The socio economic impact of various road alternatives in town centres

The application of space syntax in road planning in Rijnland and Tønsberg

Akkelies van Nes & Egbert Stolk

Department of Urbanism, Faculty of Architecture
Delft University of Technology
P.O.Box 5043, 2600 CR Delft, The Netherlands
Tel +31 15 2783077
Email: a.vannes@tudelft.nl

Abstract
During the last years the requirement for impact assessment for large urban intervention projects are emerging in various countries. The methods used are mostly based on traffic flow and travel time data from the road engineers.

However, little attention is paid on the economic effects of existing urban centres in these analyses. In 2003 the Public Road administration in Norway applied space syntax analyses on various proposed road alternatives in the Norwegian town Tønsberg. As it turned out, only one of the four proposed alternatives contributes to keep the economic vitality in the old town centre. All the other alternatives contribute to the location of out of town shopping centres. In 2011 a local action group in the Dutch Rijnland region asked to carry out space syntax analyses of two different road alternatives linking highway A4 with A44 through Leiden and Voorschoten municipalities. As it turned out, the solution in favour of the local action group seems to support economic vitality into Leiden centre whereas the other alternative contributes to segregate Leiden centre.

When comparing the results from these two projects, similarities of the best proposal to retain a vital town centre can be found. It is about to choose a road alternative that is well connected to the existing centres. The challenge to integrate space syntax in impact assessment more that what it is at present is to convince people in the various provincial administrations that it can add indications about economical vitality in existing and future economic centres on various scale levels.

1. Introduction

Present and past constructions of roads and streets presumably give directions for future city growth. Their order and structure in general exist longer than buildings. Up to now the average age of a street is about 1000 years, while the usage of urban space
along streets is changing almost continuously. The pattern of functions inside buildings can change fast, whereas the building itself might remain as it is for about 100 years. Therefore, knowledge on how the spatial configuration of the road and street net affect urban areas is needed for making reliable impact assessments on the effects on larger road projects on built environments.

Requirements for impact assessments of larger interventions are emerging in Europe, Northern America as well as in Australia. Mostly the focus is on effects on land use and on the natural environment.

In Norway, the requirement for impact assessment of larger road projects is included in the recent updated planning and building law in 2005 and in the national policy document on coordinated land use and transport planning. They are based on the European Commission’s directives on evaluating the environmental impacts of plans and programs such as advice directive of 2001/42/EF. The EU-directive 85/337/EØF of 27 June 1985 about public and private project’s impact on the environment, and EU-directive 97/11/EF of 3 March 1997 on changes of directive 85/337/EØF, are earlier implemented in the Norwegian planning and building law form 1985 and in regulations of impact assessments. The purpose with these regulations is to consider the impacts on environment and society in the preparation of planning documents of new road projects. The requirements for impact assessments are for regional plans, municipality plans, and zoning plans having impact on the environment and society. It includes also overview plans that clarifies future land uses and detail plans for concrete development initiatives (Miljøverndepartementet 2012)

Likewise, in the Netherlands there is an obligation on impact assessment on the environment for larger road projects. It is named “Milieueffectrapportage” (MER rapportage). Like Norway, the MER rapportage is based on the European Commission’s various directives on impact on the natural environment. These reports are the basis for the decision of various proposed alternatives for the municipalities. The procedures of the MER emphasize to include the various stakeholders and interest groups, and to involve an independent commission to evaluate the MER rapportage. The government weight the impacts on the environment based on the MER rapportage. The MER rapportage procedure is an open process on how the decision is made (Rijksoverheid 2012).

What are missing in these impact assessment requirements are insights on the economic impacts on land use on the changes of the spatial configuration of the street and road network. The relationship between road construction and spatial development in urban areas is not understood adequately. Most investigations and practitioners in urban planning treat these two aspects separately. Engineers tend to occupy themselves with the question as to how larger road projects produce changes in traffic flow. Their interest in this question distinctly echoes their concern with building road nets being able to carry an expected traffic flow. Architects, urban designers and urban planners, however, are often occupied with solving the formal problem of implementing various functions required in urban areas (van Nes 2002, p 2). Present knowledge about road building and urban change results primarily from
empirical studies that were carried out before and after major changes in a transportation system occurred (Falleth, Kollbotn and Tombre, 1995).

During the last two decades, research with the application of the space syntax method has shown that there is a relationship between the spatial configuration of the street and road network and the dispersal of economic activities and flow of pedestrians and car traffic (van Nes 2002, Hillier et. al. 1993 and 1998, Bruyns et al 2007, Desyllas 2000, Read 1996, Ugalde et al 2012, Serra et al 2011). The dispersal of economic activities and mobility flows are dependent on the spatial configuration of the street and road network. If a new road link changes an optimal location for economic activities, these activities will replace them to a new optimal location as an effect of the spatial changes of the street and road network.

During the last 50 years, we have built a large number of huge road projects in urban areas. Therefore it is time to learn from unforeseen effects of larger road projects on existing town centres. There exist a sufficient number of poor function examples to learn from and to apply this knowledge in impact assessments (van Nes 2002). It requires at least predictable spatial analyses tools and they need to be added to the traffic models used by road engineers.

2. Generalisation and theory development so far

As space syntax research world-wide has shown, the following general statement on urban space can be claimed so far: Independent on cultures and architecture, all built environments have in common that they consist of private and public spaces. Public spaces open up for movement from everywhere to everywhere else. Private spaces are spaces inside buildings and gardens, connected to the public ones in different degrees. These are the basic elements of the space syntax method.

The computer Mac based program Axman was used during the 1990s and the beginning of 2000s. The software can only analyse topological distances. Around 2004 the Windows based Depthmap software replaced the Axman software due to its capacity and the possibilities to deal with the angular relationship between the axial lines. In addition to analysing topological distance, the software is also able to break up the axial map into segments between junctions. Then it is also possible to analyse metric and geometrical distances. The metric distance measures the city’s street and road net as a system of shortest paths, while the topological distance, calculates the city’s street and road net as a system of fewest turns paths. Finally, the geometrical distance gives a picture of the city’s street and road net as a system of least angle change paths. Each type of relation can be calculated at different radii from each street segment, defining radius again either in terms of shortest, fewest turns or least angle paths (Hillier and lida 2005, 557–558). The consistency of the space syntax method is to represent all streets and roads as a set of axial lines in a city. No differences are made between highways and footpaths in the representing of the movement network at a set of axial sightlines.
During the recent years, metrical properties have been taken into account and it is possible to combine these different types of distances in the axial analyses of the urban street and road network. Both programs provide colour codes to the various values of each axe. In this way the integration structure of a built environment can be perceived in one glance.

Research carried out has shown that in the most spatially integrated streets, economic activities take place (Hillier 1996, p. 175 and 176, Hillier and others 1993, p. 31, 36 and 61, van Nes 2002, p. 287 - 301). Dwelling areas are mostly located in the spatially segregated areas (Hillier 1996, p. 175 - 179, Hillier and Hanson, 1984, p 140). It is possible to identify where the most spatially integrated and segregated streets are located through the spatial configurative calculations. The flow of human movement and the location of various functions can be registered along the different axial lines and be compared with their configurative measurements.

According to Hillier, all cities are made up of a very large number of short streets and a very small number of long streets and roads. This can be seen on all scale levels in which gives the city street networks a clearly fractal structure. The middle scale network is largely made up of longer streets or roads whose ends are linked by highly obtuse, nearly straight connections. The longer the line, the more likely it is to end with a nearly straight connection. The main routes through cities on all scale levels tend to consist of a set of longer lines connected to each other with almost 180 degree angles (Hillier et al 2007, 2-4). In this way, angular weighting contributes to highlight the main routes in the spatial axial analyses. Conversely, the local network is largely made up of shorter streets, which tend to intersect and end at a near right angle. The shorter the street, the more likely it is to end at a right angle. Most silent dwelling streets tend to be metrically short (Hillier et al 2007, 2-4).

An economic centre is defined to be the places where trade, shopping and finances take place. The aim for these kinds of activities is to be both in a metrical and topological central position to all potential customers. Research has shown that their optimal position depends on the configurative structure of the street net. The theory of the natural movement economic process demonstrates how a street grid's configuration determines the flow of human movement and the location pattern of shops. The location of shops and flow of human movement can influence each other, though not the configuration of an urban grid (Hillier et al. 1993). Figure 1 shows the
relationship between configuration, attraction (the location of economic activities) and movement. It explains how a built environment function independent on planning processes as regards the location pattern of shops, human movement through the urban network and the configuration of the street grid.

So far, research on the configurative structure of an urban grid has come up with the following general statements on the relationship between the dispersal of shops and urban structure. As regards the theory of the natural movement economic process, shops tend to locate themselves along the most integrated streets. The location of shops and the flow of pedestrians can influence one another, but not the configuration of the street grid. It is the configuration of the street grid that influence movement and the location of shops (Hillier, Penn, Hanson, Grajewski and Xu 1993, p. 31 and 61).

The degree of connectivity of an urban grid on a micro and meso scale seems to decide upon the dispersal of shops. A successful shopping area must have a both globally and locally strategic position in a built environment (Hillier 1999, p.119). Not only the most integrated streets on a local and global scale decide where shops locate themselves, but also a shopping street's degree of connectivity to its direct vicinity. If a centres' optimal position change through changes on a street net, the location of this centre is likely to change too (Hillier 1999, van Nes 2002). Therefore an economic centre is heavily dependent on a street structure, in which relates to topological centrality. Accessibility to potential customers is at issue.

Carrying out analyses and research in accordance with the theory of the natural movement economic process requires only registration of the location pattern of shops and calculating the configurative relationships of the street grid. It is impossible to find data about pedestrian and car-traffic flow from the past and the future. The location of shops from the past can be found from old street directories, old pictures and in some cases from old maps. Axial maps of a street grid from the past and for the future can be made on basis on old and new maps.

Two hypotheses was set up before approaching the configurative issue of Tønsberg and Rijnland. On the one hand, to survive in a competitive market, shops will always search for an optimal location so that they can reach as many potential customers as possible. If the optimal location changes as an effect of configurable urban changes, shops will relocate themselves to a new, again, optimal location.

The Tønberg case was analysed in February 2003 with the Axman software. The Rijnland area is analysed in 2004 with both Axman as well as with the Depthmap software. In 2011 the two final versions of the proposed new road alternatives between the highways A4 and A44 through Leiden and Voorschoten was analysed with the latest measurements in the Depthmap software. However, the most significant effects can be seen with the topological distance maps. It shows the ‘to-movement’ potentials, whereas the angular analysis shows the ‘through-movement’ potentials.
3. The Tønsberg case

The Norwegian town Tønsberg is located on the west side of the Oslo fjord, about 100 km south of Oslo. It is the oldest town in Norway, dated back to year 871. Today 36.000 inhabitants are living there. Due to the high quality of soil, the urban expansion of Tønsberg is scattered on the hills between the agricultural fields. In 2003 Tønsberg municipality proposed several road alternatives with purpose to solve the traffic congestions through the town centre towards the large vacation islands Tjøme and Nøtterøy. The Public Road Administration of the Vestfold province wanted to know how each of them affects the location pattern of shops and vitality of existing shopping areas.

One general statement stated in van Nes' PhD thesis (2002) is that shops locate themselves at the most spatially integrated streets. If a new street or road system changes the configuration of a town’s street grid, it affects the location of shops (van Nes 2002, p. 3, 27 and 3003). Therefore, this knowledge was used to find out how each proposed road alternative will affect existing shopping areas and centres and whether they will encourage car based out of town shopping centres or not.

The spatial analysis of Tønsberg’s existing situation has identified three kinds of shopping areas. One of them is the pedestrian-based shopping area. Shopping areas of this kind is mostly located in an urban centre. In the case of Tønsberg it is the historical centre. The location of shops is in accordance with various local integration analyses. Another type of shopping area is the car-based shopping centre. Shopping centres of this kind is located in the global integrated core. A third kind of shopping area is the suburban colonial shop with a small post office or a bank. It serves the surrounded dwellings in its direct vicinity. Its location is in accordance with a local integration with a high topological radius (area integration).
In order to understand the current situation, a historic analysis of the town was carried out. Old maps and street directories were used for revealing the correlation between shops and degree of spatial integration of the network. Figure 2 shows a global integration analysis of Tønsberg from 1890 – 1980. The red and yellow axes indicate the most vital areas. In 1890 the street Storgaten is the most integrated street, followed by Møllergaten and Øvre Langate. As the town grow, the integration core moves to the street Stoltenbergsgate. However, Storgaten and Møllergaten still provide high integration values compared with other central streets. In the 1980 analysis, the global integration core has moved eastward to the Kilen area. The main streets still have relative high integration values in 1980.
Figure 3 shows the global integration analyses of Tønsberg in 2002. A separate analysis of the vehicle routes has been carried out to show how pedestrianisation of the streets Møllergaten and Storgaten contribute to reduce the integration values and vitality in the central areas. The global integration core is increased in the Kilen area in the both 2002 analyses compared with the 1980 analysis.

Figure 4 shows the dispersal of ground floor functions in Tønsberg from 1939 – 1980. The location of shops (coloured in white) is in accordance with the highest global and radius-radius integrated lines. Until 1980 few changes can be seen in the location pattern of shops. In all cases Storgaten and Møllergaten are main shopping streets. As an effect of urban expansion, shops are located in St. Olavsgate, Stoltenbergsgate, and in side streets of Møllergaten and Storgaten in 1980. Figure 5 shows the dispersal of functions in 2002. During the last 20 years the town Tønsberg has undergone large functional changes. Shops have moved into indoor shopping centres. Other commercial functions have moved outside the historical centre. The essential changes in the location pattern of shops is the car based shopping centres in the Kilen area and the indoor shopping centre Farmandsenteret located along Stoltenbergsgate. The ovals indicate their location.
Figure 4: dispersal of ground floor functions in Tønsberg from 1939 – 1980
In the 1930’s and 1950’s almost everything could be bought in the town centre. At present, clothes and porcelain are offered in the town centre, while furniture, tools and food are offered in the out of town car based shopping centres. Only food, newspapers and flowers are offered in the local shopping areas in the suburbs. These changes in the kind of shops correlated with the spatial configurative analyses of Tønsberg.

Larger road projects seem to have effect on the town’s global core and the core of its local sub-centres. Roads of this kind have few direct connections to their vicinity, which means little effect on various local integration values. The analyses of the proposed road alternatives give indications of how they will affect the global integration core of the town centre and sub centres. If the global integration core changes, the location pattern of the car-based shopping centre will change too. Moreover, how the recently proposed road alternatives can affect existing shopping areas depends on their degree of direct connectivity to the shopping areas. Low connectivity on the proposed roads decreases the vitality of a local shopping area, while high connectivity promotes the opposite.

It is already decided to build a northern ring road in a tunnel to relieve the town centre for through traffic. An impact assessment of the proposed road alternatives has to take
this decision into consideration, and this alternative is named alternative zero. The proposed alternative zero seems to have largest effect on the global integration core compared with the other proposed alternatives. Figure 6 show how the global integration core is strengthens in the Kilen area compared with the 2002 analysis. This indicates increased car-based shopping activities in this area. The central core gets more segregated than it is today. On the other hand, the various local integration values remain the same, which means that shopping areas in the sub-centres would not be affected at all.

Figure 6: Alternative Zero
Figure 7: The proposed alternatives

Figure 8: The Hogsnes alternative
Figure 7 shows the proposed road alternatives with variations. Figure 8 shows the Hogsnes alternative with tunnel B. It increases slightly the global integration and the radius-radius values at the west side of Tønsberg. However, it does not affect the main integration core of the whole town. It is the already decided ring road north proposed in the zero-alternative affecting the global integration core.

Figure 9: The Korten alternative

The same tendency can be seen in figure 9 with the Korten alternative with tunnel B. A slight increase of the integration values and the radius-radius values at the west-side of the town. Moreover, this road alternative slightly increases the integration values in the town centre, but on a very small scale.
Figure 10 shows the central route alternative with tangents. Compared with the other alternatives, the central route alternative contributes to retain the high integration core in the city centre. In particular the street Stoltenbergsgate gets high integration values. When removing the northern ring road from the zero-alternative, the central alternative contributes to drag the high integration values from the Kilen area back to the city centre. Figure 11 shows the central route alternative without alternative zero.
Figure 12 shows the ring road south alternative. This alternative shows almost no changes from the alternative zero except that the integration values slightly increases on the ring road south. As discussed earlier, it is the northern ring road that affects the global integration core.

![Figure 12: The ring road south alternative](image)

Figure 13 shows some scatterplots of alternative zero, the four proposed road alternatives and the central route alternative without alternative zero. The thick black dots represent the axes in the town centre. The correlation coefficient increases in the central route alternative compared with the 3 other alternatives. If removing the ring road proposed in alternative zero, the correlation coefficient increases in the central route alternative.
Figure 13: Scatterplots of various road alternatives in Tønsberg

The table 1 shows the values from various scattergrams of all road alternatives. Compared with the 2002 analyses, all correlation coefficients decrease, except the central route alternative without the northern ring road. The alternative zero has the lowest correlation coefficient compared with the 4 alternatives and the 2002 analysis. This alternative will drag the integration values away from the town centre. Table 2 shows the values for the central core. The proposed road alternatives have little effects on the central core in itself. This shows how the proposed road alternatives have impact on the town as a whole than on its small local shopping areas in the suburbs.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Mean global int.</th>
<th>Mean local int.</th>
<th>R² local-global int.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative Zero</td>
<td>4%</td>
<td>-2%</td>
<td>-2%</td>
</tr>
<tr>
<td>Hogsnes</td>
<td>5%</td>
<td>0,01%</td>
<td>-0,3%</td>
</tr>
<tr>
<td>Korten</td>
<td>5%</td>
<td>0,02%</td>
<td>-1%</td>
</tr>
<tr>
<td>Central route</td>
<td>5%</td>
<td>0,01%</td>
<td>0,4%</td>
</tr>
<tr>
<td>Central route without ring</td>
<td>4%</td>
<td>0,01%</td>
<td>2,9%</td>
</tr>
<tr>
<td>Ring South</td>
<td>4%</td>
<td>0,01%</td>
<td>-1%</td>
</tr>
</tbody>
</table>
The central route alternative seems to support the vitality of the pedestrian based shopping areas in the town centre. All other alternatives, combined with alternative zero, encourage the development of car-based shopping centres located outside the town centre. In particular the Kjelle area and Kilen area will increase their vitality. There will be a risk that through travellers to the vacation areas Tjøme and Nøtterøy will do their shopping in future new car based mega malls in these areas, and hence reduce the vitality of the historic small town centre.

Some recommendations can be given for revitalise the historical town centre. Firstly the private car has to be accepted as a part of urban street life. Post war road planning has been focusing to lead them away from the town and city centres. What is not foreseen is how such planning practise contributes to car-based shopping centres located outside the urban centre. The key lies in to humanise the private car. This means reduction of speed, create more parallel routes through the town centre, and a boulevard standard on roads with pavements for pedestrians. The car and the pedestrian become equalised, which seem to be an indicator for vital urban areas. A separation of the pedestrian and the car contributes to liveliness urban areas. Congestion is one thing, but another thing is that traffic flows through a town with low speed.

Secondly, Tønsberg has a small urban core, compared with other European towns. Therefore large road projects can easily affect its vitality. The challenge is to ensure that through travellers to the vacation areas Tjøme and Nøtterøy can travel effectively through the town without destroying its vitality. Replacing the through traffic routes outside the town centre will have the effect that the car-based shopping activities follows these routes. These conclusions are based on earlier research. As research has shown, constructing a ring road around Tønsberg’s historic centre can contribute to segregate the central core it encircles on a global scale (van Nes 2002, p. 297-303, Karimi 1998, p. 226-228, Read 1996, p. 82 and Kubat et al 2001, p. 62). Therefore well-functioning solutions for using through traffic contribute to revitalise segregated central urban areas.
4. The Leiden case

The Dutch Rijnland region consists of 15 different municipalities. The largest one is the city of Leiden, surrounded by an agglomeration of the municipalities of Voorschoten, Leidendorp, Oegstgeest, Zoeterwoude, Valkenburg and Katwijk. This urban agglomeration has 254.000 inhabitants and the Rijnland region has around 500.000 inhabitants. Leiden is metrically located very central in the Randstad area. Like Amsterdam it is located close to Schiphol International airport. Moreover, two main highways A4 and A44 are passing through the region. All inter-cities trains stop at Leiden central station. The historic centre with its old styled brick stone buildings, churches, forts, museums, art galleries, canals and bridges is quite large. It is even larger than the old centre of The Hague. The city has one of the oldest universities in the Netherlands and is known to be the centre of the chemistry knowledge. Furthermore, Leiden is also located close to the sea and to the protected agricultural area of the Randstad, named “the green heart.”

In spite of its central location and all its opportunities, Leiden is less developed than the other four cities in the Randstad. The area offers a lot of space waiting for to be developed. By comparing Leiden with its neighbour cities Amsterdam and The Hague, few international and national companies put investment in the Leiden region. Culturally and historically, the city has a lot to offer. However, investment and economic growth has stagnated.

Since 2002 several proposal for linking the highway A4 to A44 through Leiden have been discussed. At present, two alternatives have been outlined in detail. One of the alternative, named ‘Zoeken naar Balans’ (ZnB) is favourised by the province of south Holland, where the other one, named ‘Churchill Avenue’ (CA) has a strong local action group.

In 2005 a workshop was held with researchers and designers to make a brainstorm session on to stimulate the economic development in Leiden and the Rijnland region. A space syntax analyses was carried out for the whole Rijnland region. As the results shows, the topological spatial structure of Rijnland’s street net is disconnected between the regional and the local scale in the following way: The two highways pass only through the region without any connection to its centres. The inter-regional road system is spatially broken up and effective east-west connections are missing. An effective well-connected main route street net through the region is missing at several parts. On a local level, the historical centre has a spatially broken up street structure, which is disconnected from the global network. There are only two successful main streets functioning as vital shopping streets for Leiden (Bruins et al 2007).

The region’s most spatially integrated core, located at the Bio-science and Valkenburg areas, has potentialities for becoming a centre for economic development. However, it lacks effective connections to the highway A4, Leiden centre and the railway station. Furthermore, this core is located on the edge of the municipalities Leiden, Valkenburg and Oegstgeest. In order to stimulate economic development in the Rijnland region, it requires agreements and co-operation between these three municipalities. As it is at
present, there are conflicting interests. Some of the municipalities want to be a part of the large metropolis in the Randstad, while others prefer to protect their image being a small settlement in the agricultural landscape.

In spite of its strong spatial potentialities, no economic development has taken place earlier at the west node. The reason is that the powerful Dutch planning system’s laws and rules and local democracy can overrun the generative power of the street net’s potentialities for economic development. In the Rijnland case, the region’s most integrated core is located on the edge of three different municipalities where each of them has conflicting political and economical interests. Furthermore, protected green belt areas and green buffers stated in national policy documents limit expansions and development on the potential nodes along the highways A4 and A44. In general, strong planning policies at all levels seems to restrict the natural movement economic process at all spatial scale levels.

![Figure 14: Global integration Leiden in 2004](image)

The spatial structure of the network and the region's division of several independent municipalities contribute to the region's fragmented settlement structure, where the local centres are poorly interconnected with one another throughout the region. An economic vital main centre, like for example as the ZuidAs in Amsterdam is missing. After all, the location of firms occurs in centres with both high global and local angular
integration, while the location pattern of shops follows the local angular integration. If the aim is to increase investment and stimulate economic growth in the region, the challenge is to make attractive centres with a street net with both high global as well as local integration. Inter-connectivity is at issue. Likewise, a main challenge is to improve connectivity between A4 and A44 with high accessibility to Leiden centre.

For years several suggestions are made and discussed by the municipality for a new road link between A4 and A44 located at the south-western part of Leiden centre. These suggestions are analysed in 2004 with the Axman software. Only topological distances were analysed. The analyses show how a new road link between A4 and A44 depends on direct connections to the city centre as well as the east and west nodes - if one wants to increase the global integration in Leiden centre.

Strategy 1: Improve and upgrade existing connection as proposed in the municipality's alt. 1

Strategy 2: Inter-connect W4 with the city centre

Strategy 3: Inter-connect W4 with the city centre + parallel road

Strategy 4: Direct highway standard on W4 between A4 and A44
However, these suggestions are already throughout discussed for years. Experiments on other alternative solutions have been tried out. Figure 15 shows the global integration of the four strategic alternatives of linking the highway A4 and A44 through the Rijnland region.

Strategy one shows the municipality’s alternative one. This alternative will increase the global integration in the area around the street Kennedylaan - Churchillaan in which can stimulate economic growth inside this area. As it is at present, the area is poorly connected to the city centre and the railway station due to the rails. Strategy two suggests making the connection to the city centre as short as possible and to link it to the main route from the city centre to the west node. This solution contributes to increase the integration in the historical city centre and the west node, which might contribute to investment in the areas around the central station and the Bio-science park.

Strategy three suggests making a direct connection between the highways at the south-western part of Leiden in addition to the direct link into Leiden centre. As can be seen in figure 15, this road link drags the global integration away from the other road link suggested in alternative 1. Both Leiden centre and the west and east nodes will benefit from an increase of the global integration in their cores, although the weight is put on the east and west nodes. In order to increase the vitality of both nodes on a national level, a direct tunnel can be constructed between these nodes. As shown in strategy four, the east and west nodes imply the highest global integration values. Nevertheless, Leiden centre and the area around the central station will have weak global integration values. Local integration will be the same in all four suggested strategies. It can be increased by implementing a well-connected local road net inside the new east and west nodes.

It is not enough encouraging new development at the west and east nodes. The inter connectivity between the local street net and the main routes network and the highway network must be topological short. This implies few changes of directions from the highway net to the local street net. Inside the nodes itself, the local street net must be well connected and have an integrated use of pedestrians, bicycles and vehicles. This is important to generate vital urban centres with the purpose to stimulate economic development for all types of firms, retail and shops and to make the area also attractive to live in.

The Valkenburg area and Bio-science park has a global strategic central position in the region. In order to maximise the potentialities of their location with purpose to stimulate investment, a new street net must also be locally integrated. Making a street net well connected to the areas in the vicinity, the highways and Leiden centre seems to be essential. Furthermore, there are potentialities for restructuring the street structure and to increase the density of the built mass of the Bio-science park area due to its topological central location, combined with the low density of the area.
What kind of strategy can be suggested to stimulate economic investment in the Rijnland region? As concluded from the 2005 workshop, *accessibility* and *interconnectivity* of its road and street net on a local as well as a national scale must be improved. More precisely, the east and west nodes and Leiden centre must be easily accessible from the two highways.

In 2011, two links with detailed information about junctions was finished on the drawing table. The local action group Team Churchill Avenue (CA) are worried about the impact of these two alternatives and wanted an analysis on the changes of the economic potentials along the street and road network in Leiden centre and the region as a whole as an effect of these two proposed alternatives. As the CA team claimed, it is lacking in most impact assessment analyses of these two proposed alternatives. Moreover, a road is more than a technical connection between two points. In most impact assessments issues such as traffic flow, impact on the natural environment and health, and sustainability are taken into consideration. Therefore, there is a need to add the economical potentials as well in the impact assessment (The economical effect report (EER)). Therefore, the authors were asked to analyse both alternatives with the help of space syntax methods and theory.

Figure 16 shows the location of the two proposed road alternatives. The Churchill Avenue (CA) alternative (the purple line) is connected to the local street net at three different nodes. It consists of a tunnel. Above the tunnel a parallel street is proposed that is well connected to the local street net. The other alternative, Zoeken naar Balans (ZnB) alternative (coloured in red) has no connection to the local urban street network. It is located on the ground level.
Figure 16: Map showing the location of the two proposed alternatives with junctions
Figure 17: Global integration analyses of the area – existing situation

All kinds of spatial integration analyses were carried out with the Depthmap software. However, the largest effect could be seen on the topological distance – the same analyses applied as in Tønsberg in 2003. Figure 17 shows a global integration analysis of the existing situation from 2011. The figure shows a zoom in of Leiden and Voorschoten centres. The largest impact of these two road alternatives can be seen in this area. The most integrated streets are located in the Bioscience Park and the roads at the junction at the highway A44, followed by the orange streets located on the edge of Leiden centre. At this moment several advance producer services and companies are located in these areas. The street Churchilllaan has high potentials for economic activities and at present it function as the local centre for its neighbourhood. It is also coloured in orange.
Figure 18: Global integration analyses of Zoeken naar Balans (ZnB) alternative

Figure 18 shows a global integration analysis of the ZnB alternative. This alternative drags the integration values towards it. It will increase on the A44, and reduce in the Churchill Avenue alternative – as feared by the local action group “Team Churchill Avenue”. This alternative has no impact on its direct surroundings (except from traffic noise) because it has no connection to its vicinity. The idea behind this proposal is to steer traffic from the A44 fast towards the Bollenstreet area where the flower production (tulips) takes place.
Figure 19: Global integration analyses of the Churchill Avenue (CA) alternative

Figure 19 shows the spatial analyses of the CA alternative. As can be seen on the map, this alternative will increase the economic potentials and vitality to the area as well as to the Bioscience Park and to the western parts of the historic centre of Leiden. Likewise, the spatial integration will also increase in Voorschoten centre. This alternative will contribute to new investment adjacent to the existing centre.

Figure 20 shows a comparison with both alternatives together with the existing situation. The 10% highest integrated lines are highlighted with purpose to show the changes. What is clearly is that the CA alternative contributes to increase the vitality and economic potentials in the Churchilllaan area and the main route between Leiden centre and Voorschoten. The ZnB alternative segregates the existing urban centre of Leiden – like the three of the four alternatives does in the Tønsberg case.
Figure 20: Comparison of the existing situation (left), Zoeken naar Balans (middle) and Churchill Avenue (right)

In addition various local integration analyses with angular weighting and metrical radii were carried out. As it turned out, the CA alternative will increase the local integration in the Churchilllaan area, due to the way it is well-connected to its vicinity. The ZnB alternative has no impact on the local integration values.

Both alternatives contribute to increase the integration in the whole region, due to an improved accessibility between the highways A4 and A44. The difference is that the ZnB alternative drags it away from Leiden centre. Both alternatives contributes to new economic potentials along their proposed routes, but the CA alternative contributes to increase the vitality of existing centres, where the ZnB alternative contributes to an increase for the potentials for the location of out of town shopping centres. Here the economic potentials are defined to be area development possibilities, development of property value, improvements of economic centres and flows of potential shoppers.

Due to the strong Dutch planning system, the location of the ZnB alternative is in an area with several planning restrictions. It will require an effort to deviate from these existing plans. The CA alternative is located in an area where there exist already plans for dedicating the land use for economic activities.

Finally, the CA alternative contributes to possibilities to revitalise existing urban areas. The ZnB does not add anything to the revitalisation potentials in existing urban areas. It only contributes to segregate them – which is in line with conclusions from other space syntax research (Ugalde 2012, van Nes 2002, van Nes 2009, Karimi 1998)

Figure 21 shows a zoom in on Leiden centre. The changes are shown in the white circles. As can be seen in the figure, the ZnB alternative segregates streets in Leiden centre, where are the CA alternative increases it.
Figure 22: Effect on the local centres Roosenvelt laan and 5 Mei plein

Figure 22 shows a zoom in on the area around the Churchilllaan (Roosenveltlaan and 5 Mei Plein). The ZnB alternative has no effect on this local area, but the CA alternative contributes to a significant increase of the spatial integration of the area. It will belong to the 2% highest integrated streets and roads in the whole Rijnland region.

Figure 23: Effect on Transferium and the Bio-Science park

Figure 23 shows the effect on the areas in and around the Bio-science park and the A44. The ZnB alternative has no effect on the existing vitality of this area, whereas the CA alternative will increase the spatial integration in the area.

Figure 24 Effect on Voorschoten centrum
Figure 24 shows how these two alternatives will affect Voorschoten centre. The ZnB alternative has no effect on Voorshoten centre, whereas the CA alternative will increase the accessibility as well as the vitality of it.

Figure 25 shows scatterplots from the whole Rijnland, and table 3 shows the degree of intelligibility of the road alternatives. Like the Tønsberg case, both road alternatives slightly decrease the degree of intelligibility for the whole Rijnland region. Since the ZnB case focuses on linking the Bollenstreek area (where the large tulip production takes place) with the highway A4 with no connections to Leiden centre, the correlation coefficient is lower than the CA case.

![Figure 25: Scatterplots from the Rijnland region](image)

<table>
<thead>
<tr>
<th></th>
<th>Existing situation</th>
<th>CA</th>
<th>ZnB</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2 whole region</td>
<td>0.148482</td>
<td>0.148298</td>
<td>0.148371</td>
</tr>
</tbody>
</table>
However, the degree of spatial integration increases in Leiden’s central streets for the CA alternative. Since the Depthmap scatterplot can not show the R2 level on selected likes (like the Tønsberg case), a selection of central streets was made for investigating the changes in the integration values. Table 4 shows how much percent change of integration values will take place along the most important streets in the area. As can be seen, the CA alternative contributes to an increase of integration values in all these streets.

Table 4, changes of integration values in important streets in Leiden and Voorschoten centre

<table>
<thead>
<tr>
<th>Straat</th>
<th>ZNB</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio Science Park</td>
<td>+0,4%</td>
<td>+4,6%</td>
</tr>
<tr>
<td>Churchilllaan</td>
<td>+1,6%</td>
<td>+6,2%</td>
</tr>
<tr>
<td>Voorschoten centrum</td>
<td>+0,2%</td>
<td>+5,8%</td>
</tr>
<tr>
<td>Haarlemmerstraat</td>
<td>-0,2%</td>
<td>+2%</td>
</tr>
<tr>
<td>Breestraat</td>
<td>-0,2%</td>
<td>+4%</td>
</tr>
<tr>
<td>Station (oostkant)</td>
<td>0%</td>
<td>+2,6%</td>
</tr>
</tbody>
</table>

The purpose of these analyses was a first initiative to try to include the space syntax analyses in the Dutch impact assessment analyses. In particular various involved stakeholders are interested in the economic impacts on the estates as an effect of various road alternatives (Economische Effect Rapportage (EER)). As the local action group claims, the economic impacts are not considered at all in the current EER when making impact assessments on various road alternatives. Impacts on the environment such as noise and CO2 pollutions, travel time, traffic capacities are taken into account. However, how various road alternatives affect the economic vitality in existing urban areas not taken into account at all.

As the space syntax analyses shows, the ZnB alternative offers few economic potentials along its route. Moreover, it drags the integration out of the historic centre of Leiden. The economic potentials for this alternative will be on its junctions, which is on the highways A4 and A44. If the plan in the current national spatial policy document is to loosen up the restrictions on the location of megamalls, there is a chance that they will locate on these two junctions. The CA alternative offers an improvement of the economic potentials in the existing urban centres, along its route as well as in the Bioscience park area. It shapes the spatial framework to revitalize existing centres. Moreover, the location of the CA alternative is in existing urban areas and not in areas with development restrictions. It will make it easier for companies and shops to locate along these routes because there are no planning restrictions to deal with on national and provincial level.
5. Comparison and discussion

In the debate on the role of street and road network in urban transformation processes, it is often forgotten that the road engineer is the urban designer. He or she is making the necessary framework for the urban life in built environments. It is all about how the new road integrates, segregates, connect or disconnect urban areas. And the effect can be seen on the location of various economic enterprises. At this moment there exist several guidelines on how to plan streets and roads in urban areas. Most of them are inspired by the Buchanan report from 1963. The report’s understanding of land use assumed in particular that “the function of the network would be to serve the environmental areas and not vice versa” (The Buchanan report 1963, p. 60). Apparently, this means that a high number of different functions in town centres favours intense traffic of both people and cars. The type of land use is thus taken to be an attractor for movement. The report takes urban environments of high quality to be safe to move through and to be free from traffic noise and pollution. However, there is little understanding of how land use occurs such as how retailers and shops establish themselves along the urban network and how they respond on where people move, whether by car or by foot. The way roads are planned and constructed in European towns and cities are still influenced by the Buchanan report. Examples on existing national road and street building guidelines are the SCAFTRapporten for the Scandinavian countries and ASVV for the Netherlands (van Nes, 2002).

The focus from these reports is mostly on traffic flow, road capacity and traffic safety. However, there is a need to bring socio-economic safety on the road building agenda. On the other hand, various impact assessments focus most on the effects on the natural environment and pollution. Therefore socio-economic impacts on the built environment are not taken into account at all and must be included in the various impact assessments.

As the Tønsberg and Rijnland cases show, a proposed route through the city centre contributes to keep the vitality of the historic town and city centres. An implementation of a fast and safe car traffic route outside the existing settlement pattern stimulates the location of car based mega malls. A parallel road solution with easy flow of traffic under the ground and slow car traffic with good connections over the ground at the same trace contribute to increase economic attractiveness in the proposed road’s vicinity. The costs of construction a tunnel are high, but the long tern socio-economic benefits are also high for the town and city centre.

In comparison with the Netherlands, Norway has a weak planning system on regional level. Shop owners, mega malls, and investors seek for streets and roads with high global as well as local integration. Location restrictions along new road projects tend to fade away. As research has shown, there are shopping malls on all the junctions on the globally integrated outer ring road in Oslo. They emerged and expanded 10 years after the implementation of this ring road (van Nes 2002). Originally, the intention of the plan was not to allow shopping malls along this ring road.
When the effects of the various road alternatives was presented for the public road administration and Tønsberg municipality in 2003, the municipality had several requests from investors who wanted to buy the ground at the most integrated parts of the proposed alternatives. Most of the ground along the most integrated roads is for agricultural use and these investors wanted to know the possibilities to change the land use from agricultural use to shopping malls.

The distortion of the theory of the natural movement economic process

The Netherlands has a strong planning system with purpose to protect the man made polder landscape from urban sprawl. However, there are some ‘holes’ in the planning systems for larger firms to establish them along the most integrated highways. While the mobility policy document prioritises high accessibility to support economical development, few visions concerning the land use along highways are taken into account in the national Spatial Policy Document. Even though various enterprises establish themselves along highways junctions close to large cities, the spatial policy document focuses on urbanisation in existing urban areas. As the document acknowledges, a highway is more than a distributor of traffic flows. It functions also as a place where economical activities establish themselves and where urbanisation takes place (VROM, 2004, 33).

In general the various existing national policy documents are conflicting with one another. Whereas the housing policy document promotes dwellings in green urban areas, the spatial policy document propose a strategy enhancing high density in existing urban areas. Whereas the mobility policy document emphasises an effective infrastructure with high accessibility, the spatial policy document promotes intensifying existing urban areas. Seen all together, the various present policy documents opens up for to let the marked forces influence the development more than in previous policy documents, but to keep up building restrictions in the “sacred” green heart. In general, since private car ownership is a “holy” issue, not spoken out at all in present planning documents, there are sufficient gaps opening up for a car dependent suburban lifestyle and car based localisation pattern of enterprises.

In a research project from the research institute Ruimtelijke Planbureau, Hamers and Nabliek investigated how urban sprawl takes place along the highways in the Netherlands. Due to existing policy documents, national organisation’s structures and division of responsibilities, the land along the highways seems to be left over to the marked forces and the municipalities’ various interests for facilitating a development of this kind. The pressure on the highway junctions is highest on towns and cities’
edges, or where highways tangent built environments (Hamers and Nabielek, 2006, 8 and 81).

In comparison with other European countries, the Dutch highways have a high density of junctions. Therefore, linear development along highways takes place. Often these areas tend to look messy, with a sprawl of buildings, randomly placement of advertisement signs and larger open spaces with parking possibilities. The types of large-scale detail shops in these areas are car dealers, garden shops, furniture shops, caravan shop, and leisure activities, such as sport and fun park facilities. The enterprises are defined to be large offices, companies, show rooms and storage possibilities.

In another research project on future shopping trends and their spatial requirements from Ruimtelijke planbureau, it is predicted that more fun shopping will take place in out of town centre mega malls than in the inner city centre areas. Already in existing spatial planning policy, the location policy decision has moved from a regional level to municipality level. The customers' demands for shopping mall with high car accessibility will make a pressure for changing existing location strategies. If one loosens up the existing Dutch restrictive location policy, pressure will increase on out of town areas. As acknowledged, shop owners search for the most optimal location in or to reach as many customers as possible and to be accessible for grocers and deliveries (Hillier et al, 1998, van Nes 2002). As Evers, van Hoorn and van Oost claim, it implies a pressure on Randstad’s highway net at the towns and cities' edges, which again will imply increased car dependency (Evers et al, 2005, 291). The focus is on the conflicts between the forces from the Dutch planning restrictions, international marked forces and the demand for optimal locations. How the road and street net's spatial set up will play a role is not discussed at all in this research. Therefore the space syntax tool is a significant contribution on linking the effects on changes in the spatial structure of the mobility network to the location of various enterprises and shopping areas.

6. Challenges for applying space syntax in impact assessments

The use of space syntax in impact assessment of proposed road alternatives has not been tested sufficient out yet. However, according to world-wide space syntax research results, there is a correlation between the spatial configuration of the street and road network and the location of economic activities, property values and traffic flow rates (Hillier et al 1993, 1998, Desyllas 2000, Read 1998, van Nes 2002). Likewise, the application of space syntax in urban design and regeneration projects in the UK has shown a high degree of predictability on the socio-economic effects on spatial interventions. Examples are on the regeneration of the Trafalgar Square, the South Banks and the location of the Millennium Bridge in London. After the implementation of these projects, the function as indicated in the space syntax analyses. Likewise, Sir Norman Foster has also applied space syntax on his plan on the regeneration of the Kings Cross area in London. It is all about how new urban projects contributes to improve or reduce connectivity to the existing street and road net and how it can
affect the socio-economic life in urban areas.

Depending on its degree of connectivity to its direct vicinity and the regional road net, a new proposed highway can have effects on the integration core on both global and local scales. The more the highway is direct connected to its vicinity, the more effect it has on the vitality of local areas. The lesser the highway is connected to its vicinity, the more effect it has on the vitality of the global scale of the whole city (van Nes 2002 and 2009, Ugalde et al 2012).

In what ways can the use of Space Syntax method give predictions of the effect of proposed road alternatives? Firstly it can calculate configurative spatial changes of an urban street grid. These mathematical calculations can be compared with the location pattern of shops on different levels. Secondly, the configurative changes as an effect of new roads can give indications of locations potentials of shops on different levels. These indications consist in whether existing shopping centres can be strengthen or weaken with these road alternatives. The configurative change can give indications if urban areas will loose they vitality or increase it as an effect of new proposed road alternatives. In what way new road projects affect various types of shopping areas seems to depend on the way they are imposed on the urban street grid and their degree of connectivity direct to its vicinity and the town’s main route network. Finally, using Space syntax method can identify new potential areas for location of car-based shopping centres outside existing shopping areas. In general, it seems to contribute to a lesser matter of guess-work of effects of proposed road alternatives than before.

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EU-direktiv 97/11/EF


