntax. In the SSUD project an attempt is made to formulate such a conceptual framework and to use space syntax as a tool to analyse different types of residential neighbourhoods. The objective is that this tool will not only be useful in formulating measures for the (re)vitalization of neighbourhoods, but also for making these measures acceptable to the policymakers and stakeholders who are responsible for the actual implementation.

The utilization of the SSUD model and interaction with practitioners has yielded several insights, which may be useful for future research and consultancy practices. Creating lively, vibrant and safe communities is not always the first priority of the stakeholders involved with the (re)development of neighbourhoods. Traffic safety, political and corporate agendas, and architectural expression are often considered more important than the spatial configuration. It is a serious challenge to deal with these other priorities when convincing the stakeholders of the advantages of spatial interventions.

Especially the current emphasis on traffic safety was a serious issue in three of the eight pilot cases. Municipalities often employ traffic engineers who have the final word in the design of the street pattern. The current traffic safety and road capacity regulations shape the mobility framework of neighbourhoods. The spatial conditions for street vitality and social safety on the one hand and traffic safety on the other are not always the same. Traffic safety is promoted by separating the different mobility networks, by locating the main routes outside the neighbourhood and by limiting the accessibility of residential neighbourhoods. Those measures create mono-functional neighbourhoods and are not favourable for an active street life, vibrant local businesses and natural surveillance.

Building companies and estate developers often want to maximise their profit on a short term. To realize this, they often try to acquire a building plot in which they can implement a single type of dwelling in the whole street or streets. The long-term effects on the neighbourhood itself, such as place quality, variation in building morphology and the relation between building entrances and streets are, however, seldom considered. At present, developers often try to improve the saleability of their projects by creating the image of intimacy. They create a sense of residential privacy and intimacy by turning the homes away from the streets. This design practice results, however, in an inward orientation of homes with no active frontages towards the streets. This generates a low level of human activities in streets and limits the possibilities for natural surveillance. When the street pattern is in addition tree-structured and without active dwelling functions on the ground floor level (e.g. because they are built up with storage boxes and parking garages), an un-necessary complex spatial framework is created that does not support street life and has a negative impact on feelings of safety.

Finally, there is a challenge to overcome the gap between the persons who design the neighbourhoods and the people who inhabit them. Often the designers of housing areas are 'trans-spatial' people. These people work during daytime and have a broad social network in their leisure time not directly bounded to the neighbourhood where they live. The 'spatial dependent' people are the unemployed, the retired and the housewives. They are dependent on what the vicinity of their home offers them in terms of amenities and social activities. A large amount of spatial dependent inhabitants combined with a poor spatial framework for supporting social activities contributes to social unsafe behaviour patterns. Large groups of loitering youngsters, noise disturbances and anti-social behaviour can often be observed in these kinds of neighbourhoods. Therefore, there is a need to gain a spatial understanding on the needs of the spatial dependent people and to communicate that knowledge to urban designers and policymakers.

REFERENCES

Alford, V. (1996). Crime and space in the inner city. Urban Design Studies, 2, 45-76.

Arnstein, S. R. (1969). A Ladder of Citizen Participation. JAIP, 35(4), 216-224.

Asmervik, S. (1998). Planning theory and the new rhetoric of Chaïm Perelman. Lecture notes from Oxford Brokes Planning Theory Seminar.

Forester, J. (1989). Planning in the face of power. Los Angeles, CA: University of California Press.

Hausleitner, B. (2010). Tracing scopes of action. Approaching the complexity of the urban block. (master's thesis, EMU, TU Delft). Retrieved from http://repository.tudelft.nl/view/ir/uuid%3A60a0a285-ee46-4703-b1c5-3cdf31e8aeb4/

Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1998). Configurational modelling of urban movement network. Environment and Planning B: Planning and Design, (20), 29-66.

Hillier, B. & Salbaz, Ö. (2005). High Resolution Analysis of Crime Patterns in Urban Street Networks: an initial statistical sketch from an ongoing study of a London borough. In A. van Nes (ed.), Proceedings Space Syntax. 5th International Symposium at TU Delft. Delft, Netherlands: Techne Press.

Luten, I. (2008). Handboek Veilig Ontwerp en Beheer: Sociale veiligheid in buitenruimten, gebouwen en woningen. Bussum, Netherlands: Thoth.

Van Nes, A. & López, M. (2010). Macro and micro scale spatial variables and the distribution of residential burglaries and theft from cars: an investigation of space and crime in the Dutch cities of Alkmaar and Gouda. Journal of Space Syntax, 1(2), 314.

Van Nes, A. & López, M. (2013) Spatio-socio classification of deprived neighbourhouds in the Netherlands. Strategies for neighbourhood revitalisation. Proceedings of the Ninth International Space Syntax Symposium, October 31-November 3, 2013, Seoul, Korea (paper 122)

Van Nes, A., Berghauser Pont, M., & Mashhoodi, B. (2012, January). Combination of Space Syntax with Spacematrix and the Mixed Use Index. The Rotterdam South test case. In M. Greene (ed.). Proceedings Space Syntax. 8th International Symposium. Santiago, Pontificia Universidad Católica de Chile, Chili.

Rueb, L., & Van Nes, A. (2009). Spatial behaviour in Dutch dwelling areas. How housing layouts affects its users' behaviour. In D. Koch, L. Markus, & J. Steen (eds.), Proceedings 7th International Space Syntax Symposium, Stockholm. Stockholm, KTH.

Yu, Y., & Van Nes, A. (2014). Quantitative tools in urban morphology: Combining space syntax, spacematrix and mixed-use index in a GIS framework. Journal of Urban Morphology, 18(2), 97-118.