Road safety in Poland

A contribution to the improvement of road safety in Poland in the framework of the GAMBIT project

R-94-58
Drs. M.J. Koornstra, ing. J.A.G. Mulder & ir. F.C.M. Wegman
Leidschendam, 1994
SWOV Institute for Road Safety Research, The Netherlands

SWOV Institute for Road Safety Research
P.O. Box 170
2260 AD Leidschendam
The Netherlands
Telephone 3170320932 3
Telefax 31703201261

Contents

1. Introduction

Road safety is a quality aspect of road traffic which should represent an equally important consideration in decision-making. The fact that the situation in central Europe has changed, caused a change in the situation in Poland as a transit country between East and West. It was concluded in Poland that road traffic and traffic safety cannot be considered only on a national level. Experiences and knowledge of other countries should help to improve road safety.
Responding to two of the main recommendations of the World Bank Report on Road Safety in Poland (World Bank, 1992), the Polish Government ordered a comprehensive project on the improvement of traffic safety in Poland. This GAMBIT project will be carried out over the next two years by many Polish universities and research institutes and deals with the problems of traffic safety.
The Dutch SWOV Institute for Road Safety Research was asked to give a general opinion upon the contents of the GAMBIT project, and to express an expectation about the future development of traffic safety in Poland. The contribution of SWOV has been realized within the framework of a 'Memorandum of Understanding' for bilateral co-operation in the field of road transport between the Ministry of Transport and Maritime Economy of Poland and the Ministry of Transport, Public Works and Water Management of the Netherlands. The study was carried out by order of the Transport Research Center AVV of the Dutch ministry.

2. Road safety in Poland

2.1. Development during the past

The development of road traffic in Poland, as anywhere else in the world, serves the transport needs of people and the economic growth of the country. But this development of motorized transport is accompanied by the adverse effects for road safety. The uprise of motorized transport between 1989 and 1994 in Poland has asked for about 7.000 fatalities and more than 60.000 injured persons per year. The level of road safety in the five years before 1989 was characterized by about 4.500 fatalities and 42.500 injured persons.

Figure 1 shows the long term development since 1955, where the increase for 1994 is estimated from the figures for the first half year (corrected by the ratio of that half year and the total year in the last 6 years).

Figure 1. *Road safety development in Poland*

There is a clear need for an effective road safety policy in order to prevent a further increase in this toll of road traffic. It is not only for moral reasons that one can hardly accept that the future development would be worsening; also from an economic point of view this would be a waste of resources. It is often not realized that the lack of road safety causes one of the larger national economic losses. According to general accepted methods in the countries of the European Union or the USA, the economic losses from the lack of road safety in Poland over the last years can be estimated to be more than 15 billion ECU's per year. Although the economic comparability of Poland and these countries still can be questioned to day, it surely means an important national factor for the further economic development of Poland. National investments in the improvement of road safety are, apart from the moral need, also an *economic* necessity.

2.2. Future development

SWOV made three quantitative prognoses about the development of traffic safety in Poland (Koornstra, 1994; see *Appendix 1*). They can be seen as rationally sustained scenarios for the future.
The optimistic scenario of steep risk reduction and moderate traffic growth may be much too optimistic, but nevertheless the most needed scenario. The cumulative difference with the next best scenario approaches the total number of 50.000 fatalities in the next fifty years.
The scenario of a vast traffic growth and moderate risk reduction could be too pessimistic. The past of Polish developments the risk reduction has shown periods with a much larger risk reduction and the overall annual reduction in fatality risk over the past forty years has been just 9%, which is more than this pessimistic scenario predicts for the future. Why should Poland not be able to achieve what it implicitly has achieved in the past? The scenario of vast traffic growth and steep risk reduction may seem the most realistic one, but it will ask for an effective road safety policy and huge investments in the road infrastructure and its safety improvement.

The scenario of moderate traffic growth and moderate risk reduction shows a somewhat less pessimistic road safety development than for the pessimistic scenario. The difference is comparable to the difference between the optimistic an more realistic scenario. From the three discussed model predictions it can be seen that the effects of moderate and steep risk reduction are much larger than the effects of moderate and vast traffic growth.
It also must kept in mind that the risk decay for the injury rate has been and will be lower than for the fatality rate, as in all other countries we have analyzed. Even the most effective road safety activities seem not to be able to improve that difference in risk developments for injuries and fatalities. The predicted amount of injured persons generally stabilizes on a rather high level, where as the reduction in fatalities seems to continue.

Apart from that less positive development for injured persons in road traffic, the effectiveness of the road safety activities can mean a tremendous difference. The cumulative difference between the very well possible pessimistic scenario and the more probable realistic scenario amounts to 120.000 fatalities more or less for Poland in the next 30 years. Road safety is indeed a national matter of live and death. A lasting lack of road safety is not an act of gods, but is the outcome of a man made traffic technology. Its safety improvement deserves a high national priority.

3. A traffic safety plan

3.1. General considerations

From the results of research in the Netherlands it can be concluded that three conditions are essential and have to be fulfilled to cope with the problems of traffic safety.
First of all there must be the political will to acknowledge traffic safety as a problem which has to be solved.
Secondly, there must be knowledge about the problem and about the measures that have to be taken to solve it. When formulating a traffic safety plan it will be of benefit that it is based on a thorough analysis of the problem. Just in the case, at the moment, the Polish traffic safety problem can be a specific one - as mentioned in the introduction - knowledge of the problem is of utmost importance. Moreover the knowledge is essential for choosing the right measures or actions in due time.
At all events, an analysis of the problem should explain:
- the extent of the problem;
- what specific problems can be indicated;
- what problems can be solved by oneself and for what problems the help of others is needed;
- what concrete target is meant to be achieved;
- what concrete measures can be implemented by oneself;
- for what measures the support of others is needed;
- what kind of deliberations are needed and with whom for those problems that cannot be directly solved;
- what financial funds and other means are available and how they can be used.

As third condition must be stated that an organizational framework has to be created in order to implement the outcomes of a plan and moreover that funds should be made available to realize the plan.
All these conditions can be unified in the construction of a plan. A plan serves for guidance for a fruitful approach in tackling the problem. Adopting the systematic approach of a plan makes it possible to assure that it will constitute an effective tool in road policy making. A systematic approach is preferably laid down in a road safety programme which aims on targets.

3.2. The Gambit programme compared with the conditions

The GAMBIT programme is the National Programme of Road Safety Improvement in Poland. It is a research project ordered by the Minister of Transport and Maritime Economy and it is sponsored by the National Committee of Scientific Research. Herewith the first condition mentioned above seems to be fulfilled: the Polish Government orders the introduction of a plan to cope with the problems of traffic safety, which is a direct indication that - judged on its own merits - traffic safety is considered a serious problem.

The organizational structure of the programme consists of four phases. In *phase I* - the diagnosis - the traffic safety problems are not only mapped out but also related to the different elements of the road safety system. Moreover, an investigation takes place into (foreign) experiences and knowledge about several subjects. This phase is fed by the results of active research projects which are now going on, and leads to a choice of main targets on the one hand and to a clear insight in the problems which need further research on the other hand.
Based on the knowledge gathered in phase I, the 'conception' *phase II* is started. Main targets and conception of the plan are elaborated more in detail. As it is stated in this phase, all relevant subjects which are necessary to satisfy the second condition mentioned in the general conditions above, come up for discussion and are worked out in the 'project' *phase III*. Such an approach allows to bring into play in this phase the results of the research projects which are executed during the phases I and II. It can be concluded that following the procedure as stated in phases II and III, the second condition is fulfilled.
The combined results of the phases I, II and III lead in *phase IV* to a programme for improvement of the traffic safety in Poland which is supported by all available knowledge (see *Figure 2*, next page). At the same time ways are given how to promote this plan and to give the realization a fair chance. It is of utmost importance to pay attention in this phase to the elements of the third condition: the creation of a organizational framework and the availability of financial funds.
We are convinced that the procedure mentioned above including the proposed contents, has the potential to lead to a programme that really shall improve traffic safety in Poland.

3.3. The added value of targets

It is difficult for governments to accept increasing numbers of road accidents and casualties, especially when the society forces the politicians to take action. It is therefore that many countries have a road safety programme which means that several activities are organized to improve road safety. In some countries the programme is based on routine road safety activities, like placing guard rail, introducing of speed limits etc.; other countries already have adopted a targeted road safety programme and again several other countries tend to do the same.

The main characteristics of a targeted road safety programme are that it is adopted as the *official road safety policy*, that it contains an overall *operational safety target* (or disaggregated operational safety targets) and that it contains *a set of countermeasures* based on the overall target or the disaggregated targets (OECD, 1994).

The setting of targets has many advantages:
- it ensures that road safety would be assigned a more prominent place in the decision making process over a period of years;
- it makes one realize the economic losses of the safety problem;
- it provides a rational basis for national consensus on priorities;
- it enables all those involved to understand their responsibilities;
- it gives direction to policy making;
- it could raise public interest and could create support among the population or among organizations to contribute to reach the goal;

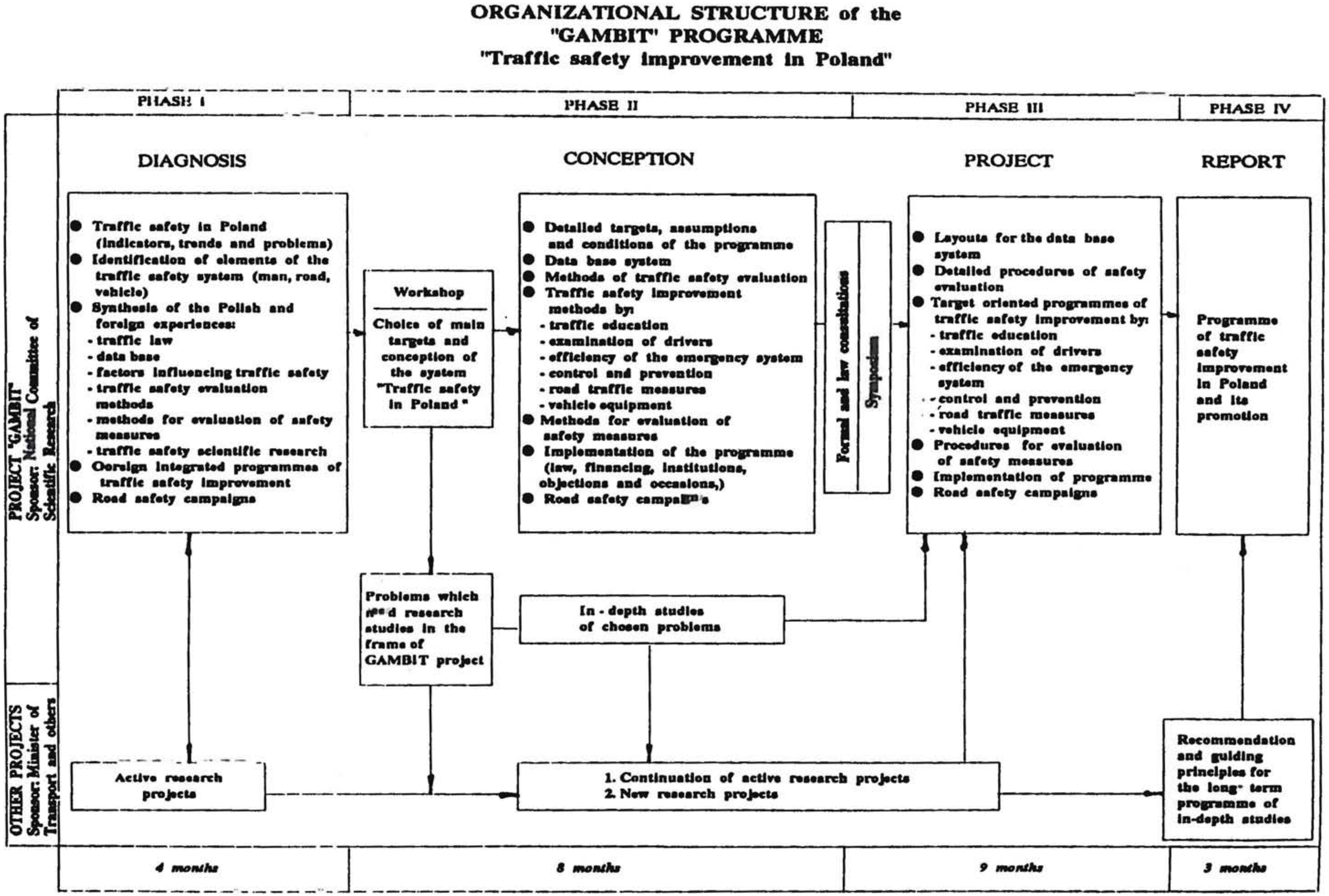

Figure 2. Organizational structure of the GAMBIT programme

- it motivates all partners involved;
- it leads to greater commitment of all actors involved;
- it leads to better use of scarce public funds;
- it improves the credibility of those responsible for road safety, government officials and politicians as well;
- it provides ability to assess achievement;
- it gives the opportunity to determine the lack of success (whether this is due to lack of planned action or poor initial assumptions of countermeasure use or effectiveness of countermeasures;
- it forces to monitor and to evaluate the programme and to report on this; this enables to continue effective programmes or countermeasures and to stop ineffective ones;
- it forces to get more knowledge about the accident process in order to improve the programme and the targets.

Another important factor in achieving improvement in traffic safety by using a plan is that *all partners involved are active*. This can be realized by well defining the field of all acting partners in an early stage and to involve them in the completion of the plan. It is of vital interest that the problems of traffic safety are not only recognized by the government and the responsible departments within it, but also by the public (as road users), (private) organizations and companies. Though the central government must take the initiative and must play a strong role in getting the necessary support, all partners have to accept their part of the responsibility.
Finally, the *organization* of the traffic safety policy is an important feature. It will be impossible to tackle all problems at one time. It will be better to search for a number of clear items which can be known by the public and focus the organization of policy on them.

3.4. A road safety information system for Poland

When formulating and implementing a traffic safety plan it is important that such a plan has the support of the community and that the contents of the plan has a relation with daily practice. Therefore it is necessary to visualize the problems in a very early stage. One should not restrict oneself to the problem of traffic safety alone, but also pay attention to related problems like economic losses, health care, etc. It is necessary therefore to have a road safety information system available to establish the seriousness of the problems.

A Road Safety Information System (RIS) has to support policy makers and researchers. That is why the contents of such a system, and the organization, have to be derived from the anticipated questions by policymakers and researchers. Description and explanation of accident causes and accident trends, data to define and assess accident problems (on macro, meso and micro level) and basic data for evaluation of measures, seem to cover a majority of answers to be given by a RIS.

As can be seen in *Figure 3*, such a system comprises several elements and from this picture it is quite clear that a RIS comprises more than data collected by the police. An example of such an information system is described in Appendix 2. It describes the different questions which ought to be answered by a RIS. First it discusses what one would want to know and why. The data that should be available are marked. Furthermore attention is paid to the organization of the collecting of the data, an overview of the required data, and the possible links between them.

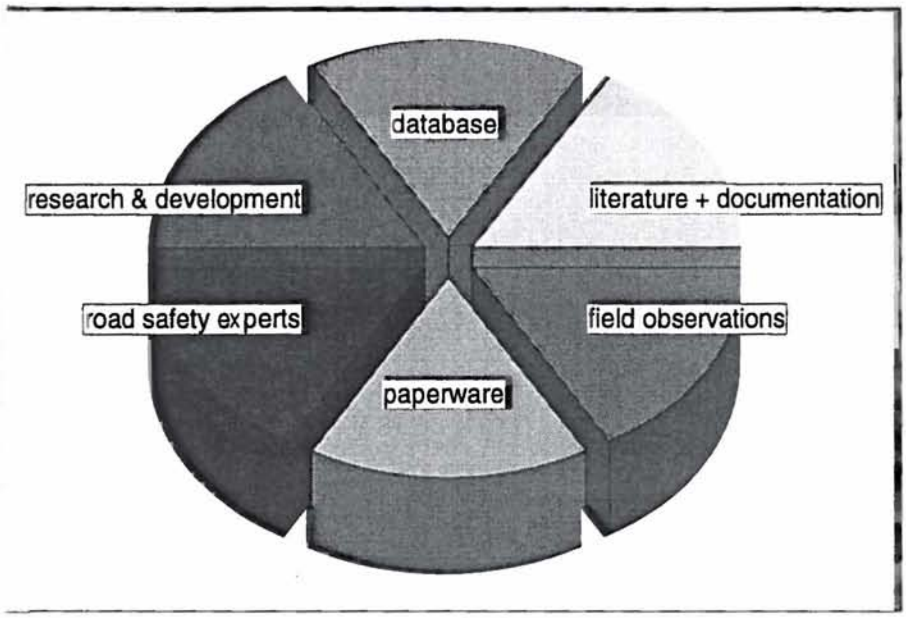

Figure 3. *Road Safety Information System*

Appendix I Development of road safety in Poland

Leidschendam, 1994
SWOV Institute for Road Safety Research, The Netherlands

Introduction

The development of road traffic in Poland, as anywhere else in the world, serves the transport needs of people and the economic growth of the country. But this development of motorized transport is accompanied by the adverse effects for road safety. The uprise of motorized transport between 1989 and 1994 in Poland has asked for about 7.000 fatalities and more than 60.000 injured persons per year. The level of road safety in the five years before 1989 was characterized by about 4.500 fatalities and 42.500 injured persons.
Figure 4 shows the long term development since 1955, where the increase for 1994 is estimated from the figures for the first half year (corrected by the ratio of that half year and the total year in the last 6 years).

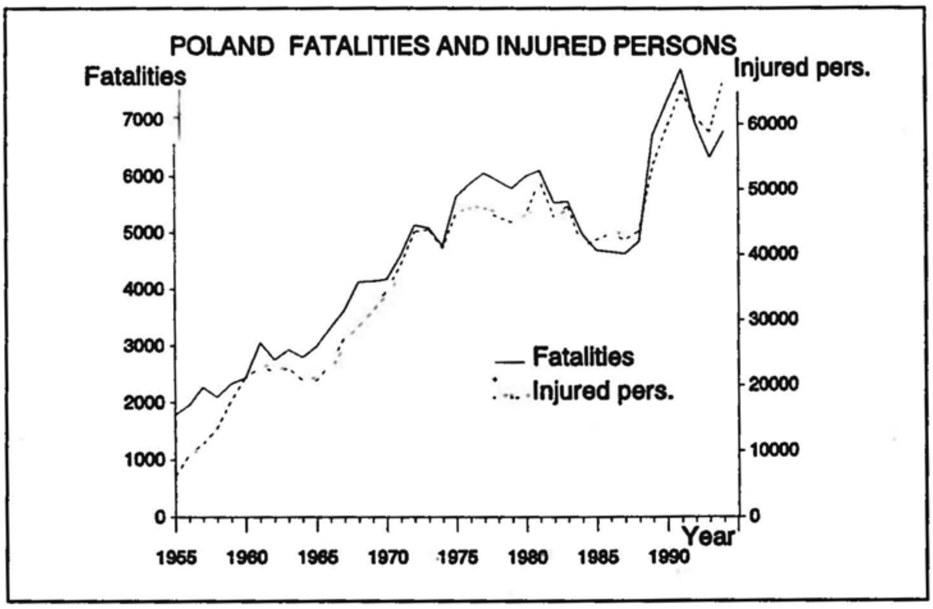

Figure 4. *Road safety development in Poland*

There is a clear need for an effective road safety policy in order to prevent a further increase in this toll of road traffic. It is not only for moral reasons that one can hardly accept that the future development would be worsening; also from an economic point of view this would be a waste of resources. It is often not realized that the lack of road safety causes one of the larger national economic losses. According to general accepted methods in the countries of the European Union or the USA, the economic losses from the lack of road safety in Poland over the last years can be estimated to be more than 15 milliard ECU's per year. Although the economic comparability of Poland and these countries still can be questioned to day, it surely means an important national factor for the further economic development of Poland. National investments in the improvement of road safety are, apart from the moral need, also an *economic* necessity.

2. Descriptive analysis

The general rising, but irregular trend (notably the temporary decrease in the mid eighties) of fatalities and injured persons in road traffic seems to be caused by the increase of motorized traffic. Since motorization in Poland is still on a relative low level compared to western Europe, it can be questioned whether it will be possible to improve the level of road safety in Poland. A marked further growth of road traffic may be accompanied by a further increase in lack of road safety.

The road safety developments in other countries have shown that growth of traffic can be combined with an improving road safety. In general, the seemingly rather irregular development in road safety of many other highly motorized countries, where a peak in fatalities is observed before the mid seventies, can be described as the result of a regular increase of traffic (measured by kilometrage or number of cars) and a regular decrease in risk (measured by the fatality and injury rates per kilometre or vehicle).
If the risk in traffic decreases more than the traffic growth increases, the number of fatalities or injuries must decrease by definition. This in general has been the case in the north-west European countries after the mid seventies. The relatively regular and monotonic developments of traffic growth and risk decay in the long run are crucial for the understanding (and possibly the prediction) of the relatively irregular and non-monotonic development of road safety.

The regular and monotonic growth of road traffic in Poland is illustrated in *Figure 5*, by the development of the numbers of all motorvehicles (including motorcycles > 50 cc.) and passenger cars.

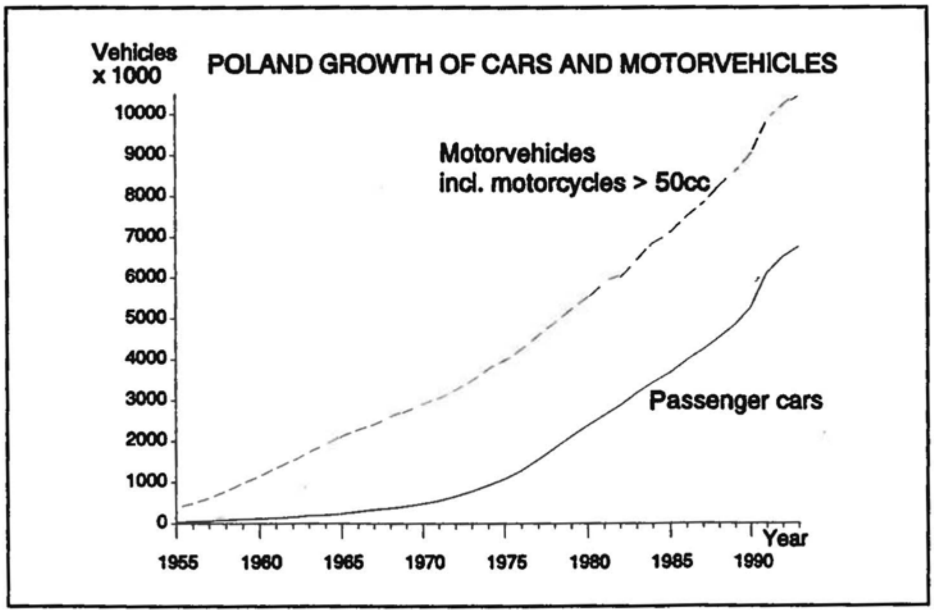

Figure 5. *Development of motorvehicles and cars in Poland*

Figure 5 shows clearly that the growth of motorvehicles after 1975 is mainly dependent on the growth for passenger cars. The increase in the

sixties has been mainly determined by the growth of motorcycles, which number has been decreasing recently. The growth of road traffic, indicated by these curves, shows a relative regular development with a steeper slope than the irregular increase in fatalities and injured persons. The coincidence of a marked increase of growth for passenger cars after 1988 and the simultaneous steep increase in fatalities and injured persons will be noted. The decrease of fatalities and injured persons in 1992-1993 may be related to the reduction of average kilometres driven per car in these years.
In view of the estimated figures for 1994, improving road safety may be a temporary phenomenon. Anyhow, an expected further growth of traffic constitutes a serious threat for the road safety level in Poland. If growth of motorization continues towards a comparable level of western countries, the number of passenger cars may grow to about 13 million (1 car per 3 inhabitants) or even to 20 million cars (1 car per 2 inhabitants; note that the (west)German level is 1 car per 2 inhabitants and for the USA motorization is even higher). If, with such growth levels, the fatality risk in the same period would not decrease, then the annual fatalities would increase to more than 14.000 or even 21.000.
However, traffic risks in nearly all countries as well as in Poland are decreasing. The question is how much and steep the further risk decay will be and whether it will be enough to prevent a worsening safety level.

Due to lack of kilometrage data for long risk time-series and because of the dominance of passenger cars in the number of motorvehicles and road safety, we use the number of fatalities and injured persons per 1000 passenger cars for description of risk development. *Figure 6* pictures the nearly monotonic risk decay from 1955 onward in Poland.

Figure 6. *Risk development in Poland*

Figure 6 shows that the risk decay in Poland, as in other countries, is exponential. The average annual decay of fatal risk over 40 years is 9% and for the injury rate 6,5%. It means that the fatality risk is halved every 7 years in the average. It is a high risk reduction compared to west European countries; only Finland shows a larger risk reduction. The relative

smaller decay in injury rate may be missed by the graphic impression, but in the late fifties the ratio of injury and fatality rates is about 5 to 1 and in the recent years it exceeds 9 to 1. This is a general phenomenon of increasing motorization in western countries: the number of fatalities tend to increase less or decrease more than the number of injured persons.
The curves in *Figure 6* show also some departures from exponential decay. The stagnated decay in the second half of the sixties and beginning seventies may be due to the larger increase of the relative risky motorcycles in that period.
By graphic inspection one also may overlook that there even is a risk increase after 1988. The proportional risk increase compared to five years before 1988 is about 20%. The rise of fatalities and injured persons after 1988 is not only due to the larger increase of motorization, but also to the coinciding increase of the fatality rate. Such worsening coincidences also can be observed in some other countries (Koornstra, 1991, 1992b). In the USA it caused several peaks in fatalities and in Japan (and Israel) it causes now a period of increasing fatalities after a longer period of decreasing fatalities.

In order to understand the interplay between relative increases and decreases in traffic growth and risk for the development of road safety, it is useful to inspect the annual change rates of traffic growth and risk development. *Figure 7* shows these change rates for Poland by the moving central average of three years change rate percentages for the growth of passenger cars and for the fatality and injury risks.

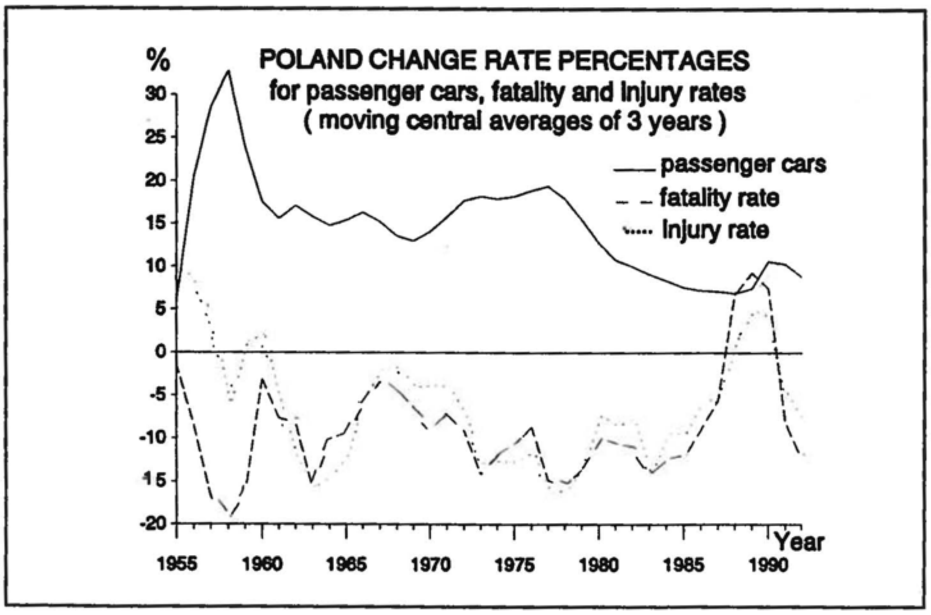

Figure 7. *Change rate percentages for traffic growth and risks in Poland*

The three curves in *Figure 7* display the average of the year before, the year itself and the year after for the annual growth percentage in passenger cars and of the annual decay percentages in fatality and injury risks (per 1000 passenger cars). Clearly the change rate for growth of cars will be ever decreasing if its growth is less than exponential, since the amounts of car increase are related to a steady increasing level of registered cars. The rates of change in the fatality and injury risks should be constant if the development of these risks is characterized by an exponential decay.

Although we see an overall decreasing trend in the positive change rate for growth and no upward or downward trend in the overall negative level of the change rate for risks, there are marked auto-correlated deviations from the hypothetical trend or level. Moreover, the deviations from a downward trend for the ever positive change rate of growth seems to be related to the deviations of a constant negative level of the change rate for risks. A relative higher increase in growth tends to be followed with a some time-lag by a relative larger decrease in risk and vice versa.
The combinations of larger increases in growth and smaller decreases or even increases in risks are only to be observed at the start of the periods of relatively increased growth. These relations are also found in several highly motorized countries in western Europe, the USA and Japan and more clearly than for Poland.

More important than fluctuations in change rate, although the increased change in risks after 1988 has been disastrous, is the generally decreasing change rate of growth and the level of the change rate for risk. Only if the positive change rate of growth becomes permanently lower than the absolute level of a negative change rate of risk by definition one can observe a lasting safety improvement. Since the overall change rate of growth will be diminishing, there will be a decreasing number of fatalities (and injured persons) after some moment in time, when the mean level of the negative change rate of risk becomes, in its absolute value, higher than the positive change rate of growth. This turning point will be the sooner, the higher negative the mean change rate of risk is. The temporary fluctuations in change rates just before 1985 show that in that short period the increase in growth was smaller (< 10%) than the decrease in risks (> 10%) and that was the only period of decreasing fatalities and injured persons in Poland.

An effective road safety policy, therefore, has to achieve such a negative change rate of risk that it becomes in its absolute value higher than the positive change rate of traffic growth. Since for Poland and other central European countries the expected growth of traffic will be still high in the next decade (or decades?), it asks for a relatively high reduction of risk. In Poland the overall level of risk reduction between 1972 and 1985 has even been more than 13% (average risk change rate -13,1%). On the other hand, the overall level of the growth rate for Poland in the last 5 years has been less than 10% and probably will decrease in the future (note that even if traffic will be doubled in the next 10 years the change rate of growth is 7%).
So only if an absolute higher change rate percentage of risk can be established (say about -10%, which has been achieved in some longer periods of the past in Poland) the road safety in Poland will be improving in the future; otherwise road safety will be worsening for a longer period. How this must be achieved, has to be detailed in a road safety plan for the future, but it surely will ask safety investments. Many road infrastructure investments will sustain the risk reduction. For example, enlargement of the motorfreeway network will enable the traffic to drive on a road type which is about a ten times safer then other rural roads. However, the strategy will ask for many other measures which have proved to enhance road safety elsewhere.

3. Quantitative model analysis and prediction

The description and interpretation of the past developments in traffic growth and risk decay may seem somewhat complicated, but in its basic elements it is rather simple. It can be stated as: *safety = risk x exposure.* Clearly a lasting safety improvement results from underlying trends for a larger risk reduction than the increase of exposure. The time dependent developments in exposure (for Poland imperfectly measured by growth of passenger cars) and risk (here described by fatality and injury rates per amount of passenger cars), has been modelled mathematically (Oppe & Koornstra, 1990; Oppe 1989, 1991a, 1991b) and theoretically explained by evolutionary self-organization in the traffic system (Koornstra, 1992b).

These model analyses have given quite satisfactory results for many countries. The basic model elements are exponential decay of risk and S-shaped logistic traffic growth, which are modulated by cyclic influences. The quantitative analysis fits the model parameters from the data for the past long term development in traffic growth and risk under the condition that the product of growth and risk optimizes the retrospective prediction of observed fatalities (and/or injured persons). In order to estimate determined parameter such data time-series must be rather long, especially if cyclic deviations with a relative long period are to be observed.

From *Figures 5* and *6* (above) it can be deduced that S-shaped traffic growth and exponential risk decay may be suitable underlying model trends for Poland as well. The quantitative model analysis for traffic growth, as also can be seen from *Figure 7* (above), show that traffic growth is modulated by a main cycle with a nearly forty year period (nineteen years of downward and upward change rate percentages).
The also cyclic deviations from exponential risk decay are more complex. Its dividing factor (traffic volume) also causes a cyclic deviation with the same period of nearly forty years, but the lagged influence of traffic investments for traffic growth on safety causes also shifted harmonic cycles of risk deviations with a period of somewhat less than twenty and ten years.
The results of the quantitative analyses for Poland are graphicly described in the sequel. The respective model curves retrospectively do fit the observed data (shown as small squares) rather well. However, due to the length of time-series for the known relevant data of 41 years and the long period of a nearly 40-year cycle, the parameter estimation for the models is not well determined. Although the model prediction is solely based on parameters for the transformation of time and time in itself can perfectly be predicted, the prognostic value of the model predictions is limited.

An earlier application of this model analysis for Poland with a rather pessimistic outcome for the expected road safety has been published in the Polish Transport Review (Koornstra, 1992c). However, that analysis was hampered by two shortcomings.
Firstly it was not recognized that the number of fatalities before 1975 are not defined as death within 30 days after the accident, but as death within 48 hours. The data before 1975 are now corrected by 21%, as the internationally accepted correction factor for this difference in definitions.

The effect is a less increase in fatalities and a steeper risk reduction. Secondly the revised analysis of the sequel is based on data from 1953 to 1993, where as the earlier analysis only used the then known data from 1960 to 1991. As can be seen from *Figure 6* (above) the added years before 1960 enables a much better estimation of the parameters for the underlying exponential decay of risk. As will be shown below the revised analysis has a much less pessimistic result for the future road safety in Poland, mainly due to the more reliable estimation of a steeper slope of the risk reduction.

3.1. Traffic growth analysis

The assumed saturation level for the S-shaped growth of passenger cars can not be estimated from the data. A reliable estimation of that level ask for a past growth period in which the growth has reached a level between half and two-third of its saturation level. This surely is not the case for Poland. The saturation level, therefore, must be assumed on a priori grounds.
As shown by the displayed results of the growth model analysis in *Figure 8* (below), we made two alternative assumptions. One of a saturating motorization level of 1 passenger car per 3 inhabitants for a future population of about 39 to 40 million in Poland. This motorization level, however, is less than already achieved level in many west European countries.
The other alternative is taken to be 1 passenger car per 2 inhabitants; a motorization level which is nowadays nearly reached in (west)Germany and already past in the USA. It results in either 13 or 20 million passenger cars as the saturation level for Poland.

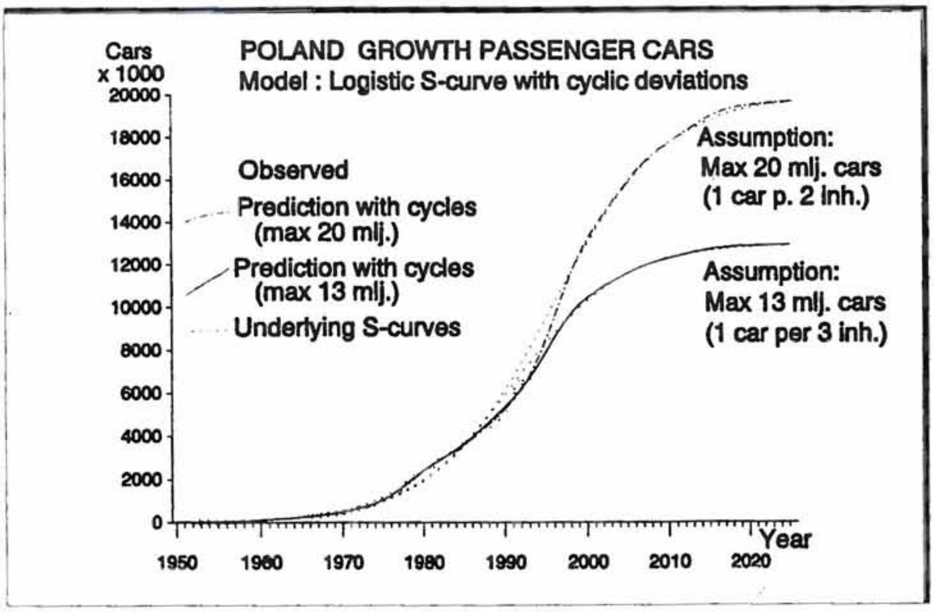

Figure 8. *Growth analysis of passenger cars for Poland*

As can be seen from these curves, the retrospective prediction by an S-shaped growth and cyclic deviations fits the past as well for both assumed saturation levels. The mean percentages of the remaining deviations from the retrospective prediction is only about 2 to 3% for both curves, which may be remarkable precise fit for over more than 40 years.

However, the prognostic extrapolation differs tremendously between the two curves for the alternative saturation levels and already very soon. In the year 2000 the higher alternative curve predicts already 30% more passenger cars than the lower alternative curve. For an equal level of risk per passenger car it also would result in 30% difference in the level of road safety. Anyhow, a moderate growth of traffic would give rise to more positive development of road safety, if the risk development is independent of traffic growth.
However, as the comparative analysis from several other countries have shown (Oppe, 1991a) the exponential risk decay is steeper if the slope of the growth curve is higher. Probably the improved enlargements of the road infrastructure and the more replacements of other subelements in the traffic system, which enables a faster traffic growth to exist, also improves the relative safety of the traffic. In terms of evolution theory, system growth and adaptation go hand in hand or, in here relevant terms, traffic growth and risk adaptation are correlated developments.
As *Figure 7* (above) also showed, relatively reduced growth is followed by stagnated decay or even increased risks. Growth asks for renewal of subsystem elements and that renewal contains opportunities for qualitative improvements. Investments in the traffic system which also improves safety are more likely to occur if traffic is growing at some rather high rate. The growth of traffic, therefore, is both a negative threat and a positive challenge for road safety.

3.2. Risk analysis

The results of the analysis for the risk developments in the past are illustrated in *Figure 9.*

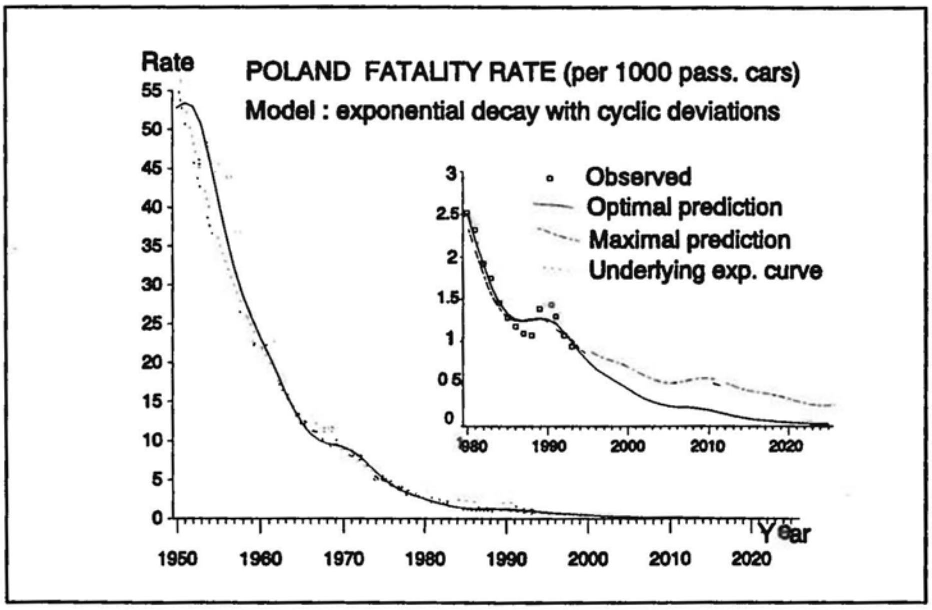

Figure 9. *Fatality risk analysis for Poland*

The underlying exponential decay is very well verified as well as the hypothesized composition of cyclic deviations. The retrospective prediction fits the risk development rather surprisingly well. The main cycles with periods of forty and twenty years for the deviations from exponential risk decay predicts a stagnation in the risk reduction around 1970 and

1990. As the enlarged inlay of *Figure 9* shows, the increased fatality risk between 1988 and 1990 can not be well predicted. If these main cycles of the past 41 years continue to exist in the future, such a major stagnation in risk reduction or even a risk increase should occur again around 2010. Also here the determination of model parameters is crucial for the validity of the prognostic prediction of risk. Although less than in the growth analysis, the variation in the parameter estimation allows for markedly different risks extrapolations, while the retrospective prediction is nearly equivalent.
We have taken two acceptable sets of model parameters with the largest prognostic difference in risk developments, which we have called the optimal prediction curve (fit Chi^2=1062) and the maximal prediction curve (fit Chi^2=988). The latter model has one additional parameter for growth of exposure (as a power function of growth in passenger cars).
Both curves predict a decreasing fatality rate, but as can be seen from the enlarged inlay of *Figure 9*, the risk reduces much less for the maximal prediction curve. The proportional risk difference increases more and more as time proceeds and is a factor 2 around the year 2005. There is no evidence to decide which curve is more valid, although the optimal prediction curve is closer to the stable estimated curve for the underlying exponential risk decay. The prognostic difference in the resulting fatalities for the same growth of passenger cars will result in 100% more fatalities around 2005 for the maximal prediction curve of risk. Not that these computational predictions are so important, but it illustrates the importance of the achievement of a steep risk reduction in the real future.

3.3. Analysis results for fatalities

The analysis results for the growth of passenger cars (*Figure 8*) and for the risk per amount of passenger cars (*Figure 9*) determines by definition the prediction results of the fatalities as the product of respective curve values for growth and risk. *Figure 10* displays the comparable retrospective fits and differing prognoses for three paired combinations of growth curves and risks curves.

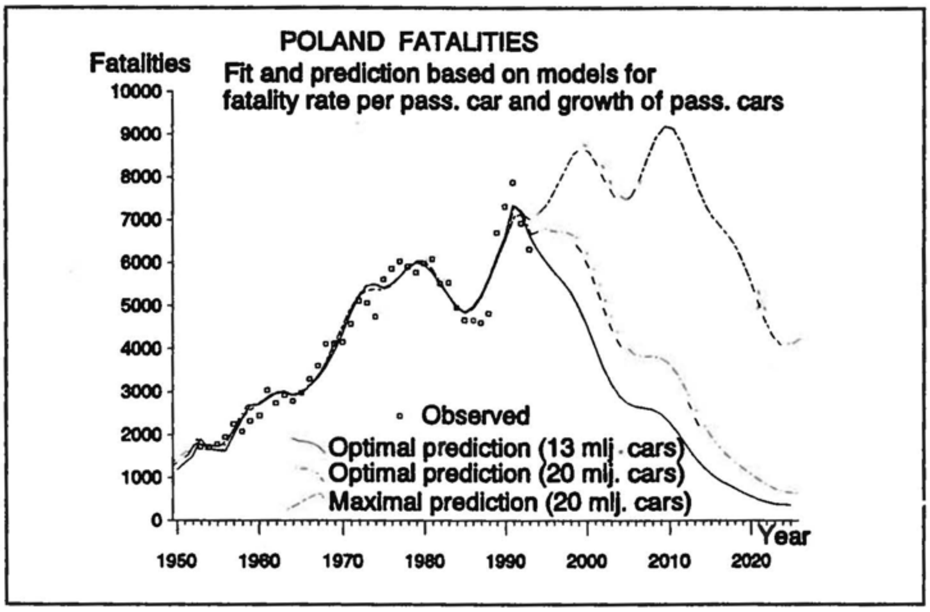

Figure 10. *Retrospective and prognostic analyses of fatalities for Poland*

As could be deduced from the rather excellent fits for growth and risks, the past developments in fatalities are equivalently well predicted.
The maximal risk prediction curve combined with a traffic growth towards 20 million passenger cars, however, shows an increase of fatalities to about 9.000 fatalities within 5 years and after a temporary reduction again an increase to about 9.500 fatalities in 2010, with sharp reduction of fatalities thereafter.
The temporary reduction is comparable to the one observed between 1980 and 1990. The optimal risk prediction curve for a growth to 20 million passenger cars predicts a rather stable level of around 6.500 fatalities in next five years and a sharp reduction of fatalities after 2000, with a temporary stagnation of that reduction between 2005 and 2010.
A similar pattern is obtained from the prediction of the optimal risk prediction curve in combination with a growth to 13 million passenger cars. The marked difference is the direct continuation of the reduction in fatalities from the last two years as well as an even steeper reduction in fatalities for the future. The provisional estimate of fatalities for 1994, on the basis of its observed fatalities in the first half year, may indicate that this last prognosis is a too optimistic one.

In the long run all possible prognoses must result in a decreasing number of fatalities, since inevitable the change rate of growth will reduce to a very low percentage that will become smaller than the everywhere observed risk reducing percentage of the change rate for risk itself.
The main difference in the three model predictions, apart from cyclic deviations, is the turning point in time from increasing fatalities to decreasing fatalities.
In the first discussed prediction model that turning point in time is around 2010, for the second model just it is located just at the entrance of the next century and for the last discussed model prediction the that turning point in time is already passed in 1991. The comparable turning point for most north-west European counties has been in the first half of the seventies, but for Spain it can be observed to be in the late eighties. If the estimated time-lag in the development of the traffic system in central Europe compared to north-west Europe is indeed about 30 years (Koornstra, 1992a) the turning point will be around or soon after the turn of the century.

4. Conclusions

The three quantitative prognoses from the above discussed analysis can better be seen as rationally sustained scenarios for the development of road safety in Poland. The optimistic scenario of steep risk reduction and moderate traffic growth may be much too optimistic, but nevertheless the most needed scenario. The cumulative difference with the next best scenario approaches the total number of 50.000 fatalities in the next fifty years. The scenario of a vast traffic growth and moderate risk reduction could be too pessimistic.
The past of Polish developments the risk reduction has shown periods with a much larger risk reduction and the overall annual reduction in fatality risk over the past forty years has been just 9%, which is more than this pessimistic scenario predicts for the future. Why should Poland not be able to achieve what it implicitly has achieved in the past ? The scenario of vast traffic growth and steep risk reduction may seem the most realistic one, but it will ask for an effective road safety policy and huge investments in the road infrastructure and its safety improvement.

The scenario of moderate traffic growth and moderate risk reduction is not shown in *Figure 10*, but it would have shown a somewhat less pessimistic road safety development than for the pessimistic scenario. The difference is comparable to the difference between the optimistic an more realistic scenario.
From the three discussed model predictions it can be seen that the effects of moderate and steep risk reduction are much larger than the effects of moderate and vast traffic growth. It also must be kept in mind that the risk decay for the injury rate has been and will be lower than for the fatality rate, as it is in all other countries we have analyzed. Even the most effective road safety activities seem not to be able to improve that difference in risk developments for injuries and fatalities. The prediction of injured persons generally stabilizes on a rather high level, where as the reduction in fatalities seems to continue.
Apart from that less positive development for injured persons in road traffic, the effectiveness of the road safety activities can mean a tremendous difference. The cumulative difference between the very well possible pessimistic scenario and the more probable realistic scenario amounts to 120.000 fatalities more or less for Poland in the next 30 years. Road safety is indeed a national matter of live and death. A lasting lack of road safety is no act of gods, but is the outcome of a man made traffic technology. Its safety improvement deserves a high national priority.

References

Koornstra, M.J. (1991). *Evolution of mobility and road safety*. In: Hakkert, A.S. & Katz, A. (Eds.). Proceedings of the 2nd Conference on New Ways for improved road safety and quality of live. TRI, Tel Aviv/Haifa.

Koornstra, M.J. (1992a). *Long-term requirements for road safety: Lessons to be learnt*. Paper OECD-Seminar on 'Road Technology Transfer and Diffusion for Central and East European Countries'. Oct. 1992, Budapest.

Koornstra, M.J. (1992b). *The evolution of road safety and mobility*. IATSS Research, V 16:2, p. 129-148.

Koornstra, M.J. (1992c). *Growth of Motorized Mobility and Strategies for Road Safety*. (Polish translation published in the Polish Transport Review)

Oppe, S. (1989). *Macroscopic models for traffic and traffic safety*. Accid. Anal. & Prev. 21: 225-232.

Oppe, S. (1991a). *The development of traffic and traffic safety in six developed countries*. Accid. Anal. & Prev. 23: 401-412.

Oppe, S. (1991b). *Development of traffic and traffic safety: Global trends and incidental fluctuations*. Accid. Anal. & Prev. 23: 413-422.

Oppe, S. & Koornstra, M.J. (1990). *A mathematical theory for related long term developments of road traffic and safety*. In: Koshi, M. (Ed.). Transportation and traffic theory. p. 113-132. Proc. 11th Int. Symp. Elsevier, New York

OECD (1994). *Targeted road safety programmes*. Paper prepared by an OECD scientific expert group.

Appendix II A Road Safety Information System for Poland

Leidschendam, 1994
SWOV Institute for Road Safety Research, The Netherlands

1. Introduction

A Road Safety Information System (RIS) has to support policy makers and researchers. That is why a content of such a system and the organization has to be derived from the anticipated questions by policymakers and researchers. This appendix follows this principle. Description and explanation of accident causes and accident trends, data to define and assess accident problems (on macro, meso and micro level) and basic data for evaluation of measures seem to cover a majority of answers to be given by a RIS.
As can be seen in *Figure 11* below, such a system comprises several elements and from this picture it is quite clear that a RIS comprise more than data collected by the police. This appendix describes the different questions which ought to be answered by a RIS. First it discusses what one would want to know and why. The data that should be available are marked. The appendix concludes with a few remarks on the organization of the collecting of the data, an overview of the required data, and the possible links between them.

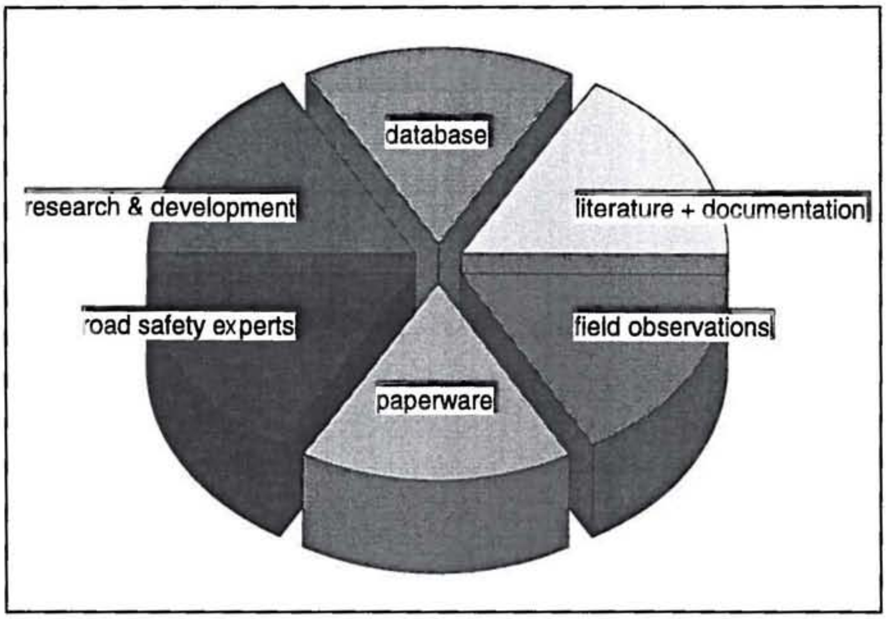

Figure 11. *Road Safety Information System*

2. How to establish the seriousness of road (un-)safety

2.1. General

Insight into the absolute magnitude of road safety supposes statistics on accidents and casualties. Possible disaggregations are discussed below. To judge road (un-)safety as a problem, the following approaches might be helpful.

2.2. Causes of death and health impairment

One can compare road accidents as death cause with other death causes. A distinction per age category can further clarify the extent to which road accidents are an important death cause for certain age groups, e.g. for children. Similarly accidents as cause of injury could be compared with other causes of health impairment.

2.3. Material damage

Road accidents cause material damage. Material damage can be calculated, but the way in which other damage has to be established, is subject to discussion.

The economic value of injuries has to include:
- years of lost lives (YLL)
- treatment in a hospital
- other treatment
- lost working days

Attention also could be paid to more subjective factors:
- loss of freedom of movement through permanent injury
- fear of participating in traffic
- suffering because of the loss of a relative

2.4. Comparing over countries or regions

Another way of assessing the road safety problem is to compare the data of one's own country (or region) with data of other countries (or regions). Rates that can be compared, include:
- percentile growth or decrease of road deaths in a period of e.g. 10 years
- number of road deaths per 100 000 inhabitants (mortality) and the percentile growth of decrease in a period of e.g. 10 years

The number of injured detained in hospital (as in-patient) could be another nominator and the amount of travelled kilometres (times 10^9) or the amount of hours spent in traffic or the number of cars could be another denominator, but as the quality of the registration of these data (if available) in different countries is less clear, it can be misleading information.

2.5. Development in time

Development of road safety in time, preferably together with the development of traffic, tells something about the effort needed to improve road safety.

In highly motorized countries the general development could be described as:

- since the Second World War the traffic is increasing;
- the absolute number of road deaths and injuries first increased, but started to decrease around the beginning of the seventies;
- during the same period the number of casualties per kilometre driven was decreasing.

One of the explanations is that society learns to handle the traffic system. The traffic system is regarded as a production process and road safety is regarded as a quality aspect of that process.

The whole set of measures, improvements of roads and cars and the increasing experience of road users results in a decrease of the number of casualties.

3. How to establish problem areas in road safety?

3.1. General approach

Effective road safety policy focuses on the most serious problem areas, taking into account the political recognition of these problem areas and the public acceptation of countermeasures.
A point for attention is the fact that the real accident risks and the perception of those risks do not always match. Researchers and policy makers have to contribute to a realistic perception of danger of the public, police, and politicians.

3.2. How to choose road safety targets?

Considerations include:
- Norms and values: road casualties are unacceptable and should be avoided. This cannot be realized immediately and asks for political decisions on priority setting and quantitative targets.
- Estimation of promising areas of countermeasures.
- Comparison of different groups of road users and situations and judgement of the probability of an injury. This is a rational approach. It leads to insight into problem areas and enables policy makers to establish priorities in the battle against road fatalities and injuries.

Of course data have to be available. It is rare that exactly those data are available that one would wish to have, but next-best data can also be very useful. Statistical analyses can help in establishing the most determinating factors and in assessing the development in time.

3.3. Seriousness of the accident

Road accidents are usually divided into four classes, depending on the severity of the injury:
- at least one road death
- at least one casualty detained in hospital as 'in-patient'
- at least one slightly injured casualty
- material damage only.

In the Netherlands the registration of road deaths can be considered 100%; of the injured detained in hospital about 70% is registered. However, this figure is decreasing. Other countries have to face the same sort of problems.
The registration degree of less severe injuries is only about 25%; of accidents with 'material damage only' the registration degree is less than 10%. For that reason we usually take only deaths and injured detained in hospital into account for statistical analysis.
The accidents with slightly injured casualties or 'material damage only' accidents can be necessary to be taken into account also, especially for detailed analysis of local road safety problems (because otherwise numbers of observations will become too small; see also paragraph 6.2).

It is to be recommended to carry out a research project (and to repeat this research every five years for example) to find out whether police accident registration practices have been changed over the years.

3.4. Time series analysis

The development in time is an important factor when looking for problem areas. The historical development and the expected development in future tell us whether a problem is increasing or decreasing.
Using statistical tools, we try to describe the historical development in time by a curve, enabling us:
- to forecast the development in future (under present policy)
- to judge the actual (recent) development compared to the historical trend.

This statistical analysis requires quality of the data regarding reliability (i.e. if one measures another time using the same method of measurement, one should get the same result) and validity (i.e. one is actually measuring what one aims at measuring).

3.5. Road casualties distinguished by modal split and age group

Some differentiations of road casualties for analysis purposes are obvious, like type of road users and age groups.
The presence of cars on the road greatly determines the traffic system and its safety. In a situation with only a few cars, relatively many people will walk, cycle, or travel by public transport. Pedestrians are a vulnerable group in the traffic: in a collision with a vehicle they always are the most vulnerable party.
When the ownership and usage of cars grow, there will be more car occupants among the casualties and policy should pay more attention to the safety of the car occupants, without forgetting the other classes of road users. Even in the Netherlands less than half of the road deaths and other injured are car occupants!

The types of road users we usually distinguish, are:
- passenger car (fast traffic)
- goods vehicle/lorry
- delivery van
- bus
- motorcycle
- moped (slow traffic)
- bicycle
- pedestrian.

Age greatly influences things like the number of trips made in traffic, choice of vehicle type, knowledge and understanding of the traffic system, and vulnerability. The age groups are composed depending on the purpose of the study. The minimum ages for driving/riding a particular type of vehicle are commonly used.
Age groups and types of road users can very well be analyzed together.

3.6. Road casualties distinguished by conflict type and road type

Statistical analysis on 20 characteristics of road accidents and casualties in the Netherlands, carried out to establish the most determinating factors, revealed type of conflict and type of road as very important.
Type of conflict has to do with counterparts and was operationalized as:
- conflict between fast traffic (see above: passenger car...motorcycle)
- conflict between slow traffic (moped...pedestrian)
- conflict between fast and slow traffic

The number of classes depends on the desired level of detail and the number of data: a certain minimum number of observations is necessary for analysis of combinations of attribute values.

Type of road can be operationalized according to the function of the road, the type of vehicles admitted, the number of lanes etc. As these data are not available for our whole country and could cause low numbers of observations per cell in a datamatrix, we also operationalize type of road according to the speed limit:
- 0-50 kph (built-up areas);
- 60-90 kph (outside built-up areas, but excluding motorways and roads only open for motorized vehicles);
- 100-120 kph (motorways and other roads only open for motorized vehicles).

The type of conflict varies of course with the type of road; that is why these characteristics should preferably be analyzed together.

3.7. Drivers involved in road accidents distinguished by usage of alcohol or none and period of the week

Also contributing to insight into road safety, is an analysis of usage of alcohol among drivers involved in accidents and period of the week.
In the Netherlands, drivers (including pedestrians) can be checked for the usage of alcohol after getting involved in an accident. This check is usually carried out if the police suspects the usage of alcohol, but not in all cases and especially not in the case of fatal single vehicle accidents.
Period of the week can be operationalized as:
- Monday - Friday, daytime
- Monday - Thursday, night-time
- weekend daytime
- weekend night-time (including Friday night)

As there is no information on the registration degree of the consumption of alcohol of persons getting involved in an accident, this analysis is mainly carried out to detect changes in time; the absolute figure cannot be trusted. In the Netherlands this analysis reveals e.g. that in some provinces alcohol is becoming a more serious problem during week nights.
To monitor the drinking behaviour of car drivers, we annually organize a national survey where the police stops drivers randomly and tests their alcohol consumption. Research showed that there is scarcely any effect of the consumption of one or two glasses of alcohol, but with higher promillages of alcohol in the blood, the probability of an accident increases rapidly.

3.8. Road users and their risk of getting involved in an injury accident

In general, differences in risk for different groups of road users can be a reason for policy makers to set priorities. Some considerations that might influence decisions, are:

- the public responds stronger to a large number of people killed at one time than to the killing of the same number of people spread over several accidents;
- the risk of a certain action that people are willing to accept, depends on the expected 'revenue' of the action and of the extent of free will;
- also the perception of one's own possibilities for control is relevant: that is one reason why accidents with public transport or airplanes usually are badly accepted;
- the extent to which a road user can be conscious of the risk he runs, is also important: one cannot expect e.g. a little child to understand the traffic system. Those groups could be considered as needing extra protection.

To calculate the risk of getting involved in an accident, one should preferably know the kilometres travelled by each separate group (the *exposure* to the traffic).
In the Netherlands a continuous survey is carried out, registering all the trips that the respondents make. This is a unique source of information about the travelling behaviour of the Dutch people (except for 0-12 year old), enabling us to relate the kilometres of road users, e.g. distinguished by age and type of road users, to accidents. Risk is then defined as the number of serious casualties divided by kilometres travelled, for each separate group. We also use these data to forecast the serious injuries for each separate group.
Another possible denominator is the number of people (*population*) corresponding to each group of road users, which also tells something about the risk of getting involved in an injury accident.

3.9. Vulnerability of road users

Vulnerability of road users has no single, agreed upon definition. It has to do with things like:

- the weaker party in an accident (because of e.g. mass, speed or extent of protection);
- the chance for serious injuries (e.g. elder people are more vulnerable in this sense);
- the possibility to maintain oneself in the traffic (related to e.g. knowledge, experience and reaction speed);
- whether one is participating in the traffic or just playing, walking, or shopping.

To analyze vulnerability, we only take accidents between two different classes of road users into account. As useful information we regard:

- A conflict table, showing the percentage of injured from different manners of participating in traffic for different counterparts. This reveals e.g. that in the Netherlands in the case of a collision between a car and a heavier motor vehicle (goods vehicle, delivery van or bus), 87% of the injured are car occupants and only 13% of the injured are occupants of the heavier motor vehicle.

- In the Netherlands the most common counterparts is the car. To judge the vulnerability of road users of different ages, one can show the numbers of injured, distinguished by age category, in conflicts with cars on one hand and with all other vehicles together on the other hand. Separate graphs can be made for e.g. mopeds, bicycles and pedestrians. In the Netherlands this reveals e.g. the vulnerability of young moped drivers and of young and old cyclists and pedestrians. The official data here underestimate the casualties among children and elderly, as the registration degree for them is lower than for the mid-age groups; also the registration degree of casualties among cyclists and pedestrians is lower than that of car occupants.

4. Road safety as a quality aspect of the traffic system

Road accidents have to do with mobility, infrastructure and modal split; these in their turn have to do with economic development and physical planning.
In Western Europe not enough attention has been paid to controlling the mobility and the negative effects of the mobility growth. Places where people live, work and relax are miles away from each other and public transport provides only for a relatively small part of the mobility needs. Many roads were designed without the knowledge that we have now about differences in safety of different road types. The design of the road should match the function (flow function, residential function or linking roads) and the actual use (e.g. types of vehicles, speed and driving direction; the higher the speed, the more homogeneity is necessary).

4.1. Road safety model

SWOV developed a model (SWOVISI) that enables us to calculate different scenario's of road safety, using data on accidents, (planned) roads and (possible) traffic volumes as input.
Important input are also safety rates for different road types. Road types are distinguished quite detailed in this case; the rates express the number of injury accidents per kilometre of road length or per million vehicle kilometres or per million vehicle hours.
The model presupposes the availability of a digitalized road network and a GIS (Geographical Information System), which allows for integrating the digitalized road network and all the other information. It is a very promising instrument in improving the road safety by influencing area (or urban) planning, infrastructure and mobility.

5. Road users and their vehicles

Of course also relevant is the behaviour of road users. Ideally a Road Safety Information system for policy and research also stores information on road user behaviours. In the Netherlands aspects of the behaviour (and some infringements) of road users are registered, but the efforts to influence this behaviour in terms of measures, surveillance, education and campaigns are not registered consistently.
Behaviour is measured in three ways:

- observing the actual behaviour and establishing e.g. infringements;
- surveying people and ask what they do or what their opinion is;
- group discussions to find out the backgrounds of peoples' behaviour.

The first method is the most objective way to measure what road users do, but it is also rather expensive and it does not tell anything about why they do so.
The second method is mainly useful to monitor the attitudes of road users and to detect changes in attitudes and stated behaviour that might predict changes in actual behaviour.
The third method is useful to find out points of impact to influence road users' behaviour.
Alcohol usage, wearing of seat belts and speed are monitored systematically in the Netherlands.

6. In-depth accident analysis

6.1. Research of possible causes of accidents

To get a better understanding of the causes of serious injury accidents, more detailed data about the accidents are needed.
In the Netherlands we have some experience in analysing detailed reports on a sample of accidents, taking into account the following data:

Location and circumstances of the accident:
- lay-out of the road (curve to the left or to the right, straight stretch, exit, junction)
- part of the road (e.g. main road or cycletrack)
- speed limit
- lighting condition
- visibility
- weather conditions
- time of the day
- day of the week

Type of accident:
- rear-end
- accident while overtaking
- head-on

Stages of the accident:
- start
- reaction of road users involved
- further course

Characteristics of the road users involved:
- age
- sex
- nationality
- modal split
- alcohol usage
- physical condition
- concentration
- experience
- speed
- position on the road
- knowledge of the environment
- trip motive
- perception and judgement of the situation

For this research we used the accident registration forms and legal reports of the police. Not all the information that we were looking for, was available from those sources. But the analysis was a valuable supplement to more global analyses.

6.2. Analysis of dangerous locations

Locations are regarded as dangerous dependent of the number of accidents that happened there or the number of casualties, during a few years.

'Locations' can be junctions, stretches or areas.
A few years are considered to differentiate between incidental accidents and structural dangerous situations.

The collecting of data is quite complex because of the way the digitalized road data are stored in the Netherlands: there is no consistent coding of junctions, straight stretches and areas, and if the coding is changed (because of changes in the situation), it is very difficult to link the historical accident data to the recent accident data. This is something which should get more attention when developing a new digitalized road network. GIS (Geographical Information Systems) can also be of help.
A common procedure is that the authorities try to improve a dangerous location and then evaluate the effect after one or a few years. In fact this evaluation should also take account of road users moving off to other roads (because of the measures), because this could result in new dangerous locations.

7. Post crash information

Survival and recovery from road casualties can be dependent of the right treatment, especially in the first hour after the accident. For that reason, in the Netherlands a trial is considered with a specialized Trauma Team flown to serious accidents by helicopter. Its main task will be to decide what has to be done and to which hospital the casualties have to be brought. As a part of the trial a few large hospitals will get a specialized department for treatment of road casualties. SWOV expects to take care of the evaluation of the trial.

Supplementary to the registration of the police, we use national hospital registrations, based on the ICD (International Classification of Diseases). They give additional information on the magnitude and the severity of the injuries. The following parties are involved:

- Police, ambulance, fire-brigade and doctor at the location of the accident. Important is the communication between those parties and the way they decide what to do;
- Hospital, where first aid is given and somebody can be detained. In the Netherlands the police gets information from the hospital if the casualty dies (if one dies within 30 days after the accident, one is a road death). Of all in-patients records are kept about the reason for being in the hospital, the treatment, and the length of stay.
- Revalidation centre and centre for mental assistance. In the Netherlands revalidation centres have a permanent registration.

8. Conclusions for a Road Safety Information System

8.1. General remarks on the organization of the collecting of the data

The information that one would like to have at one's disposal for road safety policy and research, is quite extensive.
In general, if official bodies are requested to register data, it must be clear to them why they register it. Questions that seem 'ballast' to them or could better be registered by another body, should be avoided. Besides legal arguments efficiency reasons are most important in this respect.
As a first step, it is advisable to make an overview of what is registered, by whom, how it is organized, and how well data from different sources match each other. A quality check could be most appropriate. From there, possible improvements can be proposed, including the setting of priorities. Decisions taken in this field will have their effects for many, many years and their implications could be widespread.

We suggest to create a satellite-system for the organization of road safety data. The principle for such a system is illustrated in *Figure 2* (I, II, III); see p. 9 of this report.

8.2. Overview of desirable data and the linking of data

Starting point is the registration of accidents by the police. Mostly, the registration forms consist of six parts:

1. general (e.g. number of casualties)
2. time
3. location
4. vehicle(s)
5. driver(s)
6. casualty(ies)

These topics can be used as key to link data from other sources. The data mentioned in this paper and additional data which can be useful for research will be presented in an overview, grouped by these topics.
Regarding the keys, we must say that they are only an indication; the actual application of keys depends on the available data files and their level of detail.
We consider 'location' a very important key, though not the only one.
The ideal combination is:

- accident and additional data in a relational database, where relevant with a location key
- a digitalized road network in a GIS (Geographical Information System).

We understood Poland is planning to give priority to the registration of accidents and locations; we support that plan. In a separate document, we give our view on the draft of the registration form that we received.

8.2.1. *General data*

keys: location (municipality, province/region, country) age and sex of casualty

- population and age distribution
- death causes
- cars
- area
- road length
- urbanisation
- traffic laws
- police surveillance
- public campaigns

8.2.2. *Time*

keys: time (hour/minute), date (day, month, year), location

- weather
- exposure (in terms of kilometres or hours)
- holidays
- measures

8.2.3. *Location*

keys: location (stretch (e.g. road/hectometre, road/house number), junction, route, area and all possible aggregations)

- road characteristics, leading to road category
- traffic intensity
- speed limit
- safety rates (such as number of injury accidents per kilometre of road length)

8.2.4. *Vehicles*

keys: registration number, vehicle type, country

- damage
- driving characteristics
- mass
- crashworthiness
- lighting
- reflection
- safety measures

8.2.5. *Drivers*

keys: person, groups (if person as a key is not available), country (as lowest or desired level of detail)

- personal characteristics as age and sex
- education
- possession of driver's licence
- driving experience
- use of alcohol
- use of seat belt
- use of helmet

- speed behaviour
- exposure
- stated behaviour in traffic
- attitudes

8.2.6. *Casualties*

keys: person, country

- ambulance
- hospital treatment (based on ICD)
- revalidation

9. Closing remarks

We could suggest to provide to Polish experts certain facilities to analyze road safety data which have proved to be useful in the Netherlands for policy and research purposes. Of course, these facilities have to be accommodated to Polish circumstances and conditions. Training programmes and computer software could be made available.

It is to be recommended to consider a 'Law on Road Safety Information'. Such a law could be a strong basis for data collecting and storage and for its financing. A Council or a Board could be installed to 'enforce' this law.