CONTROLLED CONFLICTS ON RURAL MINOR ROADS BY MEANS OF ROAD TRAFFIC INFORMATICS

Mr H Botma and Professor P H L Bovy,
Delft University of Technology,
The Netherlands

96ATT042

Abstract

Meetings of motorised traffic at relatively high speeds with pedestrians and cyclists on single carriageway minor roads are potentially unsafe events due to the difference in speed and the vulnerability of the unprotected road users. Separate paths for slow traffic are financially unattractive and a permanent low speed for the fast traffic is also costly to achieve and will be opposed by the public.

Application of modern Road Traffic Informatics can solve this dilemma in an elegant way. A system is proposed and discussed that can accomplish a civilised and appropriate speed behaviour of the motorised road users. The slogan is: only speed reduction when it is really needed. The system can make minor roads attractive again for pedestrians and cyclists.

1. Introduction

This paper is inspired by two developments: the world wide study of Road Traffic Information (RTI) systems; and, the plans in the Netherlands to rebuild the traffic system into a so called inherently safe system which is at least 10 times safer than the present one.

Developments in the field of collecting data about vehicles and traffic, of communication of these data between vehicles and between vehicles and road side posts, and of processing the data into useful information and presenting this to drivers are going fast. This can be illustrated by research programs in Europe (DRIVE and Prometheus), in the US and in Japan. A striking characteristic of these programs is the little attention that is given to slow traffic, such as pedestrians and cyclists; see e.g. Commission of the EC (1991). As one of the goals of these programs is to improve safety, it is needed to include slow traffic. It is neither feasible nor attractive to restrict slow traffic to special areas such as pedestrian zones.

In the Netherlands the road safety institute (SWOV, 1990) initiated a masterplan towards the development of an inherently safe traffic system. One of the main points of this approach is a rigorous separation of traffic modes when they are not compatible in terms of safety. Existing examples are the motorway, separation of pedestrians and vehicles by means of side walks; separation of cyclists and cars by means of separate cycle paths, etc. When meetings of slow and fast traffic are inevitable the speed of the fast vehicles should be strictly limited to e.g. 30 km/h. This is the solution chosen in 'Woonerf' and 30 km/h areas.

To realize an inherently safe system on a larger scale will require a lot of new infrastructure or at least a rebuilding of existing facilities. This paper presents a case where the solutions of separation and speed reduction are not efficient and the application of RTI seems much more attractive. Technical details will not be treated but the desirability of the system will be argued and some aspects and potential problems will be discussed.

2. Description of the Problem

Mixing of fast moving vehicles (FMV), e.g. cars, trucks, motorcycles, and slow moving vehicles (SMV), e.g. cyclists, pedestrians, wheel-chairs, horsemen, does not fit in an inherently safe traffic system. Two directions to make the situation safe are available: separation of traffic; and, decreasing the speed of the FMV.

In residential areas inside built-up areas one has chosen to lower the speed of FMV to a safe level of 30 km/h. The lower speed is attained by means of signs and the design of the infrastructure. These measures have a positive influence on safety, see e.g. Brilon & Blanke (1993), and can possibly be made even more efficient when the low speed is obtained by means of remote controlled vehicle speed limiters.

On main arterials inside and outside built-up areas separation of FMV and SMV is applied. Sometimes this solution is difficult to apply, e.g. in old parts of cities there is not always enough space for separation. A safety problem does also exist at intersections where FMV and SMV are using the same space. However, these problems are not considered in this paper.

Outside built-up areas separation of FMV and SMV is the preferred measure on higher order roads. However, in all countries the road length where FMV and SMV are using the same carriageway is substantial. In the Dutch guidelines the requirement of a separate cycle path is dependent on the product of the intensities of FMV and SMV. In the design manual for cycle infrastructure, CROW (1993), separation is dependent on the intensity and speed of FMV and not on the intensity of the SMV. These are both compromises and not compatible with inherently safe traffic.

We will now limit the discussion to the road type with only one lane for both directions and used by FMV and SMV. Intensities of both vehicle types are generally low on these roads and in that case the measure proposed is most relevant. However, one certainly should study the applicability to two-lane roads as well.

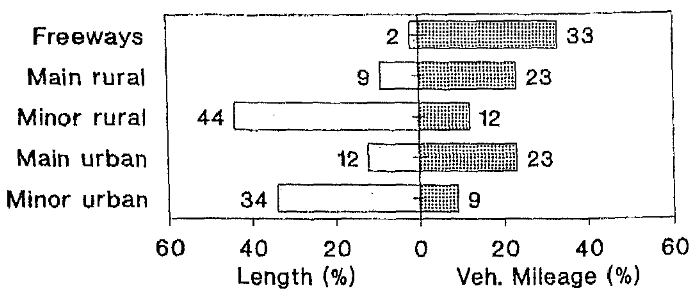

Fig 1. Distribution of road length and vehicle mileage over five main road types in the Netherlands in 1986.

We will illustrate the size of the problem with Dutch statistics in 1986. Of course the situation will be different in other countries but we guess that in quite a few the situation will be more or less the same. **Figure 1** presents the road length and the distribution of the total vehicle mileage over several road types. One-lane roads are a subset of Minor Rural Roads and have the following statistics:

- They constitute 32% of the total road length of the country;
- 4.4% of the vehicle mileage is 'produced' on these roads and about 5.5 % of the vehicle hours;
- The AADT is 314 motorised vehicles.

Unfortunately no data about the use of these roads by slow traffic is available.

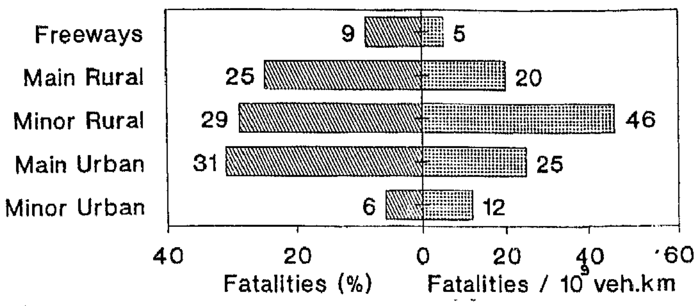

Fig 2. Distribution of number of fatalities and fatality rate over five main road types in the Netherlands in 1986.

Figure 2 presents the general safety statistics for several road types. For one-lane roads the following safety statistics are available:

- Of all people killed in traffic 14.2 percent are on these roads;
- Per vehicle distance driven and per vehicle hour spent the number of people killed is the highest of all road types;
- 7.1 percent of accidents with injuries occur on these roads;
- Considering accidents with injuries, only main roads inside built-up areas have a higher accident rate (per vehicle distance and per vehicle time).
- The number of accidents per year is only .1 per km road length. This means that on one lane roads the accident concentration is lowest. This fact alone implies that a solution of the safety problem can be better sought in measures changing the vehicles than in changing the characteristics of the infrastructure.

Separation of fast and slow traffic on these roads is not attractive because of the high costs. Lowering the speed of the FMV is neither an attractive measure, because:

- Enforcement is difficult and costly in terms of police hours;
- Modifying the road to force low speeds (humps, etc.) is also costly;
- A RTI solution would be to reduce the speed by speed limiters in the cars that are remotely controlled from outside. This is not efficient as will be shown in the sequel.

An even more important counter argument is the acceptance by the public. The roads we are talking about are nearly always empty. A permanent speed limit is not efficient because most of the time it is useless. The extra travel time for FMV due to a permanent lower travel speed, summed over the total network, would be a substantial amount, as can be illustrated. In the Netherlands 3.6 $_{10}{}^{9}$ vehicle km are driven annually on one-lane roads. If the average travel speed is reduced from 50 to 30 km/h, then the extra travel time will be: (1/30-1/50)x3.6 $_{10}{}^{9}$ = 48 $_{10}{}^{6}$ veh hour.

One could imagine that civilised drivers reduce their speed voluntarily to 30 km/h when meeting a SMV. Unfortunately that type of behaviour is not very common. It requires far too much imagination from the drivers to understand that such a drastic speed reduction is needed to lower the frequency of accidents which are and will be such rare events. On the average a car driver can travel a million km between successive injury accidents. Even experts in the relation between safety and speed do not show the required speed behaviour.

3. Outline of the Proposed RTI System

In essence the proposed system consists of a moving space around a SMV and inside this space the speed of FMV is controlled in such a way that at the meeting the speed of the FMV is as low as safety requires. Consequently the system does not only detect the presence of the SMV and signals this to the driver of the FMV, it also controls the response of the FMV; see **Figure 3**. The system is completely vehicle based, no central intelligence or road side equipment is needed. As stated before, SMV can be pedestrians, cyclists, wheel-chairs, horsemen, etc. Most important users will be usually pedestrians and cyclists. Regarding FMV cars, trucks and motorcycles will be the most frequent users.

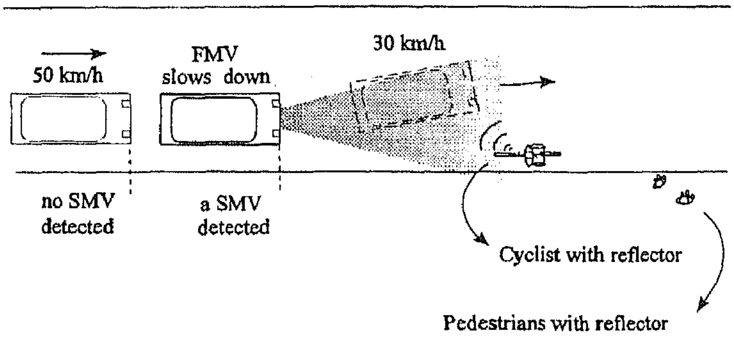

Fig. 3. Illustration of how the system could function.

All road users are equipped with a system that measures their position, speed and direction and quasi permanently transmits these data to the other road users within a certain distance. The FMV also knows on which section of the road network it is driving. This is needed for instance when a secondary road goes over or under a motorway.

The RTI systems of the vehicles communicate permanently and based on this it is decided whether a meeting (either overtaking or oncoming) is imminent. The decision to take action is taken by the FMV-intelligence. It might be a feature that the SMV-user is signalled that a FMV is taking action. The response of the FMV is a controlled speed reduction to e.g. 30 km/h. The acceleration after the meeting can be left to the driver.

The situation is becoming more complex when more than two road users are in each others neighbourhood. Then there will be several areas in the road-time plane where a speed reduction is needed. The most severe restriction will then get priority. In this case the situation is also more complex with respect to the communication.

The main new point of this system is that also the SMV are provided with RTI equipment. This will bring about costs and certainly resistance from the public. To prevent this one might be inclined to develop systems where only the FMV needs RTI because this is the user who causes the problems. An example of such a system is the experimental French vehicle Prolab2; see Rombout (1995). This car is equipped with video cameras and automatic image processing and it 'sees' fixed and moving obstacles, included pedestrians and cyclists. However, it is easier to develop systems where both users are active in collecting and communicating data. This will result in redundancy of information and that is certainly needed to meet reliability standards and get a high hit rate and a low false alarm rate.
A possible interesting solution in between would be a so called passive 'intelligent reflector' (with transponder) on the SMV. This reflector makes it much easier to detect the presence of a SMV by means of radar or laser in a complex environment with all types of objects. The type of SMV can also be read from the reflector. This will make the equipment of the SMV much more simple, cheaper and there is no need for power.

4. Aspects of the System

The system proposed has many aspects and some of these will be discussed in the sequel.

- Costs

Before any estimation of costs involved can be made, the system must be worked out much further. However, if the trend towards more RTI equipment on FMV is continuing, the extra costs for these road users will not be large. For the SMV this is really a problem. Sometimes the value of a bicycle is extremely low and then the RTI equipment would be much more in value. Therefore it is more attractive to design a system that is human bound. This is anyhow needed for pedestrians and some other types of SMV. One could imagine that it could be part of a hand held telephone or, when it can be made small enough, even part of a watch.

- Failure of the system

When the system fails somehow this could lead to unsafe situations. However, one should compare the situation with that without any measure and we know that that is pretty unsafe, both in terms of accidents happening and also in terms of subjective unsafety for the slow traffic.

- Effect on level of attention of the FMV driver

It should be investigated if the drivers after some time rely so much on the system that they become less alert. This is a point for every RTI system that assists the driver in his task, e.g. an automatic anti collision system. At first thought this point does not seem to be that important on one-lane roads. The road characteristics are generally such that they require the driver to be alert in order to keep his vehicle on the road.

- Liability

This aspect is a major point when replacing a part of the driver's task by an automatic system. If this point is not solved the application of RTI in traffic will be limited to the supply of information. In the case considered here it seems reasonable to let the FMV driver be liable also in case of a system failure. With respect to this point one should certainly not abolish the existing safety devices of SMV, such as lights and reflectors.

- Requirements for SMV
Supposing this is the only traffic situation where SMV will need the RTI equipment, occasionally users will not be inclined to buy it. This can be solved by creating the possibility to rent the equipment. On the other hand is seems likely that the same system could promote safety for SMV in more traffic environments than one-lane rural roads only.

- The fast cyclist
Suppose a cyclist rides 35 km/h and the cars have to slow down to 30 km/h, then the FMV can not overtake the cyclist. Consequently the FMV should slow down to a speed that is dependent on the speed of the SMV.

- The slow, relatively wide and difficult to manoeuvre wheel-chair
For this SMV the speed of the FMV must be reduced even more than to 30 km/h, dependent on the road width. The same might be useful for horsemen.

- The moped
This might be a special Dutch problem. Compared to FMV the moped is a SMV, but compared to cyclists and pedestrians it is a FMV.

5. Operational Aspects

5.1 Time loss per manoeuvre

For a FMV the manoeuvre consists of slowing down, driving at a low speed during the meeting and accelerating to the free speed. To illustrate this point we will choose some parameter values. Suppose:

a. a FMV slows down to 30 km/h;
b. it decelerates with a constant deceleration of 2 m/s^2;
c. it drives with 30 km/h over 30 m (means during 3.6 s);
d. it accelerates with a constant acceleration of 1 m/s^2 to its free speed.

The extra travel time then only depends on the free speed and turns out to be surprisingly small; see **Figure 4**.

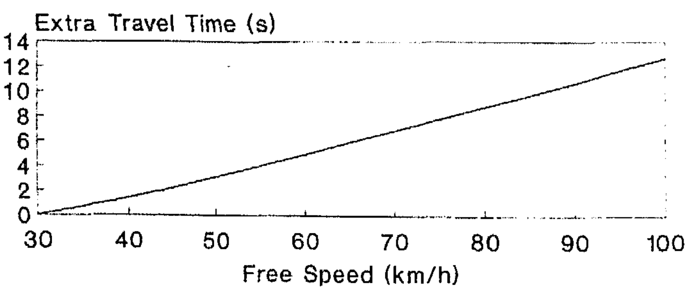

Fig. 4. Extra travel time a vehicle experiences when decelerating to 30 km/h and keeping this speed during 3.6 s. Decelerating with 2m/s^2, accelerating with 1 m/s^2.

The objective travel time loss may be low but subjectively it might seem large and the irritation of the drivers might be great, especially in the beginning. This frustration should be compared to the gain in safety; we do the same when installing traffic control at intersections for reasons of safety.

In a real situation the extra travel time over a road section will depend on the intensity of SMV and it can be calculated with a relatively simple model. If this loss becomes too large, the measure to be taken is separation by means of e.g. a separate path for pedestrians and bicycles.

5.2 Example of operation

We will consider a road section with only cyclists as SMV. Parameter values have been chosen to get round numbers as results. In reality time loss will be smaller because several slow downs will partly overlap. Suppose:

a. Road section of 6 km;
b. In each direction there are 20 cyclists per hour with a speed of 20 km/h;
c. FMV maintain a speed of 60 km/h;
d. The time loss per manoeuvre equals 5 s.

Simple calculations show that a FMV will be confronted with 8 oncoming cyclists and will overtake 4 cyclists. So a FMV has to slow down 12 times and will loose at most 60 s. This leads to a reduction of the average speed of 60 km/h to 51.4 km/h.

The real time loss will be lower because of the overlap of slow downs and because there might be other FMV that lead already to a lower speed than 60 km/h.

6. Discussion

The future of our traffic system is difficult to predict and the real break through of RTI is questionable. However, nearly every drastic change in the traffic system has lead to opposition in the beginning. Even the introduction of direction indicators on cars has met with opposition long ago. Every new feature that limits the freedom of the driver will meet with fierce opposition. Cases will be found in which the new system is less safe that the original one. However, eventually the overall loss or benefit should be decisive.

The proposed system has to be studied and developed much more deeply. There will certainly rise technical problems, e.g. the system should also function on narrow hilly roads where communication between users might meet problems. One also has to consider the situation when not all users are already equipped with the RTI devices.

The main obstacle for the proposed system might be the opposition of the drivers of SMV, because until now they did not have much obligations regarding the equipment of there 'vehicles'. But their gain can be very valuable in terms of objective safety and in terms of feeling safe. The system might make the use of the low volume rural roads much more attractive for daily use and for recreational trips.

To accustom FMV drivers to externally controlled speed the introduction of this system for residential areas is a good start; see Ekman(1995). Such a measure will certainly lead to an even better climate in these areas, in terms of safety, noise and air quality. And it will allow a much cheaper road lay out inside those areas.

References

- Brilon,W. & Blanke,H. Extensive traffic calming: results of the accident analysis in 6 model towns. Proc. 63rd annual ITE meeting, 1993.
- CROW. Sign up for the bike. Design manual for a cycle-friendly infrastructure. Centre for Research and Contract Standardization in Civil and Traffic Engineering. CROW Record 10, Ede(NL), 1993.
- Commission of the European Communities (ed). Proc. of the DRIVE conference Brussels 1991. Elsevier 1991.
- Ekman,L. ATT systems for safety enhancement. In: Smart Vehicles. Ed. Pauwelussen & Pacejka. Swets & Zeitlinger, Lisse(NL), 1995.
- Rombaut,M. A driving assistance system: the French demonstrator Prolab2. In: Smart Vehicles. Ed. Pauwelussen & Pacejka. Swets & Zeitlinger, Lisse(NL), 1995.
- SWOV. Towards a sustainable safe traffic system in the Netherlands. National Road Safety Investigation 1990-2010. SWOV Institute for Road Safety research, Leidschendam(NL), 1990.