Long-term requirements for road safety: Lessons to be learnt

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LONG-TERM REQUIREMENTS FOR ROAD SAFETY: LESSONS TO BE LEARNT

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ABSTRACT

Long-term developments in growth of motorized mobility and accompanying developments in fatality rate can be rather well described by relative simple functions of time. These functions are monotonic trends modulated by a cyclic wave function with a long period. The monotonic trends are a S-shaped curve for saturating growth of motorized mobility and a constant proportionally decreasing curves for fatality rate. Analyses of data for many countries have shown that the increase of growth and not the level of growth is related to the level of the fatality rate. This relation implies that the cyclic increase above the S-shaped macro-trend in motorization is followed by a cyclic stagnation of the fatality rate reduction (or even a temporary risk increase). With respect to safety this can mean a simultaneous combination of relative large increases in vehicle kilometers and an increase in fatality rate, which is disastrous.
The relation between mobility growth and fatality rate is theoretically understood as the result of a technological evolution under socio-economic constraints. Differences in developments between countries are interpreted as differences in onset, speed and modulation of that technological evolution due to different socio-economic constraints. This, as well as the remarkable fit of the model and the relation between growth of kilometrage and risk adaptation, are illustrated by results of the USA and (West) Germany for time series of 40 year and longer.
For Central and Eastern Europe it is argued that, due to socio-economic constraints in Eastern Europe up to now, the trend for the technological evolution of motorization is retarded socio-politically and that its cyclic wave function expresses the socio-economic repression of the last decade. The socio-political constraints in Eastern Europe are released nowadays and it can be assumed that the economic repression will turn into an upsurge in the next decade. A quantitative analysis show that these expectations are reflected in the growth of motorized mobility up to now and in the future. An analysis is shown for the countries of Hungary and the Czech and Slovak Republic(s). The tentative results show a disastrous development of road fatalities in the next decade and a fast safety improvement thereafter.
On the basis of the Gerondeau-report to the European Council and other Western experiences thoughts are given to means which may prevent these worse outcomes in the near future. The possibilities for success are limited, unless preventive safety measures are given an as high priority as the growth of the transport system.

1. INTRODUCTION

The history of the annual road fatalities for highly motorized countries generally shows, besides some irregularities, a peak in the beginning of the seventies. No explanation for the safety improvement after the mid seventies is needed, because a peak in fatalities is the necessary result of an initially high, but monotonic ever decreasing proportional growth in kilometrage and a constant proportional decrease for the fatality rate. This is illustrated by typical curves of Figure 1 (from the Netherlands).

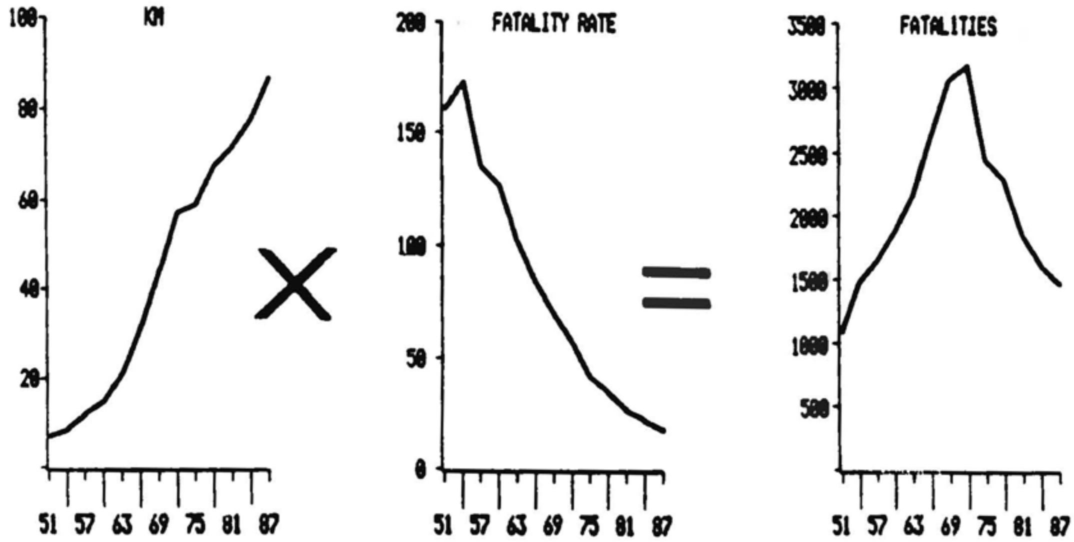


Figure 1. Typical curves for kilometrage x fatality rate = fatalities.

In fact the development of kilometrage can be fairly well expressed by a S-shaped function of time (Oppe, Koornstra & Roszbach 1988, Koornstra 1988; Oppe 1989; Oppe & Koornstra, 1990). The mileage data from the USA and their fit to the S-shaped function of time are shown in Figure 2.

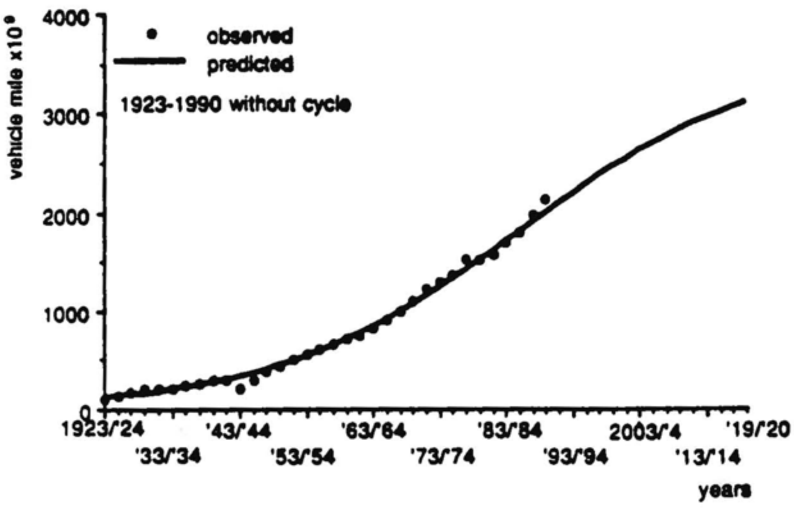


Figure 2. S-shaped development of mileage for the USA.

The development of the fatality rate for many countries has been described by an exponential decreasing function of time (Koornstra 1987; Chatfield, 1987, Broughton, 1988; Haight, 1988, Oppe 1989). Although the use of that function assumes that the fatality rate reduces to zero in the end, it has shown to be a function which in a macroscopic sense fits the data for all countries rather well. The analysis of Chatfield (1987) for the fatality rate in the USA from 1925 to 1985 is shown as an illustration in Figure 3.

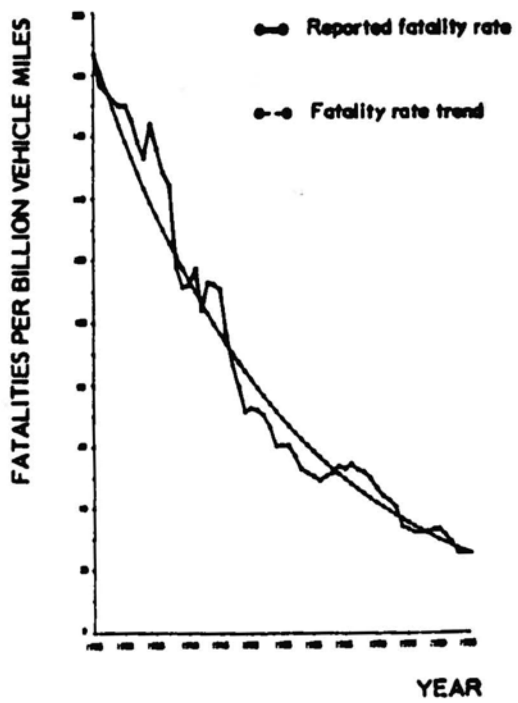


Figure 3. U.S. motor vehicle traffic fatality rates (Chatfield, 1987).

Since both functions for mobility growth and for fatality rate are functions of time, while time is perfectly predictable, one can predict the macro-development of fatalities from the fitted curves of these simple models. So has been done by Oppe (1989; 1991a) for the USA, Japan, (West) Germany, Great Britain, Israel and the Netherlands, based on the data for time-series of the post second world war period of more than 40 years. From the above pictures and other analyses it can be seen that the actual developments show marked deviations from the model curves. The product of both fitted curves necessarily show a smooth single peaked curve as the expected number of fatalities from the model outcomes. The retrospective and prospective prediction for the USA by these macroscopic models is shown in Figure 4, where the retrospective part is the actual vehicle mileage multiplied with the model prediction of the fatality rate.

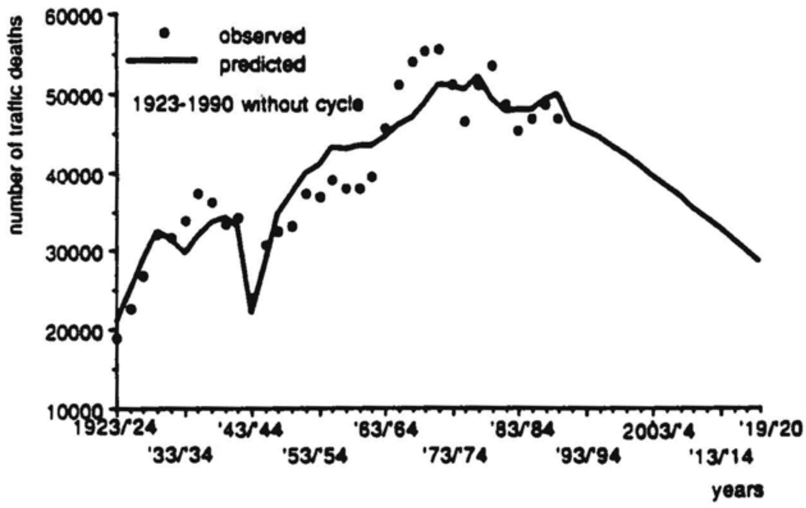


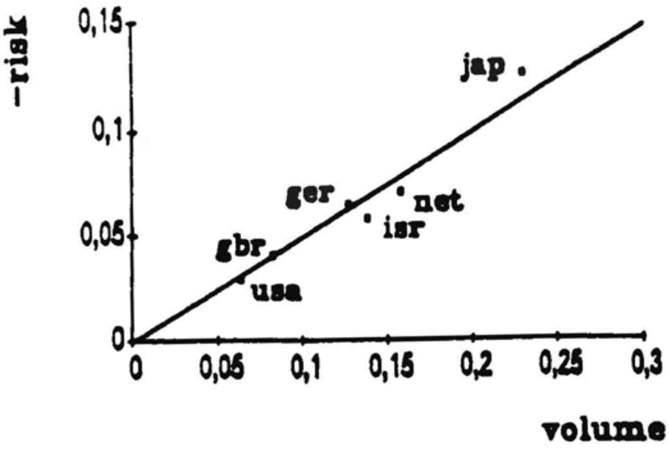
Figure 4. Macroscopic model prediction of U.S. fatalities

As can be seen the retrospective prediction is far from accurate, but it does reflect the macroscopic trend in the development and the prospective trend is one of increasing safety, because of the ever decreasing fatality rate to a virtual zero level in the infinity of time.

2. THEORETICAL BACKGROUND

On the basis of theoretical considerations from evolution theory there may exist a close relation between growth and risk adaptation. In evolution theory Teilhard de Chardin was (to our knowledge) the first who has formulated such a more or less quantitative general relation when he wrote: - **"The <evolution> process for very large aggregations - as is the case for the human mass - has the tendency to 'evolve errorless', because on the one hand of chance the probabilities of success increase, and on the other hand of freedom the probabilities of refusal and failure decrease, proportional to the multiplicity of the related units"** - (Teilhard de Chardin, 1948, Postscript Section 3). Applied to the technological traffic system the growth in kilometrage may be related to risk adaptation as the decreasing fatality rate. At an aggregate level and over a long period of time one may view traffic and traffic safety as long-term changes in system structure and throughput. Renewal of vehicles, enlargement and reconstruction of roads, enlargement and renewal of the population of licensed drivers, changing legislation and enforcement practices and last but not least changing social traffic norms in industrial societies are phenomena which are largely driven by growth of motorization and mobility. In an evolutionary systems approach these phenomena can be conceptualized as replacements of subsystems by sequences of better adapted subsystems within a total traffic system. The steadily decreasing fatality rate can be viewed as the lagged adaptation of the system as a whole.

Oppe and Koornstra showed (Oppe et al. 1988; Koornstra, 1988; Oppe, 1989; Oppe, 1991a) that the development of risk was related to the increase of the mobility growth. The evolutionary interpretation of socio-economic and technological road traffic systems inspired them to look more generally at the mathematical relations between system growth and risk adaptation. The mathematical expressions for growth of mobility and for exponentially decreasing fatality rate are related and empirical results have shown that the number of fatalities can become a proportional function of the increase of growth in kilometrage and does not dependent on the absolute level of kilometrage. The empirically found relation between the parameters for slope of curves for growth of traffic volume and fatality rate is illustrated by Figure 5, taken from Oppe (1991a).



<u>Figure 5</u>. Relation between slope parameters for volume and rate.

The meaning of this figure that the slower the growth of mobility is the less the reduction in fatality rate is. It can also be seen from this figure that growth is slower (and risk adaptation less) the longer ago the unbroken history of motorization started, which is exemplified by the range of the positions from the USA to Japan. It seems, therefore, that the more recent the motorization is the larger the annual decrease in fatality rate and the more explosive the motorization is.

The product of the macroscopic model curves with their marked deviations as the resulting retrospective predictions of fatalities, such as the one shown for the USA in Figure 4, exhibit even relative larger deviations than the underlying pairs of curves for mobility growth and fatality rate. This indicates that the deviations from pairs of curves per country are not uncorrelated. Oppe (1991b) analyzed the residual deviations of the two macro-trend curves and showed in a model free way by polynomial analysis of curves and their derivates, that indeed that changes of increase and decrease in the respective actual curves are strongly correlated. This enabled him to predict retrospectively the development of fatalities in a much more accurate way.

In an earlier study (Oppe & Koornstra, 1990) the variations around the evolutionary S-shaped trend are modelled by cyclic variation of the estimated saturating level of kilometrage. This method improved the prediction of motorized mobility and fatalities considerably, although the deviations of the fatality rate were left untouched. However, this model for deviations does not contribute to an intrinsic correlation between deviations in growth and rate. The cyclic nature of deviations from macro-trends for growth and rate as well as the intrinsic correlation between deviations for the fatality rate and the relative increase of mobility growth is nicely illustrated by Figure 6. This figure shows for the post second world war period in the USA the actual fatality rate and the smoothed, so called acceleration of growth which is the smoothed annual proportional increase of growth. As such both curves in this figure are curves of observed values without fitting any model to the data.

Figure 6. Observed fatality rate and acceleration of growth in the USA

The figure reveals a cyclic deviation around the decreasing fatality rate as well as cyclic deviations from the monotonic decreasing proportion of annual mobility growth. This monotonic decrease for the proportional increase of growth is the result of the S-shaped growth itself. As also can be deduced from this figure the cyclic deviations in both curves are strongly correlated. It demonstrates that not only the macroscopic overall trends of growth and risk adaptation are related, as shown by Figure 5, but that also cyclic deviations in both curves are related. The common cycle around these curves can also be described as a function time. Figure 6 shows that relative higher growth of mobility above the S-shaped trend results in a less well adapted traffic system with a temporary stagnated or even increased fatality rate.

This inspired the development of an integrated model for related cyclic deviations from the also related S-shaped growth and exponentially decreasing fatality rate (Koornstra, 1991a; 1991b; 1992; Koornstra & Oppe, 1992). In these studies the slope of the curves is cyclic varied as a function of time. This can be interpreted as long term cyclic influences on the speed of growth and speed of risk adaptation. Due to the nature of the relations between mobility growth and risk rate the cycle around the fatality rate will show a time lag of a quarter of its cycle period with respect to the cycle around the S-shaped growth curve. Such a lagged influence of growth on safety can be understood as the lagged safety result from enlarged and improved infrastructures, renewal and enlargement of car fleets, revised and improved laws and improved licensing, education and enforcement practices. All together the technological evolution of road traffic is pushed by the demand for traffic and indeed do make the growth of traffic possible. The safety effects of these sequences of replacements in the traffic system are lagged in time with respect to the growth of traffic, because the realization of needed and planned changes asks for a certain time periods before the implementation is completed. Since in the integrated evolutionary model the macroscopic trend curves and the common cyclic deviations around these trends are both functions of time, it enables one to predict retrospectively as well as prospectively the developments in growth and rates in a much more accurate way. It also gives in a marked improved prediction of the past and future development of road safety. This is shown in the next sections. The deviation cycles around macroscopic trends are interpreted as economic circumstances with relative long cycle periods which alternatingly deter and accelerate the technological evolution of system growth and risk adaptation.

3. FORECASTS FOR HIGHLY MOTORIZED COUNTRIES

3.1. United States of America

Figures 2 to 4 showed for the USA from 1923/25 onwards the macro-trend analysis without cyclic effects. Although the downward trend in the prediction of Figure 4 may be correct, its actual forecast value is doubtful in view of marked deviations for the past period. An analysis by the integrated model with cycles around macro-trends shows that the apparent cycle is disrupted by World War II. If we analyze the post war period only by our integrated trend and cycle model the precision of the predicted values of mileage and fatalities enhances markedly. This is shown in Figures 7 and 8, where mean two-year values of mileage and fatalities in the USA from 1949 onward are given.

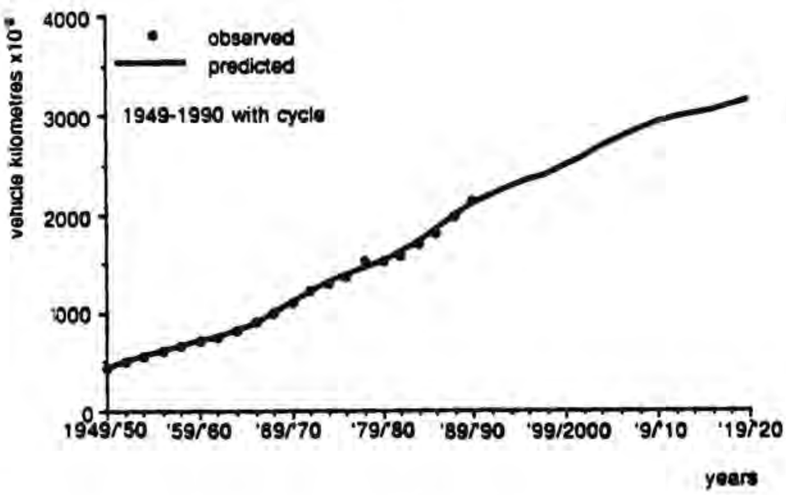


Figure 7. Mobility analysis in the USA from 1949 to 1990.

Figure 8. Observed and predicted fatalities in the USA from 1949 to 1990.

The retrospective prediction error for yearly mileage for the USA remains within the 5% range and for fatalities per year within the range of 8%. The effects of the cycles with a period of 20 years in the USA are also very well visible in the forecast up to the year 2020.

3.2. (West) Germany

Figures 9 and 10 give the results for motorized kilometers and fatalities in former western Germany as two-years mean values from 1953/54 on ward to 1989/90 retrospectively and prospectively predicted to 2019/20, obtained by the same integrated model with cycles around monotonic trends.

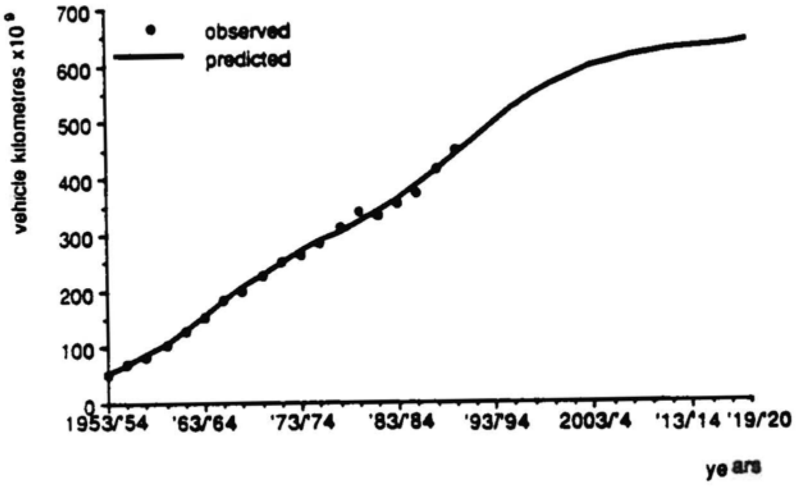


Figure 9. Mobility analysis for (West) Germany.

The saturation level for (West) Germany is not very well defined by the fit of its growth development, but due to the theoretical relation with fatalities it can be taken to be about 675 x 10^9 km. Higher estimates, however, are not significant worse. There is a significant cyclical deviation from the sigmoid growth trend with a period of 38 years.

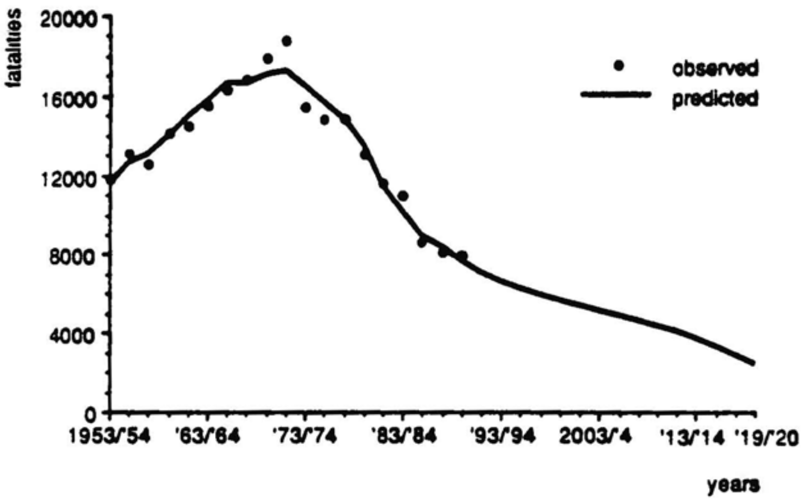


Figure 10. Observed and predicted fatalities in (West) Germany.

The retrospective and prospective prediction of fatalities (the solid lines of Figure 10) are again obtained from the observed and predicted vehicle kilometers and the fitted fatality curve. The cycle around the exponential fatality rate contribute significantly to the estimates.

The presented analyses for these and other highly motorized countries (Koornstra, 1991b, 1992) illustrate that mobility growth, fatality rate and the resulting fatalities can be modeled by processes which only depend on time, while the effects of relatively increased and unadapted growth can be disastrous for the development of the fatalities. So it has been in all highly motorized countries with a peak in road fatalities in the beginning of the seventies and so it will be again for Japan (Koornstra 1991b) and Israel (Koornstra, 1991a) in the nineties. The relative larger proportional increase of growth in the recent past has also caused, a temporary increase (Japan, Israel) or delayed reduction (Western Europe) of the fatality rate. As shown in the prospective predictions, this is not a sign of permanent worsening of road safety in the future. On the contrary, the long term predictions are optimistic due to the best fitting limit value of zero for the fatality rate (time proceeding to infinity). Since the independent variable is time which is perfectly predictable and because the past period of 40 years or more in many countries is accurately predicted by our time-based models it probably is a reliable prediction method for the future development of mobility and road safety in the next decade. Moreover, the integrated model is rooted in the general theory of technological evolutions (Koornstra 1991a; 1991b, 1992) and, therefore, the model also provides a scientific acceptable basis for prediction.

4. FORECASTS FOR CENTRAL AND EAST EUROPEAN COUNTRIES

The above theory and models may be as well applied to the development of motorization and safety in Central and East European countries. The development there can be seen as a technological evolution of motorization which up to 1989/90 has been retarded by socio-economic constraints and political system conditions. On top of this retardation a possibly present cyclic wave around starting developments may express the stagnation of further growth for the worsened situation by a socio-economic repression in the period after the seventies. Socio-political constraints in Eastern Europe are released some time ago and it can be assumed that the economic repression will turn into an upsurge. The model analysis may show whether these expectations are reflected in the growth of motorized mobility up to now and if so it may be a basis for model prediction of the future. In another paper we have sketched developments of mobility and safety for Eastern European countries on the basis of the macro-trends only (Oppe & Koornstra, 1992). Recently we have given an alternative and more detailed description, using the integrated model of related macro-trends and related cyclic deviations (Koornstra & Oppe, 1992). The following analyses for the countries of Hungary and the Czech and Slovak Republic(s) are taken from that most recent study. For these countries we do not have a complete set of annual kilometrage, but the number of annually registered passenger cars from the sixties onward can be used instead. Generally the development of the number of passenger cars is strongly correlated with the total motor vehicle kilometers.

The series of data for 30 years or less and the particular circumstances in the East European countries do not allow that we determine the estimation of the saturation level of motorization from the development of the given data over that period since the sixties. It, therefore, is assumed that the saturation levels of motorization for these countries will be the same as for (West) Germany. This means we, given the predicted saturation for (West) Germany which is 47% higher (see Figure 9) than the present level of motorization (about 2 persons per car), we fix the saturation level of motorization on 1.4 person per car. The resulting saturation levels for the number of cars for a fixed number of inhabitants per country are given in Table 1.

Country	Inhabitants x1000 in '90	Cars '90 x1000	Ratio pers./cars in '90	future	Saturation level
Germany (W)	62.679	30.684	2.04	1.4	44.800
Czech/Slovak	15.519	3.122	4.97	1.4	11.100
Poland	38.038	5.261	7.32	1.4	27.200
Hungary	10.375	1.945	5.34	1.4	7.400

Table 1. Inhabitants, motorization and resulting saturation level.

With these tentatively fixed parameters the other parameters are fitted to the data of passenger cars and fatalities for the mentioned Central-Eastern European countries. In Figures 11 to 14 the predictive results of the analysis are given in the same way as before, but now for growth of passenger cars and by fatality rate per passenger car.

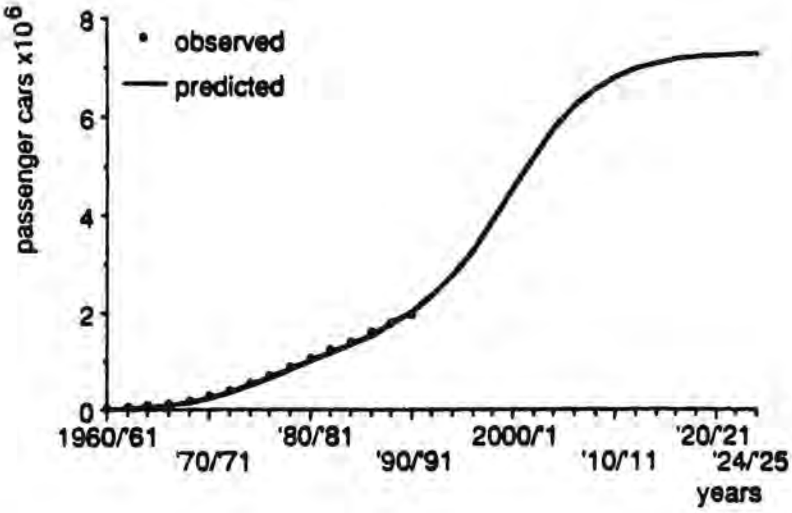


Figure 11. Forecast analysis of motorization in Hungary.

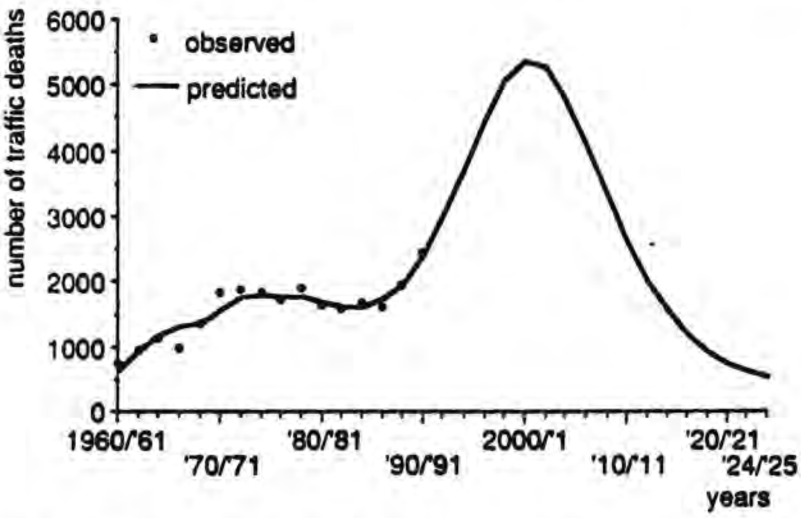


Figure 12. Forecast analysis of fatalities in Hungary.

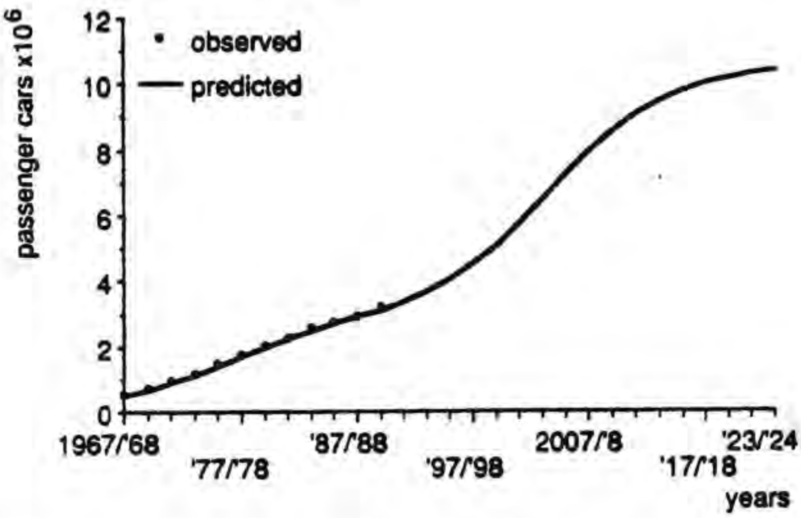


Figure 13. Forecast analysis of motorization in Czech & Slovak Republic(s)

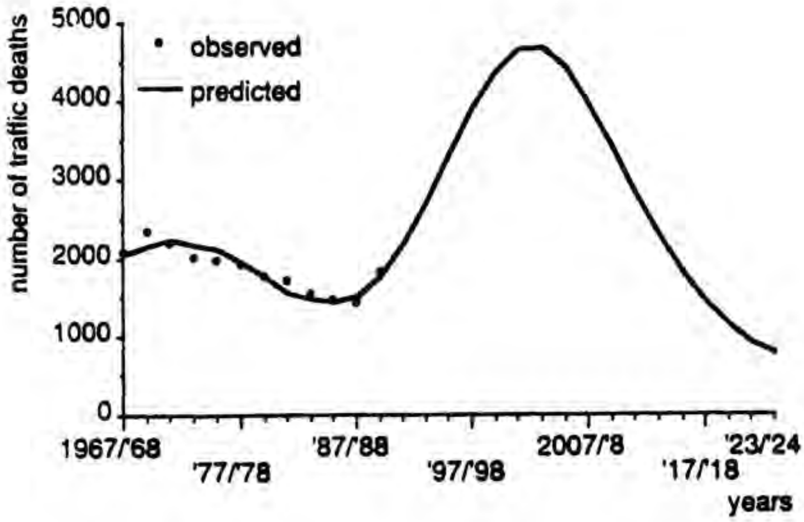


Figure 14. Forecast analysis of fatalities in Czech & Slovak Republic(s)

Despite a priori fixed saturation levels the retrospective prediction of the annual number of cars is quite satisfactory. The same holds for the fit to the observed fatalities over the 31 years period for Hungary and the 24 years period for the Czech and Slovak Republic(s). The optimal cycle period for these countries is about 40 years, a period comparable to the one of Germany (west). The most encouraging fact for the possible validity of the predictions, however, is that the respective slope parameters for growth of motorization and fatality rate (per car in this case) also tend two show the theoretically expected ratio of a half, just as was shown for the industrialized countries in Figure 5. The values of the respective slope parameters are shown in Table 2.

Country	Volume parameter	Risk parameter
Czech/Slovak	0.0981	0.0511
Poland	0.1174	0.0596
Hungary	0.1432	0.0685

Table 2. Comparison between slope parameters of volume and rate.

The satisfactory retrospective fit and the above table in relation to Figure 5 can be seen as evidence for the tentative validity of the predictions. The prediction of the safety development is far from reassuring. The industrialized countries have experienced a tremendous increase in fatalities between the second half of the fifties and the onset of the seventies. Just in the same way the East European countries have to envisage a comparable increase in fatalities between to day and the next ten years. Their development can be regarded to be retarded by about 30 years with respect to North-West Europe, but in the coming decades the Central European countries will catch up the backlash in motorization with all the adverse consequences for road safety. The total number of fatalities for the sum of Hungary, Poland and the Czech and Slovak Republic(s) is predicted to increase from 12.000 nowadays per year to about 25.000 per year at its maximum around the year 2003. This prediction may even be somewhat optimistic, because the marked increases of fatalities in 1990 are already underestimated. On the other hand, one should realize that these forecasts are based on restricted empirical evidence and on a hypothetically assumed level of saturated motorization. After the first decade of the next century the annual number of fatalities is predicted to decrease gradually to about 5000 in the year 2025, but such long term predictions must be taken as far from reliable. However, from the evolutionary theory it follows that a gradual reduction must be observed after the increase to a certain maximum.

5. PREVENTIVE ROAD SAFETY ACTIONS

One may wonder whether it is possible to prevent the predicted increase of fatalities by safety policies. This would ask for a steeper reduction of the fatality rate which have to take place before the increase in motorization take place. From our evolutionary theory (Koornstra, 1991a; 1991b, 1992) improved safety is the result of better adapted replacements of sequences of subsystems or elements in the traffic system. Whether these renewal processes concern infrastructure, cars, laws, or generations of better educated road users, all these processes asks for investments and time. Therefore, it is doubted whether the increase in fatalities can be actually reduced in the next ten years, given the economic circumstances in Central and Eastern Europe. Specific actions which are beneficial may be taken, based on the experiences of West European countries with regard to effective measures, but is not likely that the priority for road safety will dominate the upgrading of the transport system. Most likely such an upgrading of the road traffic system will be pushed by the growing motorization and the safety effects of that upgrading will be lagged in time with respect to the growth of mobility. It is hoped that these forecasts for Central Europe motivate decision makers to provide possibilities for research cooperation between East and West Europe in order to establish more priority for effective road safety policies, which surely ask also for joint financial support for the necessary actions to be taken.

In Greece, Spain and Portugal the motorized kilometers have grow greatly in the last decades and there we also have seen a large increase in the number of fatalities. If no effective action is taken one may expect that the same will also hold for the Central and East European countries in the next decade. In this respect the mobility and safety differences between West and South as well as between West and Central or East Europe may be regarded as a matter of advances and backlashes in macro-development of mass-motorization. National policies are a main factor in the determination of the growth development and, moreover, the safety policy in the national countries can influence that safety development.

In view of the differences between European countries and between Europe, Japan and North America the report of the High-Level Expert Group for an European Policy for Road Safety (Gerondeau, 1991), a group of which I was a member, concluded that road accidents are not an unavoidable corollary to the increasing motor traffic. That so called Gerondeau-report states on the contrary that authorities and their policies can, if not to abolish, at least reduce the number and seriousness of road accidents. In this matter, so also states the Gerondeau-report (Gerondeau, 1991, p. 15):
"- the authorities have a fundamental part to play, trough the action which they do (or do not) take:
- they are responsible for the road network and its equipment;
- they are responsible for the standards applying in building and controlling vehicles;
- they are responsible for organizing assistance;
- lastly, they are to a very large degree responsible for the opinions and the behaviour of road users, whom they can influence through education and training, information, traffic regulation, enforcement and penalties. The Gerondeau-report acknowledges that individual mistakes or bad conduct can be demonstrated in 90% or more of road accidents, but warns not to draw the wrong conclusion from that point. It states that:-"the behaviour of every road user is in fact largely dependent on circumstances of his journey outside his control (road network characteristics, other users' behaviour, the regulations, the degree of enforcement, etc.)".

And indeed the frequency of road user mistakes vary considerably with the characteristics of the road system. The Gerondeau-report concludes: " Whilst the part played in accidents by individual faulty actions of large numbers of users is often used as an excuse for inaction, there is a need for the awareness that, in spite of the appearances, **the responsibility for taking action against traffic accidents is primarily collective and that it falls firstly on the various public authorities which might take such action**. ... Progress is only possible through this approach, as is shown by the experience of those Community countries which have achieved the best results. ... Of course, other groups besides the authorities should and can take action on road safety: the car makers, the insurance companies, the media (etc.). And voluntary bodies also can play an important part in attaining public awareness and in changing attitudes in any coherent action, their potential support must be sought. Nonetheless, there is a fundamental need for a commitment of preventing accidents, from all the public authorities involved.

6. POLICY FOR SUSTAINABLE ROAD SAFETY

The objective of an improved road safety can be reached, according to the Expert Committee, by adopting measures which have shown to be effective in reducing the number and seriousness of road accidents in some countries, but which are not applied in all countries. In the Expert Committee we were very pragmatic and realistic. We did not concentrate on modern electronics and telematics, despite the potential value which such measures may have in the future; nor did we made innovations or propagate until now unapplied measures. Nearly all our concrete proposals are already at least applied in one or more countries with positive results on road safety which are judged to be also effective in the other countries. The only innovations were some combinations of varieties of similar measures which were judged to yield a more optimal effect. The Expert Committee listed 64 proposals for such concrete measures. These proposed measures can be taken on different levels, either by authorities on the supra-national, national, regional or local level. For this active role of the highest level towards actions to be taken by lower levels the Expert Committee listed 14 proposals of a more process and organization oriented nature which I can not discuss here. Nor can I discuss all the 64 concrete measures that has been proposed, but I shall try to highlight and illustrate some general ideas beyond the scope of these measures which are as well applicable in Central and East Europe. First of all and beyond these proposed measures, we have realized that human behaviour is not infallible and also that no one really wants to become involved in an accident by his own behaviour, but that the frequency of the seldom failures of millions of road users, which nonetheless results in the enormous amounts of losses in road safety, is largely dependent on the human made traffic system. Since one can not create an infallible human being by measures, the reduction of failure frequency must be sought in an improved traffic system which elicits less opportunity for failure.

Such failure opportunities, however, are also elicited by the road user behaviours of others. Of the concrete proposals 24 measures concern that improvement of road user behaviour with respect to the others directly. The idea beyond them lies in the fundamental principal that behaviour is conditional to circumstances and individual backgrounds as well as to the expected utility of the outcome of behaviour. The individual background is mainly shaped by public information, education and training as well as by the experience in traffic which are conditioned by the physical traffic structure as well as by traffic laws or regulations and their enforcement and penalties. The 24 behavioural proposals are directed to these domains which condition the road user behaviour. I regard the proposals for

(a) graded licensing and the practice of accompanied learner driving,

(b) speed regulations and

(c) specific and general enforcement practices

as the most important behavioural proposals for an effective road safety strategy on this topic which surely also apply for the future traffic safety situations in Central and East Europe.

If the proposals on the training and licensing of drivers of the report (Gerondeau, 1991, p. 20) would be applied then the risks of young drivers could be reduced considerably. The French experience with such procedures shows that skills and knowledge alone are insufficient for safe driving by youngsters, but that danger perception and responsible driving can be learned in a very practical way. If the French results apply in general then the risks reduction of young drivers reduces even by a factor of seven times, which in general would mean more than 10% less serious accidents. It is a very important live saving measure which only depends on the political willingness of their adoption.

The level of mean speed given the road type and the variation in speeds

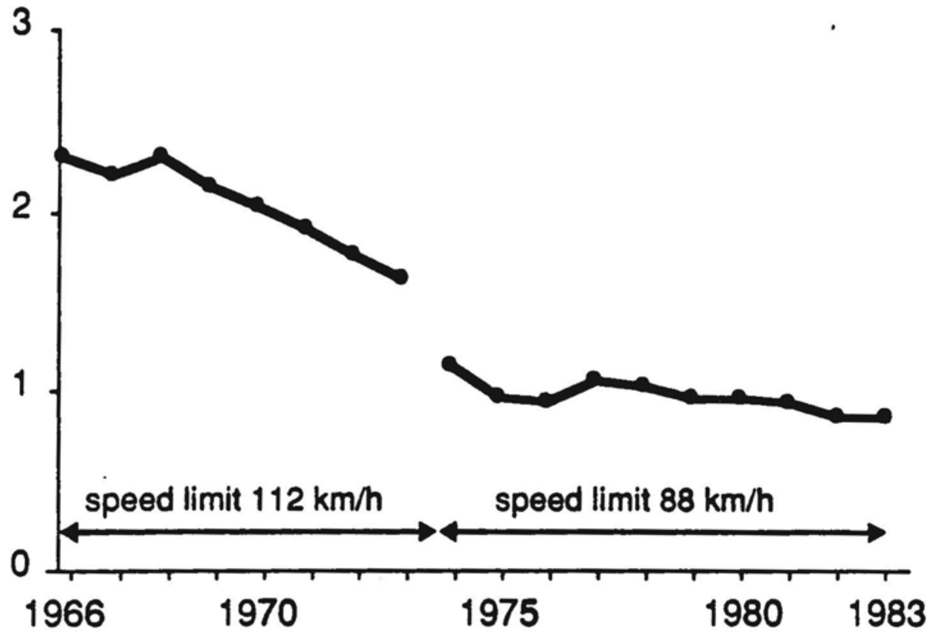


Figure 15. Fatality rates on US Interstate highways in relation to the speed limit change in 1974.

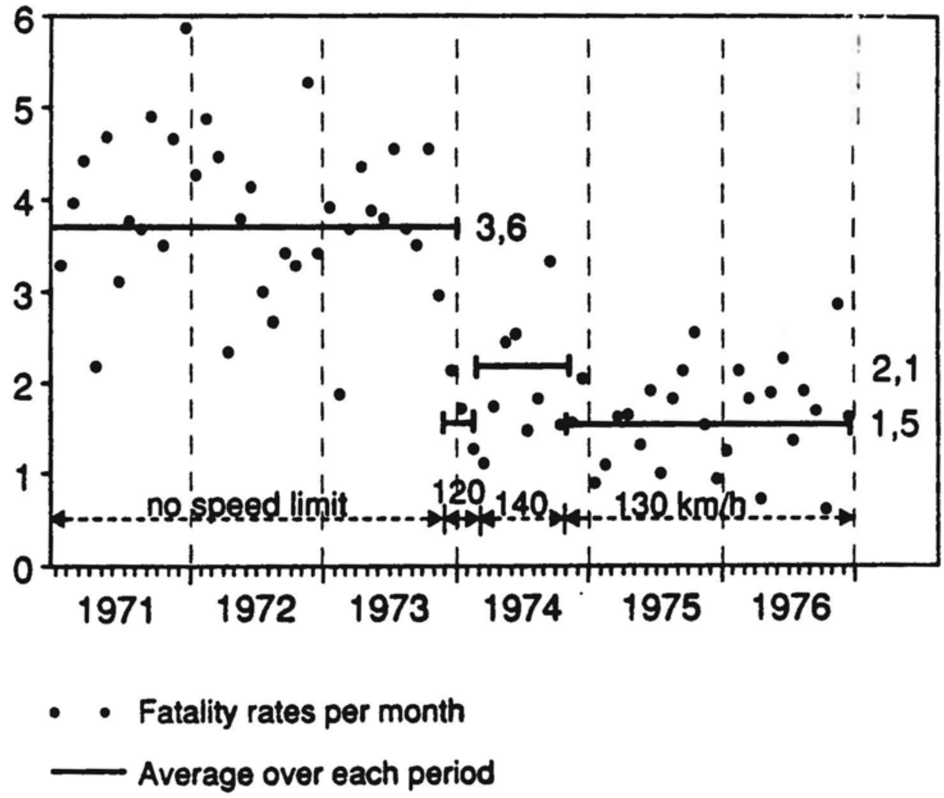


Figure 16. Fatality rates on rural motorways in France in relation to the speed limit changes in 1974.

are important factors in traffic safety. The variation in speeds on the road (also between catagories of road users) determines to a large extent the number of accidents. If the standard deviation of speeds is reduced, then the number of accidents approximately changes nearly by a quadratic effect of that reduction (Cirillo, 1968). The absolute level of speeds determines also quadraticly the seriousness of the outcomes of a given accidents. Since generally variation of speeds reduces with a reduction of absolute mean speed, it follows that mean speed reduction easily can have a fourth power effect on safety, which for example means that a reduction or increase of 10% in mean speed (factor .90 or 1.10) can change the number of fatalities by a reduction of 34% (factor $.90^4 = .656$). These theoretical considerations are confirmed by empirical Swedish studies (Nilsson, 1982) and are also confirmed for motorways in the USA and France, as is shown by two pictures taken from the Gerondeau-report.

But not only on motorways this relations between speeds (and speed variations) and accidents holds, also the Danish actual speed reduction from the urban speed limit change of 60 km/h to 50 km/h and the Dutch results on so called "woonerf" by traffic calming measures inside living areas which reduce speeds from 50 km/h limit to speeds below 30 km/h affirmed these relations between speeds and accidents. The network related proposals of the Expert Committee on speed limits, speed enforcement and automatic control as well as the proposals for car-manufacturing and their advertisement, therefore, are of utmost importance. Their application in a harmonized way to all types of roads could save many thousands of lives. This includes their application to rural roads; speed limits on these roads could stop the increase of the share of traffic fatalities on rural roads. The rising speeds on Central European roads must be a major cause of the increased road fatalities.
The importance the proposals for a renewed enforcement practices of specific and general police control in the Gerondeau-report are illustrated by the results of the intensified random breath testing in New South Wales in Australia.

Not only show these results that such a high density of testing leads to lasting reduction of 25% of the number of fatalities, such a high density also is cost effective since it yields a return rate of 2 for 1 cost unit as Dutch research has shown.

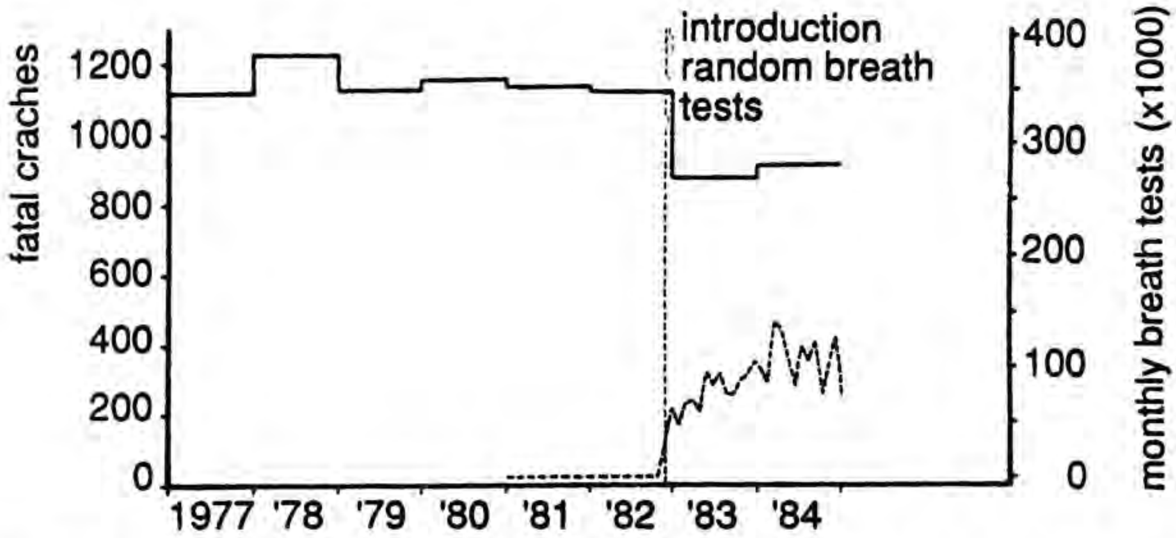


Figure 17. Annual fatal crashes and number of random breath tests in New South Wales (after Arthurson, 1985).

The proposals in the Gerondeau-report which are directed to action for the infrastructure of the road network are 12 in number. The ideas beyond these infrastructure proposals are based on a hierarchical categorization of the roads in the network with homogeneous characteristics along the routes within each category and their uniform layout of connection links within and between types of roads. The road system has evolved gradually from the network that was originally fitted for carriage and pedestrian travel. The road transport system has never been designed in such a way that the opportunity for accidents is prevented a priori, like it has been in the rail- and air-transport systems. Rail and air passenger transport are more than a factor of 200 times safer than passenger transport on our European roads.

Traffic mode		Area	Fatality rate
road	1)	EC	3.5×10^{-8}
rail	2)	West Europe	1.6×10^{-10}
air	3)	USA	0.4×10^{-10}

1) Gerondeau report (1.3 pass. p. veh.). 2) Schopf (1989). 3) NTSB

Table 3. Risk per passenger kilometer for different transport modes.

The Central and East European Countries do have a large share of passenger transport by rail. In view of the safety of that rail system compared to the road system it would be wise to keep that rail system in shape and to enlarge it where possible. Central and East Europe must not make the same mistake of many countries in Western Europe, which in the sixties have abolished many tram- and local railways in order to use the space for the enlargement of the road system.

The gradual upgrading of the road system nowadays constitutes a network of roads which is more an unpredictable concatenation of a nearly endless variety of road sections by an also endless variety of cross-connections. The result is a road system which is too complex for the road user to allow reliable predictions for the next oncoming situation. Only the lay-out of the motorway system permits relative reliable predictions. Since this road category is relative well predictable and because speed variation is relative low it is a relative safe type of road, in spite of the high speeds driven. The fatality rate per kilometrage on motorways approximates the safety of rail and air transport. A comparable level of safety holds for well designed residential calming areas, where speeds are so low that the variation in speeds is also low.

Road type	Max. km/h	Mixing fast/slow	Level crossings oncoming traffic	Injury rate per million veh. km.
calming area	< 30	yes	yes	0.20
resid. street	50	yes	yes	0.75
urban arterials	50	yes/no	yes	1.33
rural roads	80	yes/no	yes	0.64
rural motor road	80	no	yes	0.30
rural motor road	100	no	no	0.11
motorways	100/120	no	no	0.07

Table 4. Injury rate for road categories in the Netherlands, 1986.

As can be seen from Table 4 of injury rates on Dutch roads, which together with the British and Swedish networks belong to Europe's most safe road networks. All road types other than motor roads and calming areas have considerable high injury rates. The lack of safety varies with the combination of the level of speeds and the amount of variation in speeds due to discontinuities (level crossings and oncoming traffic) and mixture of slow and fast categories of road users on the road type. The rural main roads and the urban arterial roads are the most dangerous ones. The redesigning of the road categories between motorways and residential calming areas to a limited number of categories of self-explaining roads with well predictable uniform layouts of routes and crossing types is most urgent. This is a major long term task which should be undertaken in a coordinated way in West, South, Central and East Europe, since diversity in Europe increases the unpredictability for the foreseen increase of cross-national travel of road users.

The ingredients of such a redesigned road network ask for more research on safer layouts, but many elements are know already. Increasing the area of redesigned urban streets to traffic calming areas with maximum speeds of 30 km p/h. is one very effective safety-design principles. Again Central and East Europe must not make the errors of West Europe which first has upgraded many roads in and trough the center of villages or towns and later either closed such roads for cars or restructured these roads to calming areas, while through traffic is circulated around buildup areas on main roads. Separation of slow and fast traffic and traffic with large mass differences is another safety-design principle. This means only pedestrians on sidewalks and cyclist on separated cycle paths, while crossings for pedestrians and cyclists on rural main roads and arterial urban roads preferably should not be designed as crossings on the same level. In the Netherlands we are now asking ourselves why we did not design quite differrent networks of routes for motorcars and cyclists which do not exhibit the design stupidity of joint or parallel routes with crossings for cyclists on places where also motorcars are crossing. The same principle also may mean special truck routes for inter-regional heavy good transport and limitation of masses of trucks in urban areas, where delivery by smaller vans from just-in-time transit centers outside towns can be foreseen. Separation of tracks for oncoming traffic on rural main roads and urban arterial routes is also needed, combined with increased safety on reconstructed crossings and accesses to these roads. Road constructions which physically forces car traffic to slow down on crossings and which reduces differences in directions between crossing flows is a third safety-design principle. Research in France and The Netherlands has shown that the British round-about with priority for round-about traffic is a much safer type of crossing than sign-regulated or unregulated crossings; reductions to even 10% of the accidents has been observed after reconstruction of crossings to round-abouts. The relative low share of fatal car-car accidents in the UK, compared to other West European countries may be explained by the frequency of the British round-abouts in their road network. There is a long way to go before such a consistent road categorization can be established. The first steps, according to the proposals in the Gerondeau-report are the conceptual creation of the hierarchical structure of the categorized and homogenized road network and the clarification of its principles. The report proposes to begin with the introduction of a systematic, periodical, external and compulsory inspection of the safety of the road system and to prepare and disseminate reference material with all the principles and rules for an upgrading to the safest-possible road network by building new roads and rebuilding and modified maintenance of the existing road network. It must be possible to achieve such a safer road network in a time scope of the next two or three decades.

The Expert Committee has also proposed 21 measures directed to actions on vehicles and certain categories of road users as well as 6 proposals for the improvement of the assistance to the injured. The proposals range from improved active and passive safety of motorcars, heavy vehicles, powered two-wheelers and cyclist to programmatic schemes for pedestrian safety, first aid, alert and emergency services. Again nearly all proposals are proven to be effective in one or more countries, but are not generally applied or less intensive applied in other countries. Except the proposal for less dangerous car fronts to pedestrians and cyclists, the proposed measures in this area do not need much further research. These measures could be introduced to day, the only obstacle is the time needed for regulation if the willingness for its introduction is present.

In view of the sad record of European road safety, compared with other industrialized continents as well as compared with other modes of transport, there clearly is a need for an active road safety policy. This does as well apply to the South and West as to the Central and East parts of Europe, because of the forecasts for the Central and East parts are not worse than the past in the West parts and the present situation in many Southern parts. The Expert Committee has expressed the opinion that road accidents are too often seen as the inevitable price for the utility of travel and transport. And hence the possibility of an active road accident prevention policy is ignored. Such an active policy, however, can be possible on the basis of the recommendations discussed above and formulated in more detail in the report of the Expert Group to the European Commissioner for Transport (Gerondeau, 1991). National authorities are in the right position to do so. They have done so in matters of health services, environmental protection and the advancement of science and technology. They should surely take a comparable action in a matter to which its citizens are highly sensitive, since it concerns the preservation of life itself and the safety of millions of citizens. It seems not a too ambitious task to bring the level of road safety in the whole of the Europe on the level of the USA, which is also the level of safety in some of the more advanced countries in Europe. The achievement of that goal would save about 35.000 lives and nearly a million injured on a yearly basis in the whole of Europe. In the achievement of such a target the national States (and their regional and local authorities) have to play a major role, but on the international level the promotion of and assistance to the implementation of a common transport policy within which road safety is an integrated major element should be undertaken without further delay. At present there is no entity on the international level that matches these tasks with respect to transport and safety and the establishment of such an organization, comparable to the European environment or technology organizations, is needed barely in view of the economic and human problem described It is, however, not only a matter of organization and political dedication. In a democratic Europe the basis for common action and their resource allocation is based on public support. Therefore, we should by an active social marketing promote the need for a common road safety policy and defeat the unjustified belief that road accidents are an inevitable phenomenon. Road transport is a man-made technology and this man-made technology can be made much safer. Although further research is needed, much know-how on road safety is already there. The dissemination of that know-how and the organization for an improved safety is our collaborative task, but the realization of the proposed road safety policy in concrete actions asks for a response which has to come from the responsible authorities in Europe.

REFERENCES

- Arthurson, R.M. (1985). Evaluation of random breath testing. Res. Note RN10/85. Traff. Auth. New South Wales. Traff. Accid. Res. Unit.
- Broughton, J. (1988). Predictive models for road accident fatalities. Traff. Eng. & Control 29: 296-300.

- Chatfield, B.V. (1987). System-wide safety improvements: an approach to safety consistency. Transp. Res. Board R-132. Washington.
- Cirillo, J.A. (1968). Interstate system accident research study II. Public Roads 35: 71-75.
- Gerondeau, M. (1991). Report of the High-level Expert Group for an European Policy for Road Safety. EC, Brussels.
- Haight, F.A. (1988). A method for comparing and forecasting annual traffic death totals: The United States and Japan. Int. Conf. Proc. "Road Safety in Europe", Gothenborg. VTI, Linkoping.
- Koornstra, M.J. (1987). Ridendo dicere verum. R-87-35, SWOV, Leidschendam.
- Koornstra, M.J. (1988). Development of road safety in some European Countries and the USA. Int. Conf. Proc. "Road Safety in Europe". Gothenborg. VTI, Linkoping. (R-88-33. SWOV, Leidschendam.)
- Koornstra, M.J. (1991a). Evolution of mobility and road safety. In: Hakkert, A.S. & Katz, A. (Eds.) Proc. 2nd Int. Conf. "New ways for improved road safety and quality of life. Tel Aviv. TRI, Technion, Haifa.
- Koornstra, M.J. (1991b). Mobility and road safety. Paper presented at the 3th ISRT Round Table "The Future of Mobility", Toulouse (to be published in IATSS Research).
- Koornstra, M.J. (1992). The evolution of road safety and mobility. Paper presented at the 6th World Conference on Transport Research. Lyon. (to be published, available as draft report from SWOV).
- Koornstra, M.J. & Oppe, S. (1992). Predictions of road safety in industrialized countries and Eastern Europe. Paper at Int. Conf. "Road Safety in Europe" Oct. 1992, Berlin (to be published in Conf. Proc.)
- Nilsson, G. The effect of speed limits on traffic in Sweden. VTI-report No. 68. National Road and Traffic Research Institute, Linkoping.
- Oppe, S. (1989). Macroscopic models for traffic and traffic safety. Accid. Anal. & Prev. 21: 225-232.
- Oppe, S. (1991a). Development of traffic and traffic safety in six developed countries. Accid. Anal. & Prev. 23: 401-412.
- Oppe, S. (1991b). Developments 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 developments of road traffic and safety. In: Koshi, M. (Ed.). Transportation and traffic theory; pp. 113-133. Elsevier, New York.
- Oppe, S., Koornstra, M.J. & Roszbach, R. (1988). Macroscopic models for traffic and traffic safety. Proc. Int. Sem. "Traffic safety theory and research methods". Session 5, Time dependent models. SWOV, Leidschendam.

- Schopf, J.M. (1989). Bahn oder Strasse: Verkehrssicherheit im Vergleich. Beiträge zur Verkehrsplanung: 145-170. Tech. Univ. Wien.
- Teilhard de Chardin, P. (1948). Le phénoméne humain. Editions de Sueil, Paris.