Impact of spatial planning on sustainable traffic safety,
the mix of different transport modes as explanatory element (case study on the city of Mechelen)

Tony Dufays & Therèse Steenberghen,
K.U.Leuven R&D/Ground for GIS, Vital De Costerstraat 102, B-3000 Leuven, Belgium
tony.dufays@agr.kuleuven.ac.be

1. Background and objective

The research project presented in this paper is part of the broader research programme on 'Sustainable Mobility' (1998-2000), launched and sponsored by the Belgian Federal Services for Scientifical, Technical and Cultural Affairs (SSTC). This programme includes the examination of explanatory and determining factors of traffic safety in Belgium.
The objective of the study is twofold: first, to examine the carrying capacity (in terms of safety) of different land uses for traffic, and second, to examine the carrying capacity (in terms of safety) of roads for the traffic generated by different land uses. The number of accidents per land use - road type combination is used as an indicator of this carrying capacity. The distinct road types are identified in terms of road design and traffic.

In a previous paper[1] [2]the preliminary results were presented concerning the analysis of accident locations in relation to different road type - land use combinations for a first case study on the city of Mechelen[3]. The ***mix of different transport modes*** seemed to be an important element in the explanation of the accidents.

In nearly half of all accidents (998/2216) vulnerable road users were involved, of which over 80% were cyclists (809/998). The highest ratios of accidents are observed on combinations of road type and land use type that are typical for the mix of vulnerable and motorised road users (city centre, densely built areas).
This paper presents the results of the research that focused on the hypothesis that the mix of different transport modes may be an explanatory element of these high accident ratios.
Interventions that may affect the mix of different types of road users can be found on two levels. First, on the level of the road infrastructure itself (the same types of traffic are kept on the road, but separate tracks are reserved for the different users), and second on the level of zones within the concerned area (for some road users access to certain parts of town can be denied or restrained). The impact of cycling tracks and the special situation on crossroads and the effects

of the implementation of a new traffic scheme in the city centre will be discussed.

2. Method

Accident data are available at the National Institute of Statistics (NIS). All accidents ***with injuries*** between 1991 and 1996 were located through a GIS, based on the combination of streetname-housenumber or streetnumber-hectometre marker[4]. 2210 out of 2800 accidents could be localised manually on a digital roadmap. For each accident, more than 100 attributes are available, such as the type of road user, the date and time of occurrence, descriptive information concerning the roads, the weather, authorised speed, etc..

A digital roadmap provides information about the type of roads (functional road class, physical road class).

Other digital maps concerning land use were used as well (zoning maps, land use maps; etc.).

Finally, new maps, mainly based on density calculations[5] of accidents, and tables were computed, eventually differentiated by the attributes of the accident data.

Findings

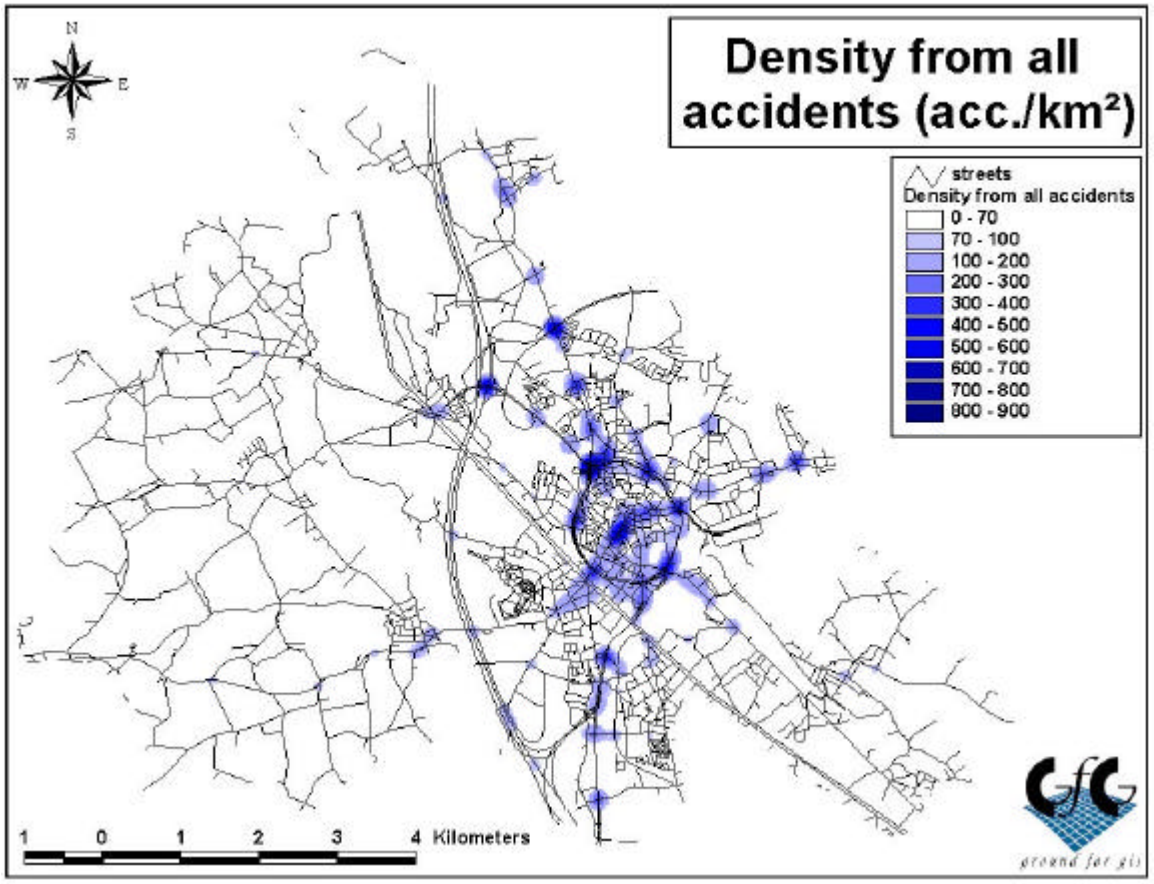
3.1. General descriptions of the accident occurrence in the city of Mechelen

3.1.1. Description of all accidents (Map 1)[6]

In general, relatively more accidents (up till 3 times the mean in the city centre) are observed within the urban district. The high ratios in the city centre mainly have to be explained by the main roads. Geographically, a whole zone of higher accident ratios is observed in the southern part of the city district.

The number of accidents involving only motorised vehicles in the city centre is still twice the mean, but much less than the observed ratios for all accidents. It follows that the high numbers of accidents in the city centre have to be explained by accidents with vulnerable road users. This is expected, considering the importance of their presence there.

On the main entry roads, concentrations around some crossroads can be observed as well. Along the smaller entry roads, the map also shows higher ratios than in average.

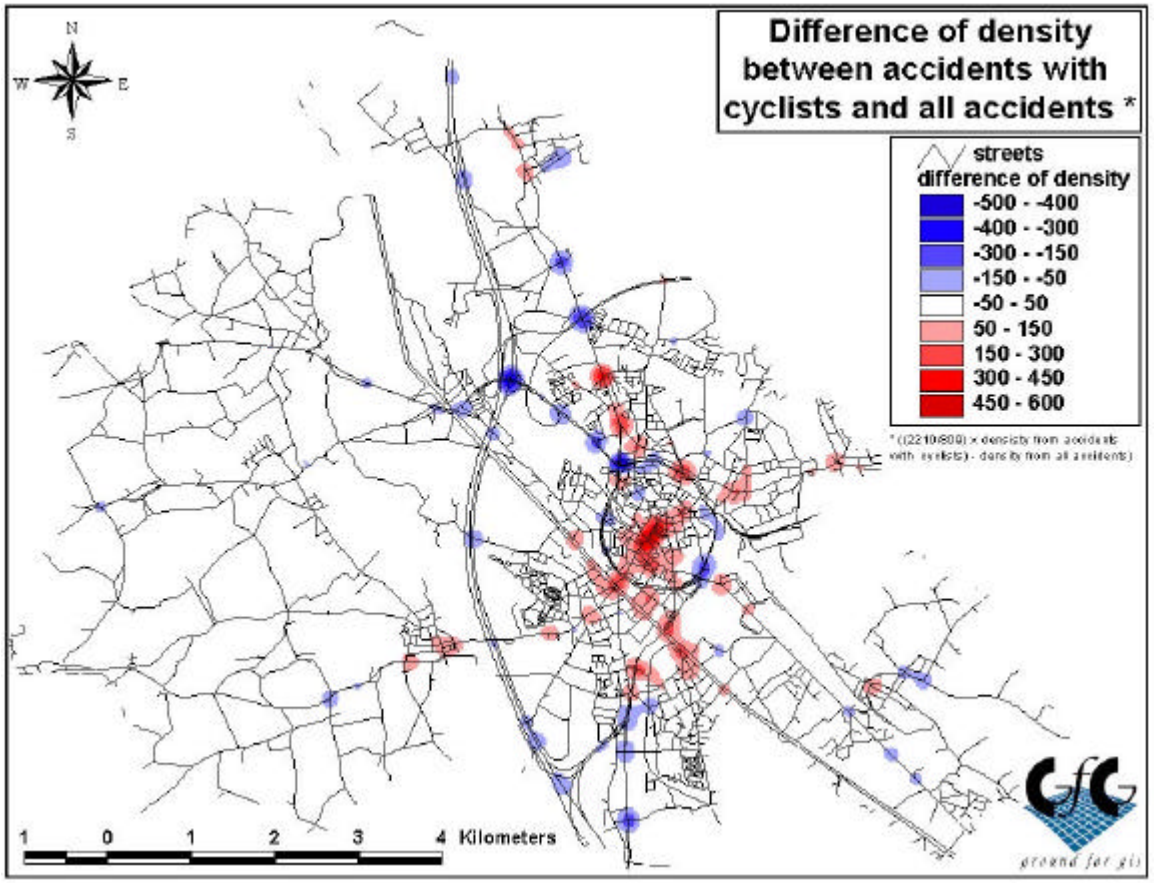


MAP 1: *Density of all accidents in accidents/km²*

3.1.2. Description of the accidents with cyclists

Map 2 shows the difference between the density map of all accidents and the density map of all accidents involving cyclists. A remarkable over concentration of accidents with cyclists can be found in the inner city and in the densely built areas outside of the urban district. Comparison between the order of magnitude of this map and of the one all accidents (respectively 500 accidents/km² and 800 accidents/km²) argues that the high ratios of accidents in the city centre have to be explained by accidents with cyclists. The city centre definitely has the highest accident ratios. In the near of the city centre, especially to the south an other area of higher risk can be found, reaching even further than the ring road. Higher ratios of accidents with cyclists can also be observed on the crossroads of the entry roads in the neighbourhood of the city centre. On these same roads, but further out of town, an over concentration of accidents with only motorised vehicles can be observed.

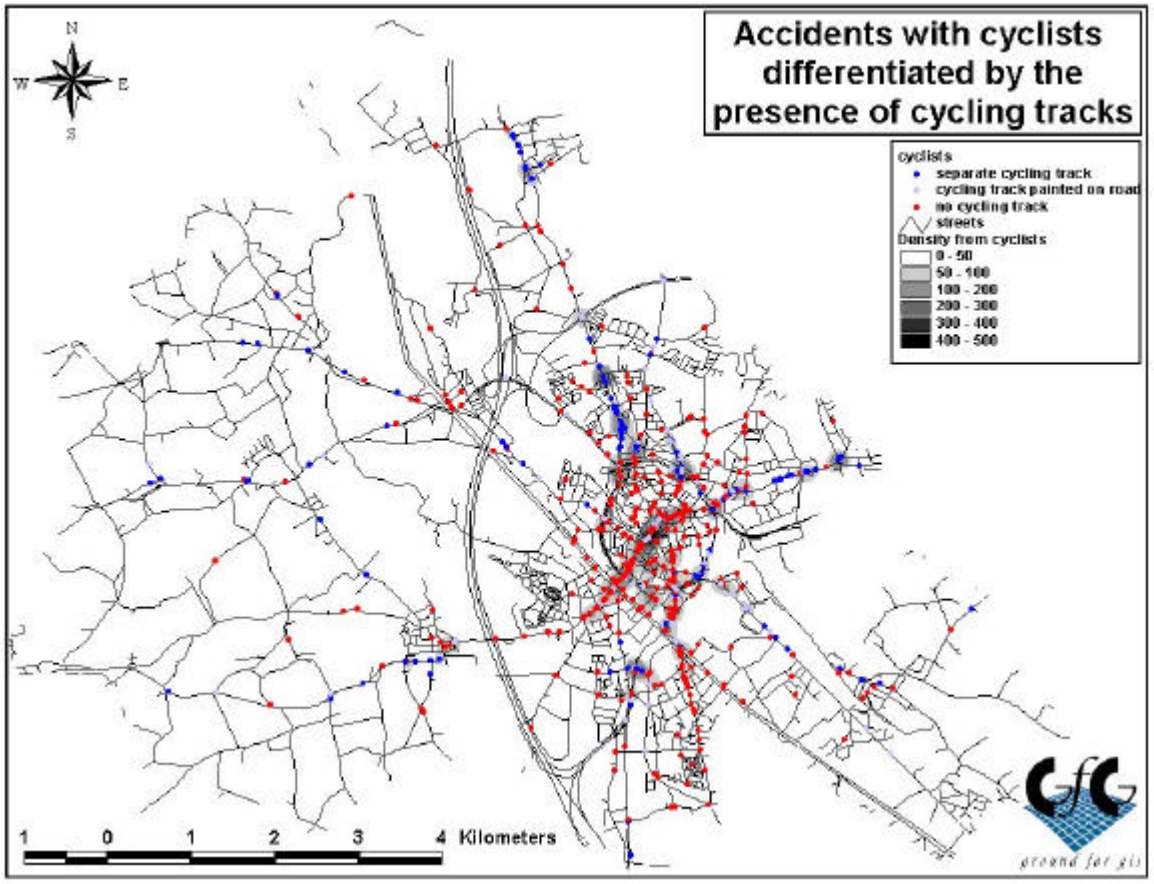
No data about the use of these areas by vulnerable road users are available, but there are serious reasons to believe that to a certain degree, a map of the road use by cyclists would look rather similar. However we believe that there are certainly more factors needed to explain the occurrence of accidents than only the traffic, like for example the mix of different traffic modes.



MAP 2: *Difference of density between accidents with cyclists and all accidents*[7]

3.2. The absence of cycling tracks as explanatory element for high ratios of accidents

In quantitative terms, two types of land use show the highest accident ratios. On one hand the city centre (255 accidents)[8] and on the other hand the densely built areas outside of the urban district (275 accidents)[9]. Map 3 shows all accidents with cyclists differentiated by the presence of cycling tracks.



MAP 3: *Accidents with cyclists differentiated by the presence of cycling tracks*

The highest concentration of accidents is found in the city centre, and clearly corresponds to the total absence of cycling tracks[10], even on the main roads.

486 of all 809 accidents involving cyclists (or more than 60%) were accidents on roads without separate cycling tracks in a densely built area (city centre (235); outside of the city centre (251)).

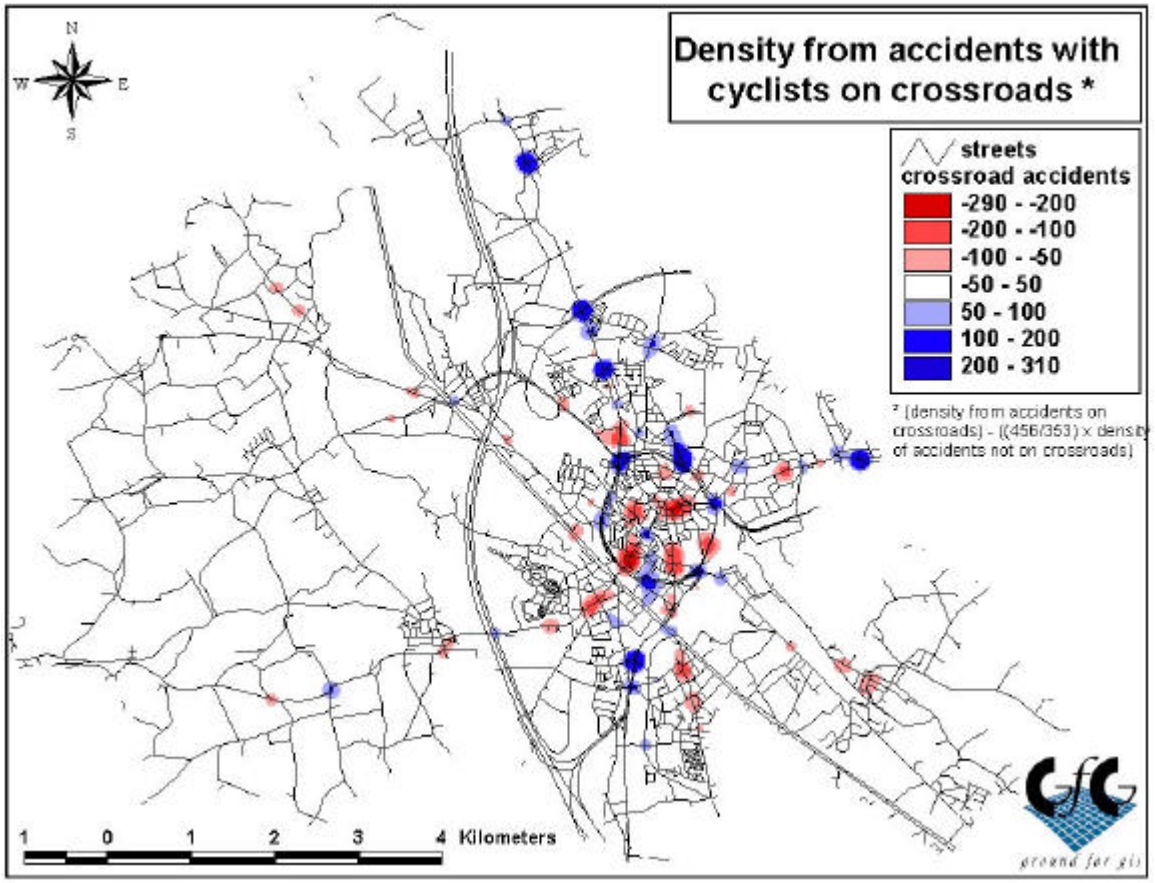
The other places besides the city centre where high concentrations of accidents with cyclists can be found are entry roads. On the entry roads where separate cycling tracks are available, twice as much accidents occurred at crossroads, thus where the separate cycling tracks stop for a while. This is not the case on the other (entry) roads (see table 1).

	cycling track	no cycling track
cross road	165 (69%)	115 (50%)
no cross road	74 (31%)	115 (50%)
	239 (100%)	230 (100%)

TABLE 1: *Accidents in built area out of the centre of town*[11]

Map 4 shows the accidents differentiated by the occurrence: on a crossroads or not. Here to,

we clearly see, compared to map 3, that high densities of accidents on entry roads without cycling tracks, mainly has to be explained by the accidents that did not occur on crossroads and the accidents on entry roads with cycling tracks did occur in a larger amount on crossroads.



MAP 4: *Density from accidents with cyclists on crossroads*[12]

As there is no reason why on the roads where there are actually cycling tracks, the proportion of accidents which occurred on crossroads versus these which did not would be different, the influence of cycling tracks would be as much as a halving of the accidents along the roads.

3.3. The implementation of a new traffic scheme.

In the second part of 1993 a new traffic scheme was implemented in the city centre of Mechelen. The objective was traffic calming in the centre of town (in the middle of the centre even car free). Loops were developed for through going motorised traffic within the centre (see map 6).

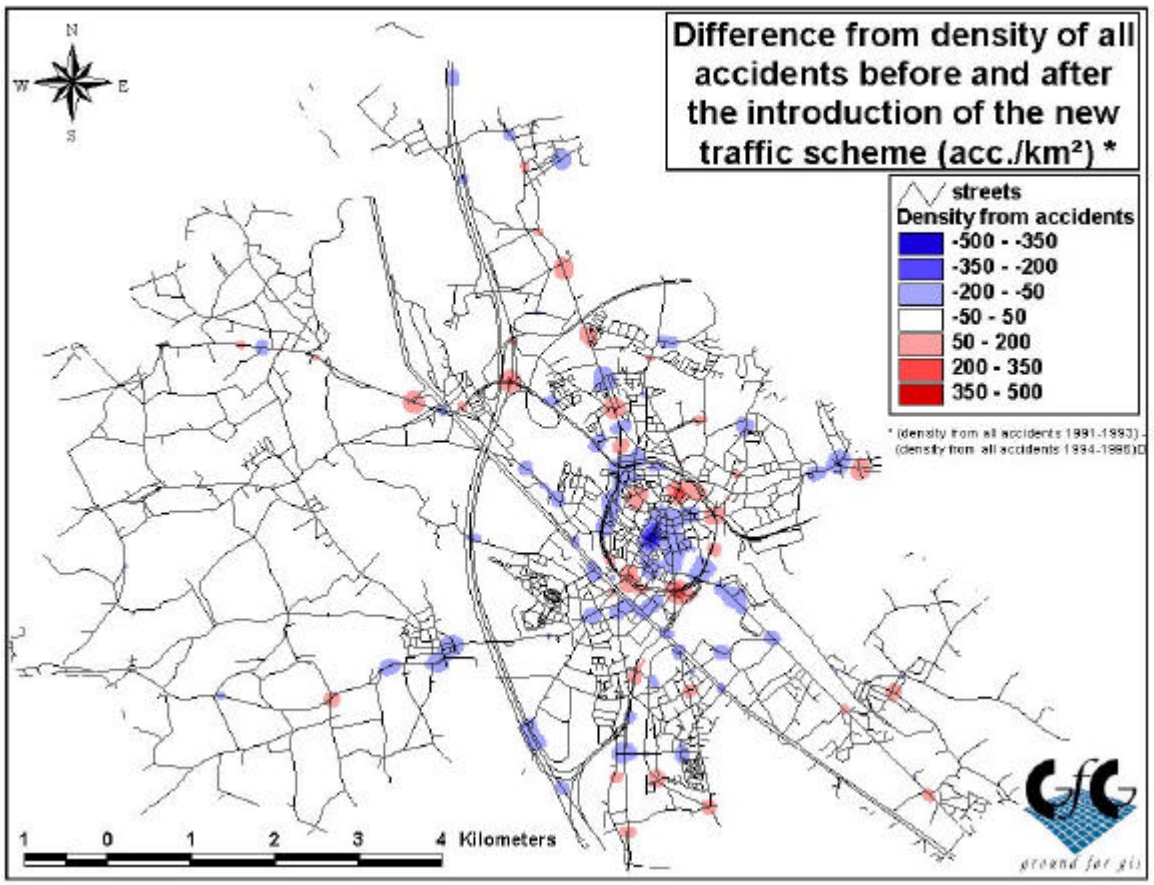
A decrease of the total number of accidents can be observed in the centre of town (including the ring roads), which at first sight does not seem to be large, but is significant[13] (table 2). In that same period of time a decrease of the total number of accidents (with injuries) on the Belgian national level is observed as well, which in general is explained by the use of safer cars (Steenberghen et all, 1998). The largest mean difference however, is observed by accidents

with cyclists[14], which is not influenced by safer cars.

	Cars	Pedestrians	Cyclists	Total
1991	**43**	**18**	**43**	**104**
1992	**40**	**12**	**59**	**111**
1993	**50**	**18**	**36**	**104**
Average	*44*	*16*	*46*	*106*
1994	**37**	**20**	**37**	**94**
1995	**46**	**10**	**43**	**99**
1996	**44**	**14**	**37**	**95**
Average	*42*	*15*	*39*	*96*

TABEL 2: *Accidents in the city centre by different transport modes*

Map 5 gives the difference between the computed density of the accidents before the end of 1993 and the density of those occurred after the beginning of 1994.

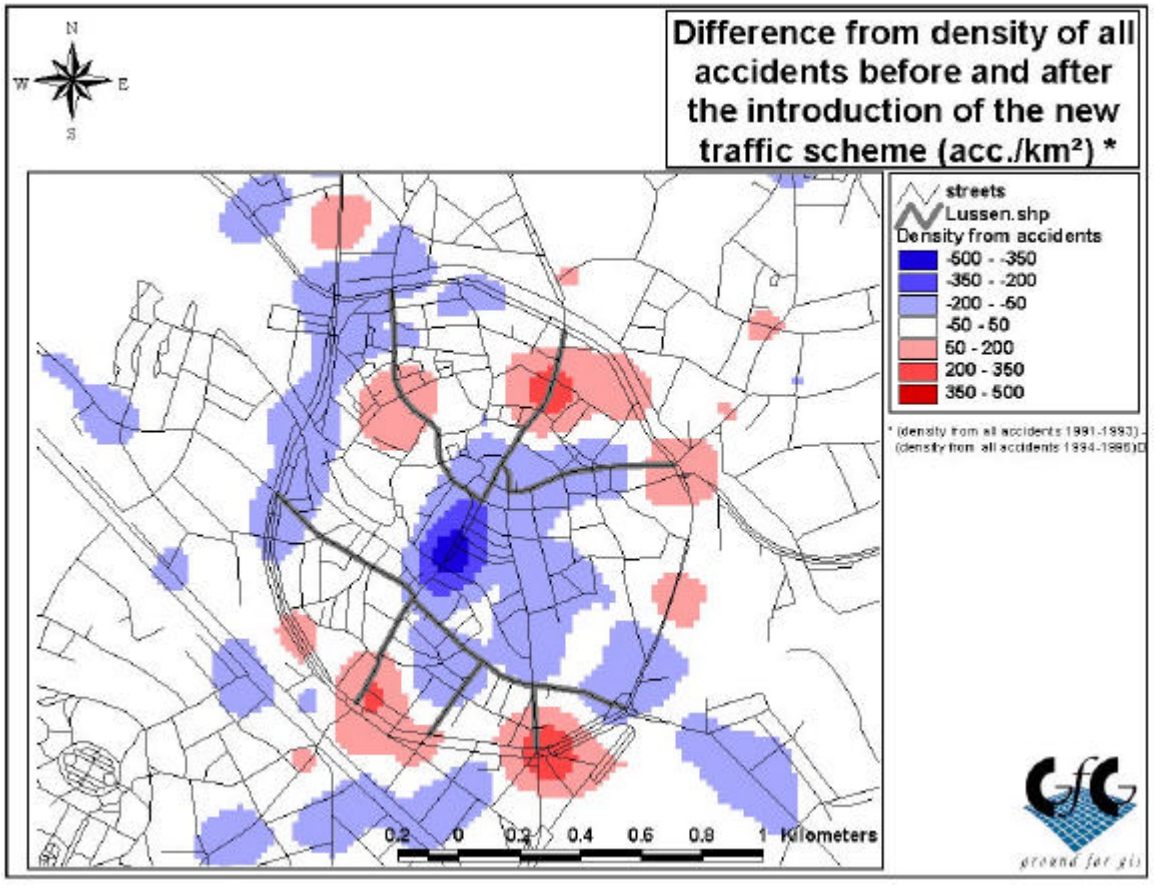


MAP 5: *Difference from density of all accidents before and after the introduction of the*

new traffic scheme (acc./km²)[15]

The most notable evolution is the substantial decrease of accidents in the middle of the centre of town to zero. As there is no reason to think a decrease of cyclists would be observed, this has to be explained by the absence of motorised road users (or at least the substantial decrease of their presence and/or their speed) , as they have no longer the possibility to pass through the centre.

While this decrease seems to be a very good result, we also observe that a rather important increase of accidents is observed around the centre. More specific, map 6 shows that this increase can be found at important crossroads on the new loops in the city centre and even as far as the beginning of the loops on the ring road. So, probably the new traffic scheme involved that other places now are confronted with a high amount of traffic and that they are not (yet) adapted for this use.



MAP 6: *Difference from density of all accidents before and after the introduction of the new traffic scheme (acc./km²)*

4. Concluding remarks…

Even though we are aware of the fact that a lot of other elements have an important role in explaining the occurrence of accidents, like local conditions, traffic, road capacity and properties of the infrastructure (especially on crossroads), etc. , this kind of research on a larger scale leads to the following interesting conclusions.

In areas where the traffic consists of a mix of different types of road users, higher accident ratios can be found. It cannot be denied that cycling tracks can play a major role in preventing accidents in these areas. Since the construction of separate cycling tracks on all roads is not possible (neither financially, neither spatially, especially in historical centres), other approaches will be necessary. Mainly two other possibilities can be suggested, such as the reduction of the mean velocity of the traffic flow to the velocity of the vulnerable road users, or the reduction of motorised traffic in the areas with high numbers of these vulnerable road users, or de facto again preventing contact between different types of road users.

Like planning new cycling tracks, reducing the velocity of motorised road users often means expensive infrastructure works, as this velocity has to be reduced to 30 km/h or less[16]. Finally the reduction of motorised traffic in areas with high numbers of vulnerable road users through the introduction of a new traffic scheme was discussed. At first sight the results were positive, but they were certainly not satisfactory. It seems that the lack of safe connections between the existing cycling paths on the entry roads and the city centre (see map 6) is still the reason for the observed high number of accidents.

Therefore besides interventions such as new separate cycling tracks and zones with speed limited to 30 km/h, separate preferential networks, without interruptions, of cycling (and pedestrians) tracks, connecting densely built areas outside of the city centre (including neighbouring cities) and all important locations inside and outside of the city centre, could probably provide a further step to solve this problem.

It is definitely so, that a large amount of other factors such as badly conceived crossroads and other road infrastructure, have an important influence on the occurrence of accidents. These elements however will need research on another scale.

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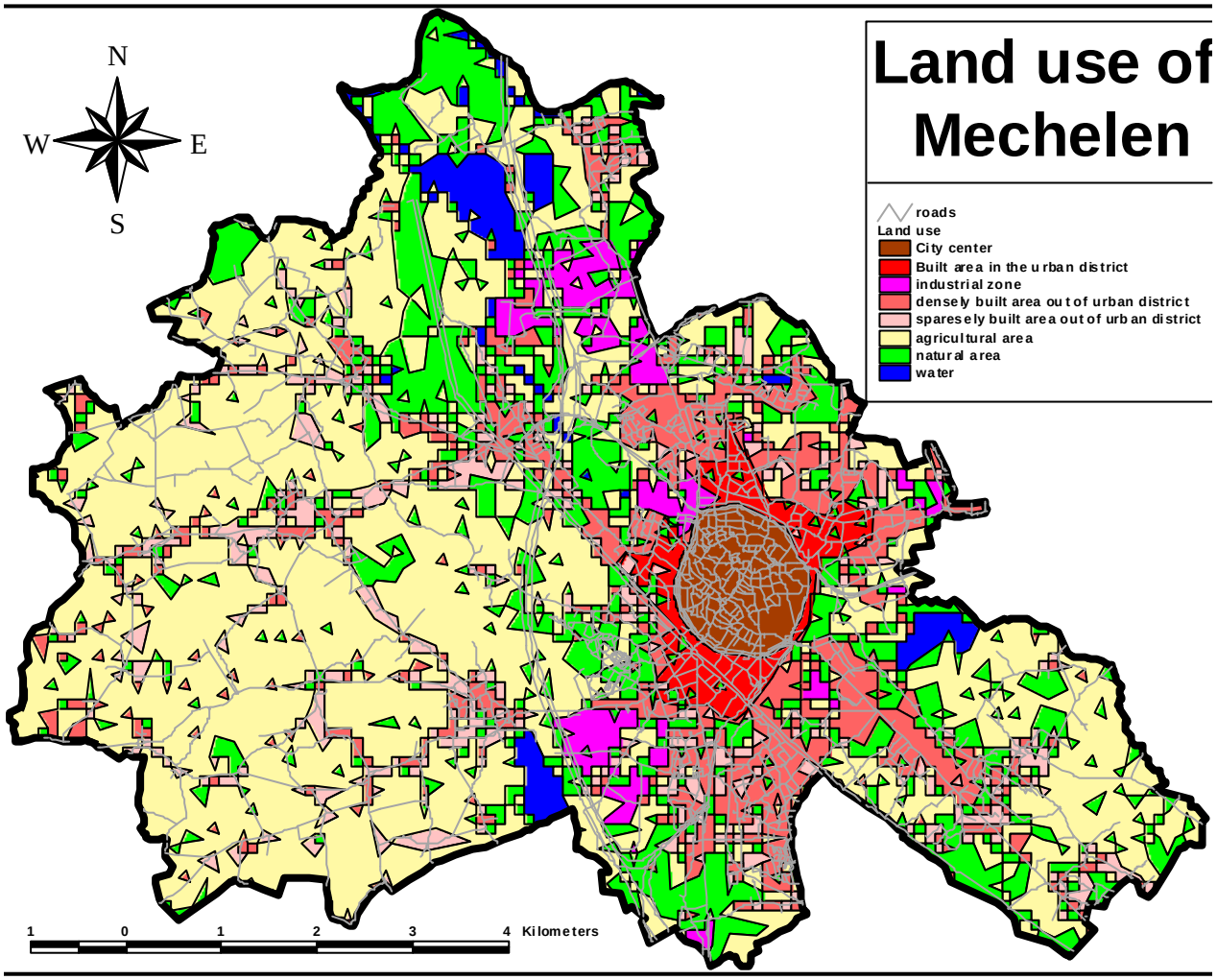
APPENDIX 1: Land use of Mechelen



The Land use map of Mechelen shown above is the result of a transformation of a raster image based on satellite information with pixels of 20m by 20m. Following transformation has been made:

- Reclassifying:
  - deleting irrelevant classes like 'infrastructure (mainly the roads itself)'
  - add new classes " city centre" and "urban district"
  - refill of empty cells based on neighbours
- Enlarging of cell size till 100m by 100m (based on accuracy of overlay and localisation of the accidents.

APPENDIX 2:

TABLE 2: Significance of difference since new traffic scheme on total of accidents in the city centre

F-Test Two-Sample for Variances				t-Test: Two-Sample Assuming Equal Variances	
	Variable 1	*Variable 2*		Pooled Variance	11.66666667
Mean	106.3333	96		Hypothesised Mean Difference	0
Variance	16.33333	7		Df	4
Observations	3	3		t Stat	3.705208689
df	2	2		P(T<=t) one-tail	0.010370355
F	2.333333			t Critical one-tail	2.131846486
P(F<=f) one-tail	0.3			P(T<=t) two-tail	0.02074071
F Critical one-tail	19.00002			t Critical two-tail	2.776450856

TABLE 5: Significance of difference since new traffic scheme on accidents with cyclists in the city centre

F-Test Two-Sample for Variances				t-Test: Two-Sample Assuming Equal Variances	
	Variable 1	*Variable 2*		Pooled Variance	75.5
Mean	46	39		Hypothesised Mean Difference	0
Variance	139	12		Df	4
Observations	3	3		t Stat	0.98666607
df	2	2		P(T<=t) one-tail	0.189831895
F	11.58333			t Critical one-tail	2.13184648

	3				6
P(F<=f) one-tail	0.0794701			P(T<=t) two-tail	0.379663789
F Critical one-tail	19.000026			t Critical two-tail	2.776450856

[1] T. Steenberghen, T. Dufays (1999) "Impact of spatial planning on sustainable traffic safety, Belgian situation analysis". Second Road Research Conference, 7-9/6/1999. 14 pp.

[3] Mechelen is a city of approximately 100.000 inhabitants located between Brussels and Antwerp. Between 1991 and 1996 exactly 2800 accidents ***with injuries*** were recorded.

[4] A more detailed evaluation of the accuracy of the localisation techniques, and the methods to increase the accuracy can be found in Steenberghen & Dufays, 1999.

[5] Density maps were computed with the Kernel Method in ARC/VIEW on cells of 20mx20m, with a search radius of 200m.

[6] For a map of the land use of the city of Mechelen, see appendix 1.

[7] ((2210/809) x density of accidents with cyclists) - density of all accidents). The factor is necessary to rescale the density map (all accidents: 2210 in total; all accidents with cyclist: 809 in total). If we wouldn't do so, the result would be the density map of all accidents with pedestrians and motorised road users. Now, we get an idea about over and under concentrations of accidents with cyclists compared to the concentrations of all accidents.

[8] On a total of 809 accidents

[9] On a total of 809 accidents

[10] The amount of accidents on roads without separate cycling tracks in all densely built areas (city centre (235) and out of city centre (251) 486 of all 809 (or more than 3/5) accidents with cyclists.

[11] Due to the localisation method, which performance is slightly better along the main roads, than along the less important roads. There are serious reasons to think that this even is an underestimation of the discrepancy.

[12] (density from accidents on crossroads) - ((456/353) x density of accidents not on crossroads); see also footnote 6

[13] See appendix

[14] The difference between accidents with cyclists before and after 1993 is not significant, due to the much larger variance. See appendix.

[15] (density from all accidents 1991-1993) - (density from all accidents 1994-1996)

[16] For having some results on road safety, a speed reduction till at least 30 km/h will be

necessary. Reducing speed till 50 km/h definitely is not enough, as nearly 2/3 (505/809) of all accidents with cyclists occurred on roads where speed was limited at 50 km/h and even more than 80% (658/809) on streets with speed limited at 60 km/h