Accessibility calculations in six Swedish towns

M. Reneland

Department of City and Mobility, School of Architecture, Chalmers University of Technology, Göteborg, Sweden

Abstract

The Swedish National Road Administration (Vägverket) has financed the development of a GIS-method (Geographic Information System) to analyze different users’ accessibility to different facilities in real footway, cycleway, public transport and car networks. The focus is on the standard setting user groups (children, elderly and the disabled) in Swedish transport policy as well as on women and their assumed demands concerning safety, security and comfort in foot- and cycleway networks.

The method has been used in six Swedish towns, Helsingborg (86872 inhabitants), Umeå (70844), Luleå (57560), Trelleborg (24722), Alingsås (22183) and Säffle (9222). The foot- and cycleway networks have been given 24 different attributes, which are considered to be of importance for the safety, security and convenience of the user groups studied. Different accessibility analyses have been performed within the project.

To calculate public transportation accessibility, a GIS-model has been built, which connects bus stops to the foot- and cycleway network. The GIS-model for car use considers one-way streets, forbidden turns and average speed. Like the other models it can calculate travel time between real estate coordinates of free choice.

Using these three models it is possible to calculate accessibility and travel time quotients between the four modes of travel with origin and destination of free choice among the real estate coordinates.

The latest report from the project, (Reneland) is written in Swedish. A paper on the background of the project was presented in English at the Urban Transport IX conference (Reneland).

Keywords: GIS, accessibility, traffic safety, impaired individuals, children, walking, bicycling, public transport.
1 Introduction

The work of the Swedish National Road Administration (Vägverket) with regard to the national transport policy goals includes focusing on accessibility, safe traffic and a sound environment. They have noted a need for developments within the following fields:

- Public transportation accessibility to facilities of importance.
- Pedestrian and cyclist separation from car traffic with respect to street environment and function.
- Accessibility for the disabled.
- Walking accessibility for the elderly to facilities of importance (home – food store).
- Accessibility for children to schools and recreational activities.

Mats Reneland at the department of City & Mobility, Chalmers University of Technology was asked by the Swedish National Road Administration (Vägverket) to develop a method to calculate different user’s accessibility in real networks. The focus was on the standard setting user groups and their assumed demands. Population information on real estate coordinates, created by Statistics Sweden, is used as origins for trips.

This GIS-method, based on ArcView 3.x, was developed in several projects from 2000 till 2004. These projects have been cooperations between Mats Reneland and SWEGIS AB. Today all different GIS programme applications developed within the project are joined into one user-friendly tool, ArcTVISS, and a manual for accessibility analyses.

The method has been used by Urban Analys (Mats Reneland), INREGIA AB and Trivector Traffic AB to calculate accessibility in six Swedish towns of different sizes: Helsingborg (86872 inhabitants), Umeå (70844), Luleå (57560), Trelleborg (24722), Alingsås (22183) and Säffle (9222).

2 The TVISS-method

Foot- and cycleway network input data is collected through field inventory. This network is characterized by 24 different attributes which are considered to be of importance for the safety, security and convenience of the user groups studied. The foot- and cycleway network is digitalized and the result from the field inventory is transformed into GIS link attributes. In the GIS-program the foot- and cycleway network is a table with fields (columns) and records (rows). Each field represents one of the 24 quality parameters and each record represents one unique part of the network, which differs from the surrounding parts concerning at least one quality parameter value. The time consumption to create the foot- and cycleway network database is for field inventory 60 hours per 10000 inhabitants, digitalization 40 hours and forming attributes 60 hours.

To be able to build the data base for public transport a special extension to ArcView GIS, LogiNet, has been developed. LogiNet creates new links to connect the foot- and cycleway network with the public transportation stops and
distributes cost/traveltime proportionally to the length of links according to the time table in question. Travel time is the sum of time to walk/cycle from the home (real estate coordinate) to a stop, waiting time at stops, travel time on bus between stops, time to change between public transportation lines, time to walk between stops when changing lines and finally time to walk/cycle from the last stop to the destination in question. The time consumption to create the public transportation data base is about 60 hours per 10000 inhabitants in all.

There are some ready-made street network data bases produced as car navigation systems, which can be used for TVISS analyses. The street network must have attributes about one-way streets, forbidden turns and average speed on each link. In our studies we have used Tele Atlas.

Once the network data bases have been created ArcTVISS automatically connects the real estate coordinates (with population information about number, age and sex) the shortest way to the nearest link in the network in question. In this way the number of a certain age group connected to a network with accessibility to a specific destination can be calculated.

As the foot-and cycleway network is characterized by 24 quality parameters it is possible to select those links which fulfil a specific traffic safety standard, a standard for those individuals with impaired mobility or impaired vision to create a sub-network with the standard in question. ArcTVISS calculates backwards with the destination, e.g. a school, as the origin for building a continuous sub-network and then calculates the number of the population group in question living in real estates connected to this sub-network. If it is possible to use detailed population information the TVISS-method has shown that it is possible to perform detailed accessibility analyses.

Figure 1: Children play in the traffic environment, having fun and training motor activity, balance, vision etc.
3 Children’s safe cycleway to sports grounds

Children do not have sufficient maturity (wide-angle vision, ability to react etc.) to cope with the traffic environment, which therefore should be designed in such a way that children are allowed to behave in an unsafe manner, which children do, without running into dangerous situations. We know from research that the outcome of an accident with a car depends very much on the car speed. Therefore a safe standard for children should mean that they should not be in contact with cars at a higher speed than 30 km/h. This means that children should bicycle on cycleways separated from car traffic. It also means that crossings should be in different levels or have speed reduction measures. The third quality for children’s safety is that the cycleways should have lighting. In the GIS program a sub-set of links can be selected which fulfils the above mentioned criteria. The full set of quality parameters can be seen in Reneland [2].

To these three criteria, another must be added to make the analyses useful: The sub-set links must reach one of the sports grounds in the town. Using the sports grounds as origins for analyses in ArcTVISS or the ArcView extension Network Analyst, it is possible to create the continuous sub-set networks which links real estate coordinates to the sports grounds. Then it is just to summarize the 7-12 year olds living in these real estates, to calculate how many of all 7-12 year olds with access by cycle to a sports ground in a safe way. With an assumed bicycling speed you have information about bicycling time from home to sports ground for each real estate.

Table 1: Children’s safe access to sports grounds by cycle in six towns.

<table>
<thead>
<tr>
<th>All 7-12 year olds</th>
<th>H-borg</th>
<th>Umeå</th>
<th>Luleå</th>
<th>T-borg</th>
<th>Alingsås</th>
<th>Säffle</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of network safe for children</td>
<td>42,6%</td>
<td>42,4%</td>
<td>48,1%</td>
<td>43,6%</td>
<td>41,8%</td>
<td>29,8%</td>
</tr>
<tr>
<td>% of all 7-12 with safe way to sports grounds</td>
<td>24,0%</td>
<td>4,0%</td>
<td>19,1%</td>
<td>2,2%</td>
<td>16,0%</td>
<td>2,7%</td>
</tr>
<tr>
<td>Average distance to sports grounds metres</td>
<td>1945</td>
<td>998</td>
<td>610</td>
<td>633</td>
<td>730</td>
<td>742</td>
</tr>
</tbody>
</table>

As can be seen from table 1 almost half of the cycle networks have the right safety standard for children, except for the small town of Säffle. Still a very small proportion of the children can reach a sports ground in a safe way due to the fact that many links with the right standard are not part of a continuous sub-network in contact with a sports ground. The average cycle distance in Helsingborg (H-borg) is very high compared to those of the other towns. From figure 2 we can see that those living in the south-east part have to make a long detour to the north to reach the sports ground Olympia due to an unsafe crossing (within the ellipse). Speed reduction measures at this crossing would be a good improvement to children’s safe cycle accessibility.
Figure 2: The safe cycle network to the sports ground Olympia in Helsingborg illustrating the need for speed reduction measures at a crossing to create a safe and direct access for those living in the south-east.

Figure 3: Photo from the crossing in figure 2.
4 Accessibility to food retail stores for mobility impaired individuals

Just over one million Swedes consider themselves to have limited ability with regard to movement, some 220 000 are using some means of assistance like wheel chairs, walking frames or walking sticks. The good standard for mobility impaired individuals investigated can be described as follows:

- The pedestrian lane must be separated from the bicycle by different paving material in foot- and cycleways.
- Accepted paving materials are asphalt, paving stone and asphalt/paving stone.
- There must be no obstacles on the footpath.
- Staircases must have railings on both sides and have a ramp with railings on both sides.
- Traffic islands at crossings must be deeper than 1.5 metres.
- Crossings must have wheel chair ramp or bicycle ramp.
- The inclination must be lower than 2 %.
- The width of pavements and footpaths must be at least 1.2 metres and of foot- and cycleways 4.1 metres as they are separated.

Figure 4: It is difficult manage a normal kerbstone when using a wheel chair or walking frame.
Table 2: Mobility impaired individual’s accessibility walking to food retail stores in six towns.

<table>
<thead>
<tr>
<th>Urban population</th>
<th>H-borg</th>
<th>Umeå</th>
<th>Luleå</th>
<th>T-borg</th>
<th>Alingsås</th>
<th>Säffle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban population</td>
<td>86872</td>
<td>70844</td>
<td>57560</td>
<td>24722</td>
<td>22232</td>
<td>9222</td>
</tr>
<tr>
<td>Proportion with walking access to a food store when mobility impaired</td>
<td>1.6%</td>
<td>0.8%</td>
<td>0.1%</td>
<td>1.5%</td>
<td>0.6%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Average distance</td>
<td>166 m</td>
<td>211 m</td>
<td>109 m</td>
<td>146 m</td>
<td>23 m</td>
<td>196 m</td>
</tr>
</tbody>
</table>

It is obvious that the few destinations (food retail stores) affect the accessibility in a negative way. A very small proportion in all towns has the possibility to go to a food retail store when mobility impaired. In Umeå we can see that many retail food stores are not possible to access for mobility impaired individuals (figure 5). And those which can be accessed have very short pedestrian networks around themselves.

Figure 5: Part of Umeå with foot network for mobility impaired individuals adjacent to food retail stores (squares).
5 Accessibility with different means of transportation to work place concentrations in six towns

In this analyse the accessibility for the age group 25 – 64 years has been calculated. They are supposed to use all types of crossings but are not allowed to use streets when cycling. The destinations are four points surrounding the town centre and one point representing the major town hospital. These destinations represent a high concentration of employees.

Table 3: Accessibility for the age group 25 – 64 years by cycle, bus and car to work place concentrations in six towns.

<table>
<thead>
<tr>
<th>Town</th>
<th>H-borg</th>
<th>Umeå</th>
<th>Luleå</th>
<th>T-borg</th>
<th>Alingsås</th>
<th>Säffle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban pop</td>
<td>46112</td>
<td>39210</td>
<td>31173</td>
<td>12547</td>
<td>11092</td>
<td>4553</td>
</tr>
<tr>
<td>Proportion with access by cycle</td>
<td>13.4%</td>
<td>28.8%</td>
<td>12.7%</td>
<td>32.1%</td>
<td>22.7%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Proportion with access by bus</td>
<td>75.2%</td>
<td>73.3%</td>
<td>54.2%</td>
<td>60.6%</td>
<td>62.2%</td>
<td>43.2%</td>
</tr>
<tr>
<td>Proportion with access by car</td>
<td>100.0%</td>
<td>100.0%</td>
<td>99.1%</td>
<td>99.9%</td>
<td>99.6%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 6: Accessibility by cycle and car to work place concentrations in Trelleborg. Grey = accessibility by car but not by cycle. White = cycle is faster than car. Black = car is faster than cycle.

As can be seen from table 3 the whole urban population in all towns can use the car, if they have access to one, to reach the work place concentrations. Compared to car accessibility, accessibility by cycle is poorer. In Trelleborg as much as one third of those in the age 25 -64 years have accessibility, whilst in the small town of Säffle only very few have accessibility.
The geographical distribution of accessibility with two modes of transportation at the time is shown for Trelleborg in figures 6 and 7.

From figures 6 and 7 we can learn that from the whole urban area work place concentrations are accessible by car. In the fairly small town of Trelleborg cycle is faster than car except in the outskirts of the urban area (figure 6). Bus is faster than car only in the vicinity of the work place concentrations. These bus trips are made by foot as LogiNet automatically chooses accessibility by foot direct from origin to destination if this is faster than going to a bus stop, waiting for the bus, travelling by the bus and finally walk to the destination.

Figure 7: Accessibility by bus and car to work place concentrations in Trelleborg. Grey = accessibility by car but not by bus. White = bus is faster than car. Black = car is faster than bus.

6 Conclusions

ArcTVISS is shown to be a most useful tool to perform accessibility analyses, to form the basis of decision-making on measures in the traffic environment, and at the same time it highlights the need for operational knowledge about the relations between street design and the users’ safety and security.

The three analyses presented in this paper are meant to be just examples of the enormous possibilities for in-depth accessibility analyses. In the Swedish research report some 30 analyses have been presented and they are still just examples of what can be analysed.

In Sweden of to-day planners are of high age and a large part of them will retire within 5 – 10 years. Very few of them have any skills in working with GIS-programs. In most municipalities there is at least one GIS-engineer. Using GIS as a tool in everyday planning is therefore very rare as those familiar with the planning problems, the planners, do not know how to use GIS-programs and those who can use GIS-programs are not aware of the planning problems. This situation will probably change in the next 10 years. As about 80% of all information dealt with in a municipality is geographic, it seems as a natural
assumption to think that the use of programs which can work with geographic information will increase. Local geographical databases will be built and used for analyses and consequence calculations at municipality level and the use of GIS-programs will be as normal as using Word or Excel in every-day work.

References