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Current and future trends in VRU accidents in Europe – why we need ITS solutions

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Abstract

Vulnerable Road Users (VRUs) is a collective term used to describe cyclists, motorcyclists, moped riders and pedestrians. This paper describes work undertaken within the EC's VRUITS project which focuses on reducing VRU accidents through the use of ITS solutions. The paper determines the current accident numbers within Europe for VRUs between the years 2002 and 2012 using the CARE database. Accident forecasting is then applied to predict future accident numbers if current trends continue and no successful countermeasures including ITS solutions are introduced into the Road Transport System. This shows the number of VRU fatalities in 2030 to be almost comparable to those of car accidents since car fatality rates are reducing at a far increased proportion compared to VRUs. The results of the study emphasise why the introduction of effective ITS solutions are necessary to improve the overall safety of VRUs.

Keywords: 1. Vulnerable Road User 2. Road Accidents 3. CARE data

Introduction

Road Safety remains a major societal issue within the European Union. In 2012, some 28,000 people died and approximately 250,000 were seriously injured on the roads of European, the equivalent of a medium-sized town. However, although there are variations between Member States, road fatalities have been falling throughout the EU. Over the last 20 years, most Member States have achieved an overall reduction, some in excess of over 50%. During this period, research on road safety and accident prevention has predominantly focused on protecting car occupants, with significant results. However, at the same time the number of fatalities and injuries among other categories of road users has not fallen to the same extent. Indeed, in some cases, they have risen. The "Vulnerable Road Users" (VRUs) in particular are a priority and represent a real challenge for stakeholders of the road transport system. Accidents involving VRUs comprised approximately 46% of all fatalities in the EU during 2012 with Pedestrians comprising around 23%, Powered Two-Wheelers (PTWs) comprising 18% and cyclists comprising 7% of the total numbers of fatalities.

The EC-funded VRUITS project is currently assessing the safety and mobility impacts of ITS applications for all VRUs and how the ITS applications can be improved to enhance the safety and mobility of VRUs without impacting on traffic efficiency. The VRUITS project takes a VRU-centric approach to determining recommendations for ITS applications aimed at improving the safety, mobility and comfort of VRUs, leading to a full integration of the VRU in the traffic system. Basic principles of the project are:

- using empirical evidence from accidents and conflict studies to identify critical situations for each VRU sub-group to be addressed by ITS;
- involving stakeholders from all relevant areas from VRUs to traffic planners;
- making use of existing (low-cost) technologies and aligning with existing and in-development standards in order to achieve accelerated deployment of the VRU ITS applications;
- modifying impact assessment methodologies to account for VRU behaviour; determining HMI design principles for specific VRU groups;
- identifying the types of information that can be supplied to VRUs in a safe and effective way; and
- Testing and evaluating selected technologies in trials.

Overall, the VRUITS project will achieve the following main objectives:

- To assess societal impacts of selected ITS and provide recommendations for policy and industry regarding ITS in order to improve safety and mobility of VRUs.
- To provide the evidence-base for recommended practices as to how VRUs can be integrated into ITS and how HMI designs can be adapted to meet the needs of VRUs

The impact of the VRUITS selected ITS services on safety, mobility and comfort is based on accident data, literature and expert analysis. For the safety assessment, the methodology which has been developed for in-vehicle safety systems by Kulmala et al. (2010) is adapted towards VRU applications. The methodology covers the three dimensions of road safety – exposure, crash risk and consequence. It not only considers the intended effects, that is, the safety factors that the ITS is designed to influence, but also the unintended effects, e.g. the effect of behavioural adaptation (Kulmala, 2010), in a comprehensive, systematic and transparent way. In the analyses, the three main factors of traffic safety were covered by nine behavioural mechanisms as first described by Draskóczy et al. (1998). The method for quantifying the safety effects explicitly takes into account the general accident data available from e.g. the CARE database. The accident data is further subdivided according to different background variables, such as vehicle type, collision type, road type, weather and lighting conditions and location. The inputs for the safety estimates were: expert estimates of effects by mechanism, the total number of accidents / fatalities or injuries from accident data and the share of accidents in each variable category. Some estimates were based on evidence from the literature, others on expert opinion due to lack of data or incomplete data (Kulmala, 2010). For improving validity and reliability of expert opinion on safety and comfort/mobility impacts expert judgment models are used, which use the opinion of different experts, as developed by Leden et al. (2000): The quantification forms input to a socio-economic impact assessment, taking into account accident trends for target years (2020 and 2030), road exposure trends and estimates on the fleet penetration of the application.

Therefore, much of the activity within VRUITS involves data analysis in terms of defining the current situation with regard to VRU accidents and determining the likely perspective in future years. This helps the prioritization process as well as facilitating the development of cost-benefit analyses aimed at understanding the implications of greater reliance on ITS for safety effects. More importantly, the data analysis helps to contextualize the likely situation in the event that countermeasures to VRU accidents are not developed or are not successful.

Therefore aims of the analysis within this paper are twofold:

1. To establish the historical/current accident, fatality and injury rates for VRUs within the EU
2. To estimate future accident, fatality and injury rates for VRUs if no ITS safety system interventions are introduced.

Method

Current Accident Trends (2002-2012)

In order to establish the current VRU accident numbers on an EU 28 level it was deemed necessary to use the CARE (Community Road Accident Database) database. CARE is a European Commission database resource comprising accident data from the EU Member States. The data comprise macroscopic information on road accidents which resulted in death or injury (no statistics on damage-only accidents are kept). The major difference between CARE and most other existing European databases is the high level of disaggregation – for example, CARE is based on detailed data of individual accidents as collected by the Member States. This structure allows for maximum flexibility and potential with regard to analysing representative information contained in the system and opens up a whole set of new possibilities in the field of accident analysis.

National data sets are integrated into the CARE database in their original national structure and definitions, with confidential data blanked out. However, transformation rules are implemented in the database in order to increase data compatibility and thus enhance the functioning of the system. The CARE database was therefore chosen as the core database for analysis within the VRUITS project as it involves records of accidents on a European-wide level and so is more representative of the EU as a whole. This is as opposed to analyses of national databases whereby it is necessary to apply findings to countries outside of the national scope.

The CARE database contains many variables including, but not exclusive to: age, accident severity, vehicle type, accident type (single vehicle, multi-vehicle etc.), first point of impact, light conditions and weather conditions. CARE has some limitations, in particular in that some countries joined the database at a later stage which can make comparing across years difficult. Inclusion of more countries in the database inevitably means an increase in accidents and can therefore impact on results. There is also variability in the quality of the accident data entered into CARE by country with some being highly detailed and accurate whereas others containing records where the information is unknown due to inaccurate recording of injury severity, age and other factors at the scene of the accident. This in turn can make cross-country comparisons very difficult. Finally, not all accidents are recorded by the Member States and hence CARE suffers from underreporting. This issue is more prominent for less severe accidents, and less so for fatal accidents. For most Member States, the level of underreporting is not known.

In this study, the data from the CARE database was used to classify the fatalities and injuries according to several background variables (collision type, road type, weather conditions, lighting conditions, time of accident, accident scenario, junction information, age and gender). However, it was not possible to distinguish if the VRU had been in an accident with a heavy or light vehicle (with the exception of pedestrian accidents). This is because the CARE database does not allow for the collision partner to be identified - it can only distinguish by one vehicle type e.g. it is possible to determine that a cyclist had been involved in an accident with multiple vehicles but it is not possible to distinguish the characteristics of the other vehicles.

Analyses were conducted on CARE data spanning a ten year period to give a complete picture on the recent European VRU accident numbers. As 2012 was the most recent ‘complete’ year, the data used ranged from 2002 to 2012. The analysis used data from all the EU countries which the CARE database could provide.

In order to compare VRU accident trends to other vehicle accidents, ‘passenger cars’ have been included in the analysis. Furthermore, a category labelled ‘all’ is also featured in the analysis- this represents all vehicle types combined including: VRUs, cars, LGVs, HGVs, buses and tractors.

Accident Forecasting

In order to predict future VRU accident and fatality rates, exponential regression was applied to the current 2002 to 2012 accident numbers for each VRU type as well as 'cars'. This meant current data trend lines were expanded to estimate future accident numbers. This analysis therefore represents likely future VRU accident numbers on the assumption that no ITS safety intervention is implemented. Of course ITS interventions will possibly influence the VRU trends (hopefully in terms of prevention and reduction) and therefore further decreases are predicted.

Results

Figures 1, 2, 3 and 4 contain details of historical data from 2002 to 2012. The trend in accident numbers of all severities is shown in figure 1. As can be seen, there is a significant decline in the numbers of accidents overall with car occupant casualties showing a modest decrease. However the decline in accident numbers for the VRU's is much less pronounced with bicycle and pedestrian casualties remaining relatively constant.

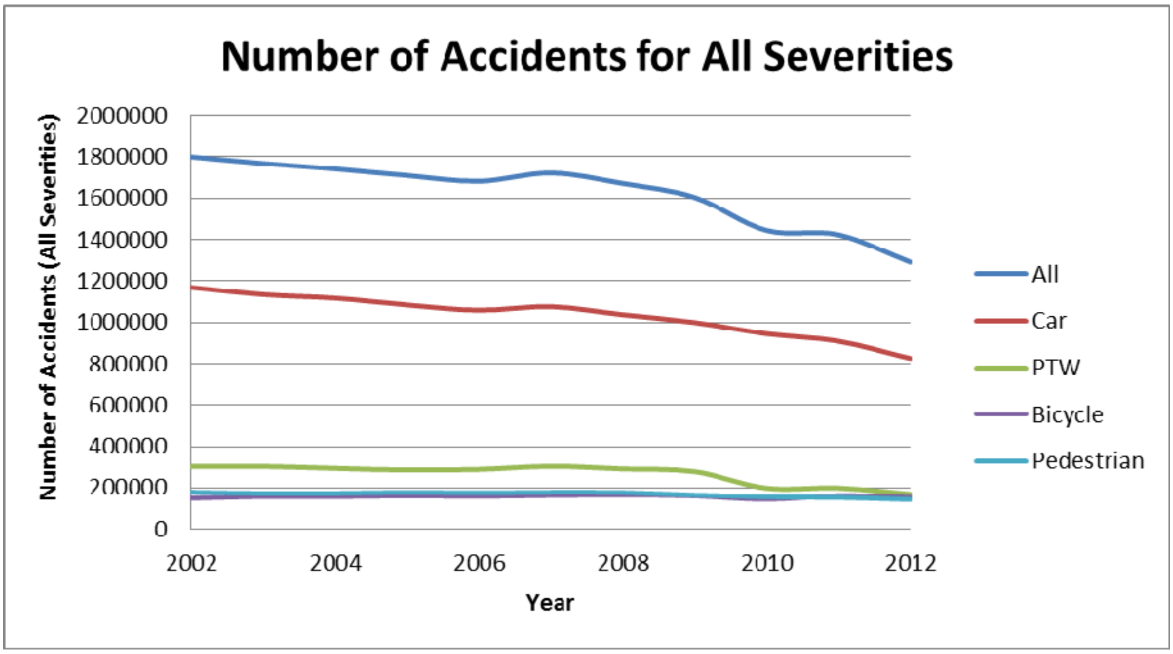

Figure 1 - Trends in numbers of accidents (all severities), 2002 to 2012

The trends in fatalities from 2002 to 2012 are shown in figure 2 below. As can be seen, passenger car fatalities have declined steeply over the period whereas the decline for the VRU groups is again much less pronounced, with bicycle fatalities showing a negligible decline. The trend in fatalities is similar to that for Serious Injuries (figure 3) although the rate of decline is perhaps not as pronounced for passenger car users whilst the number of VRUs who are Seriously Injured does not change between 2002 and 2012. The trend for 'Slightly Injured' casualties (figure 4) is similar to those observed for Fatal and Seriously Injured road-users although bicycle and pedestrian casualties appear to have increased slightly during the period.

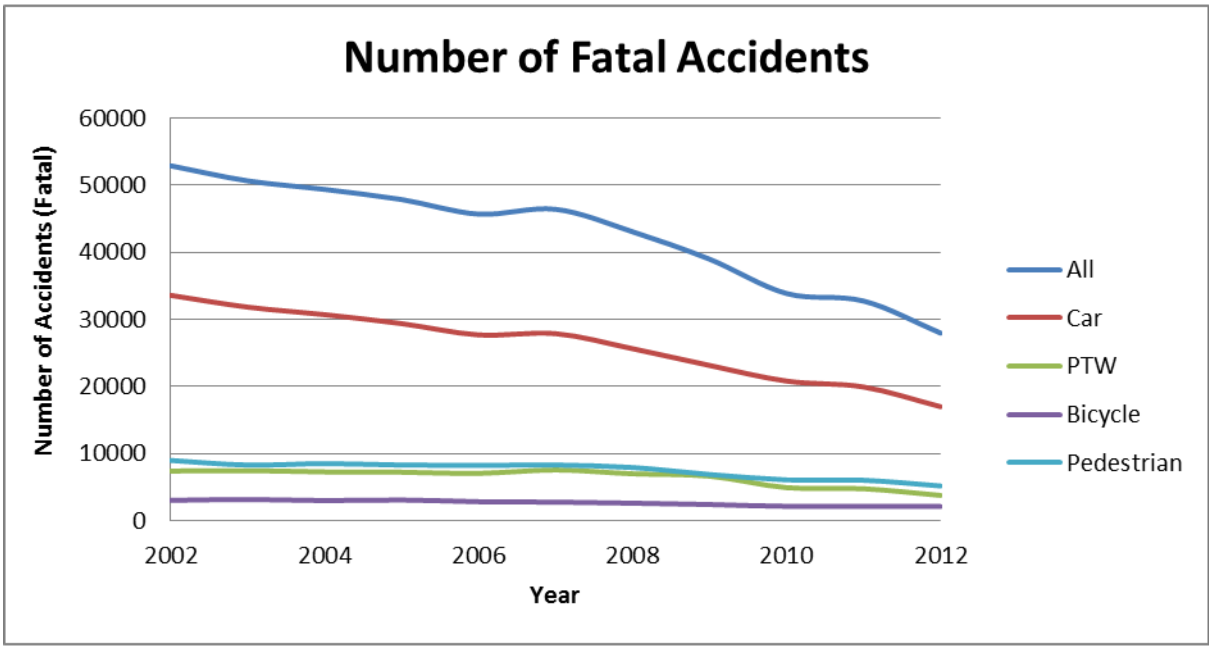

Figure 2 – Trends in numbers of accidents (Fatalities), 2002 to 2012

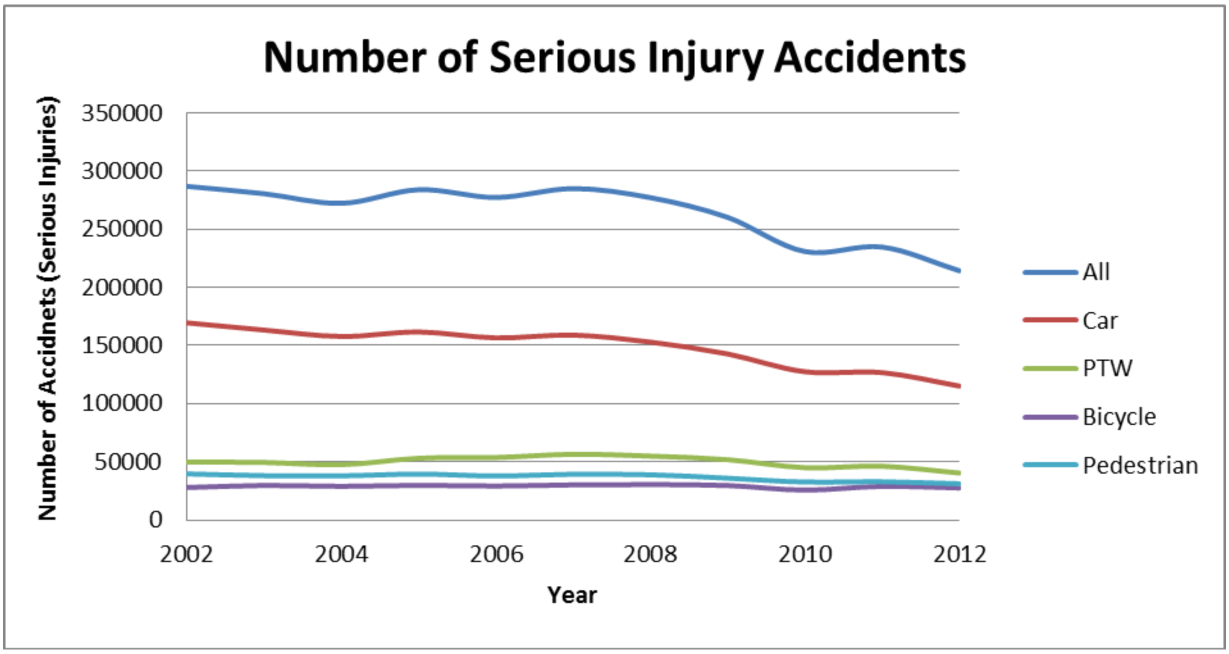

Figure 3 – Trends in numbers of accidents (Serious Injury), 2002 to 2012

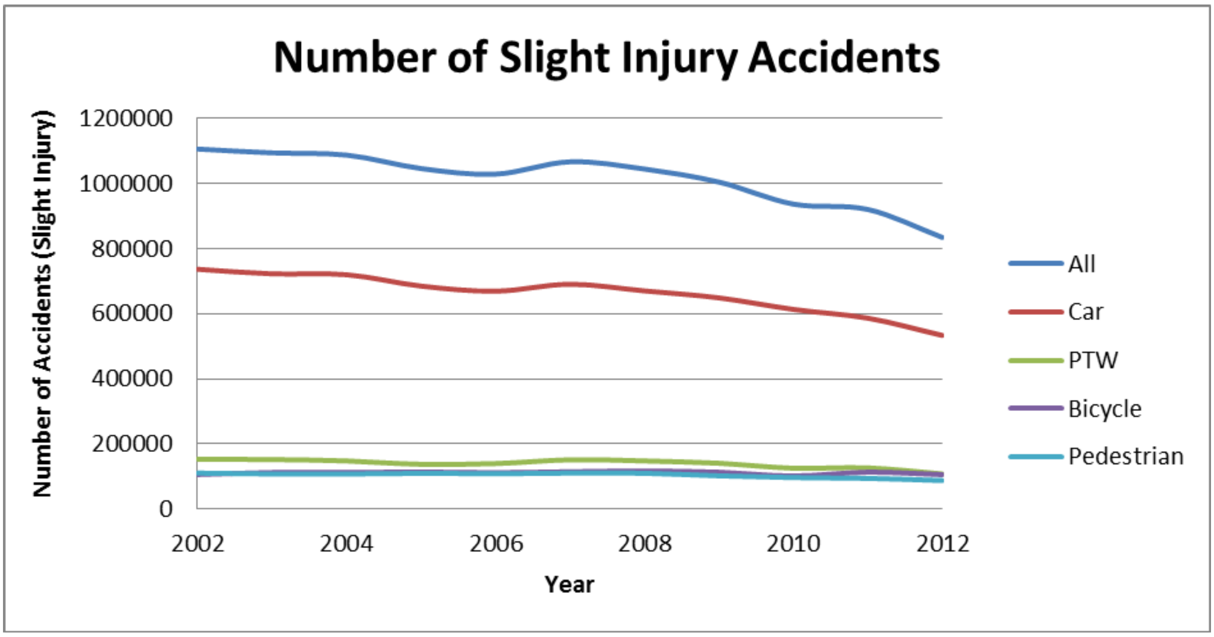

Figure 4 – Trends in numbers of accidents (Slight Injury), 2002 to 2012

In the following figures, the data have been analysed further to predict the likely numbers of casualties by transport mode for each accident severity in the event that the rate of decrease observed between 2002 and 2012 continues at the same rate. This has been conducted using regression analyses. In each figure, the prediction is plotted as a solid curve while the data points are plotted as crosses.

Figure 5 shows the likely trend in all road-user fatalities assuming that the current trends in road casualty numbers remain the same until 2030. As can be seen from the figure, car occupant fatalities will fall to just around 6,000 from the 2002 figure of 35,000 which represents a dramatic decrease. However, the predicted decrease for the VRU groups is not so dramatic.

Interesting trends are shown in figure 6 which shows the predicted number of accidents for each VRU group. As can be seen, PTW accidents are predicted to decrease dramatically whilst the numbers of bicycle accidents are actually expected to increase.

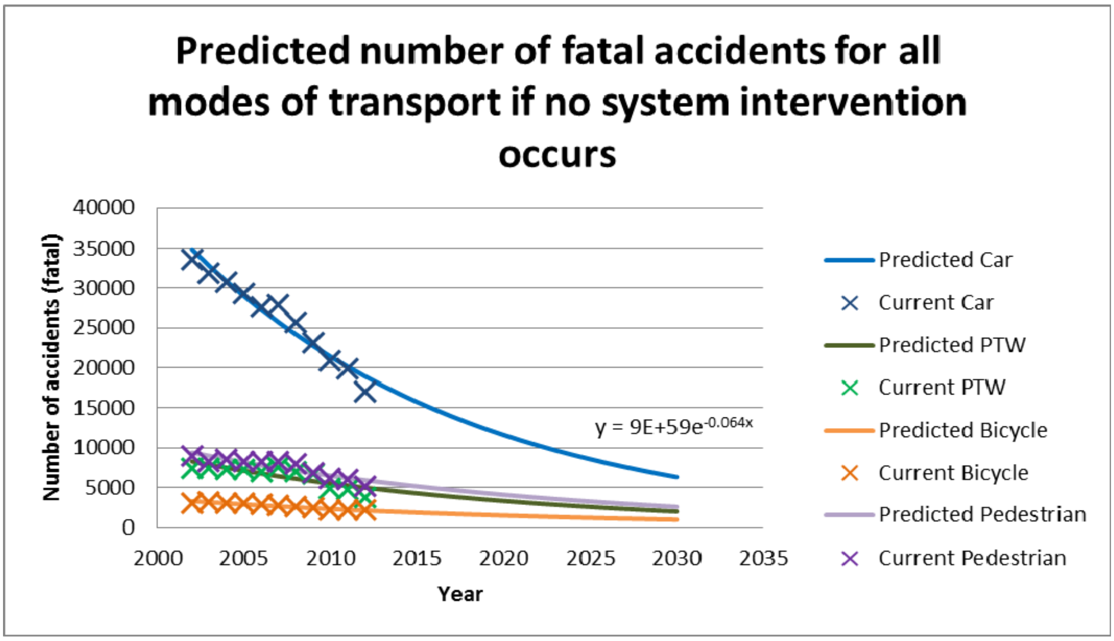

Figure 5 – Predicted numbers of Fatalities by 2030 by Road-user Group

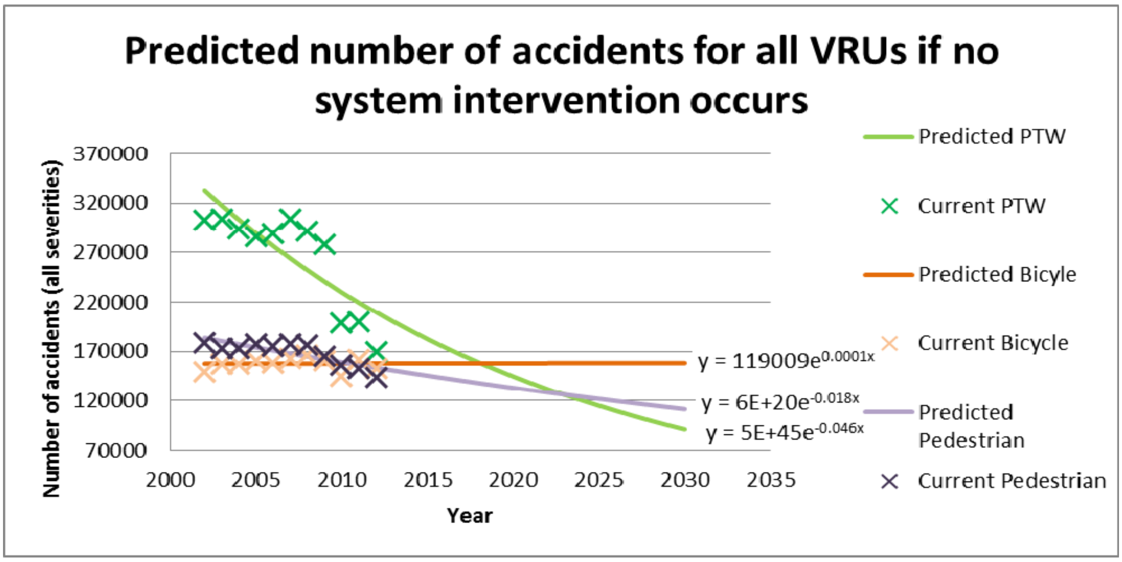

Figure 6 – Predicted Numbers of Accidents by 2030 for the VRU Group

Figure 7 below shows the predicted numbers of VRU fatalities by 2030 assuming that the current trends remain constant and that there is no system intervention during this period. The trends for pedestrian and PTW user groups are predicted to be similar whilst the trend for the bicycle users shows a decrease which is not to the same extent as the other road-users. Even despite this decrease, the model predicts that over 5,000 VRUs will be fatally injured during 2030 assuming that no effective countermeasure is introduced.

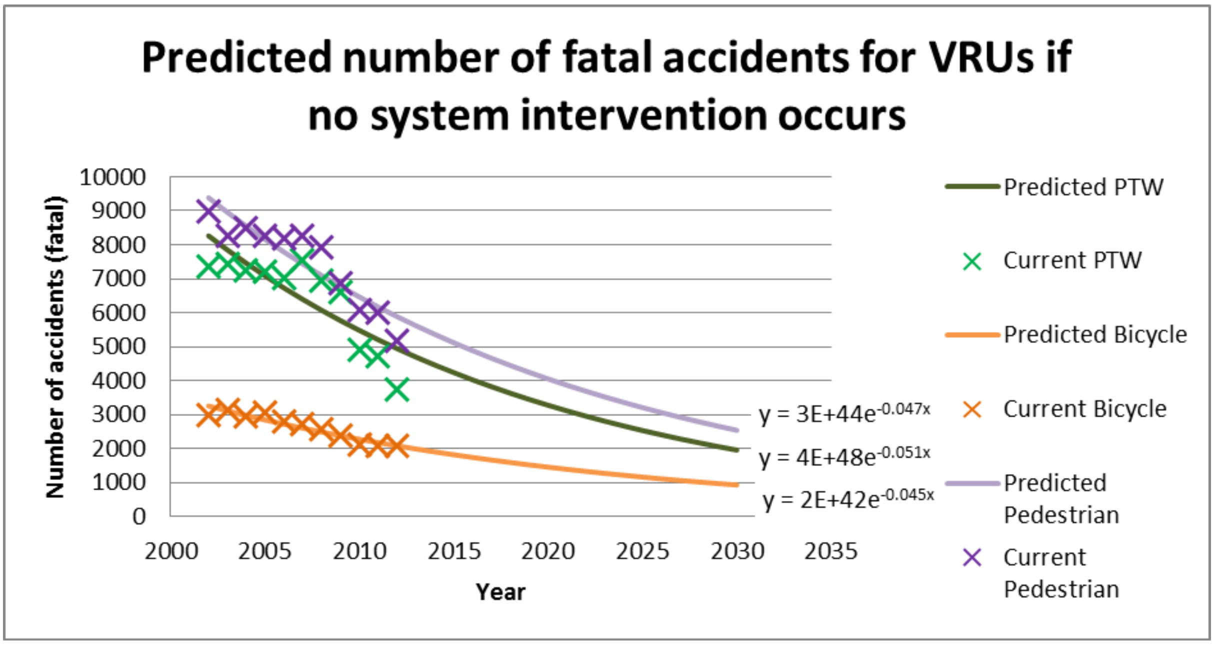

Figure 7 – Predicted Numbers of Fatal Accidents by 2030 for the VRU Group

Figure 8 shows the predicted numbers of 'Serious' road accidents by road-user group by 2030. As can been seen from the figure, the decrease in seriously injured car occupants is substantial whilst the decrease in VRU accidents is much less pronounced. The data for the VRU group have been analysed separately (figure 9) and it can be seen that numbers of 'Serious' Bicycle accident casualties are expected to surpass pedestrian accidents by 2030.

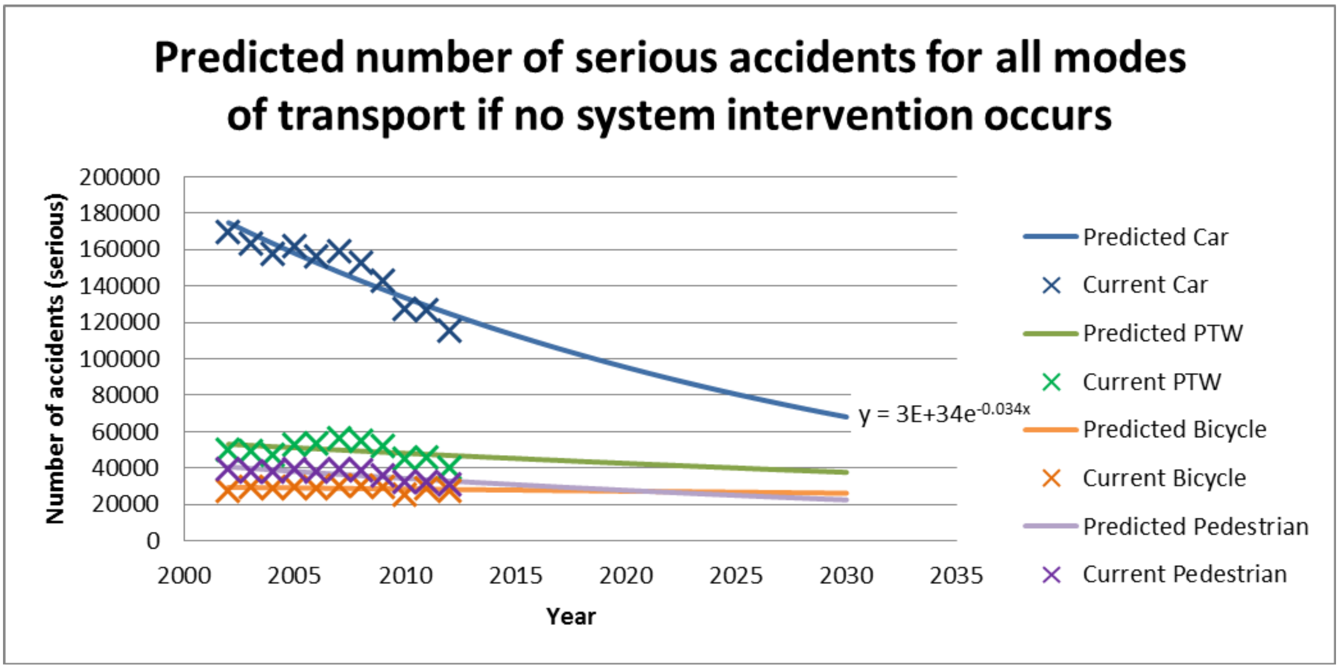

Figure 8 – Predicted Numbers of Serious Road Accidents by 2030

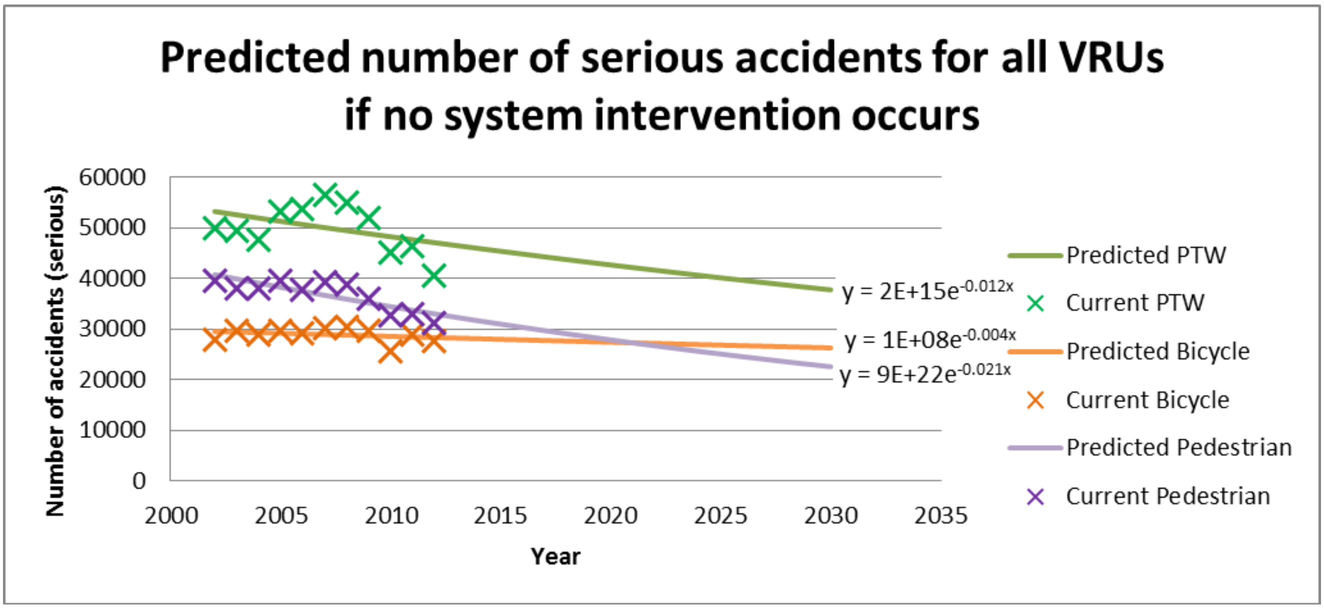

Figure 9 – Predicted Numbers of 'Serious' Road Accidents by 2030 for the VRU Group

Finally the trends for 'Slight' accidents are shown in figures 10 and 11. Again, the trends in predicted car occupant 'Slight' casualties suggest a rapid downward decrease in numbers with VRU casualties expected to decrease much less dramatically. When VRU casualties are analysed separately (figure 11), it can be seen that bicyclists are expected to be the most frequently injured VRU at the 'Slight' injury level by the year 2017.

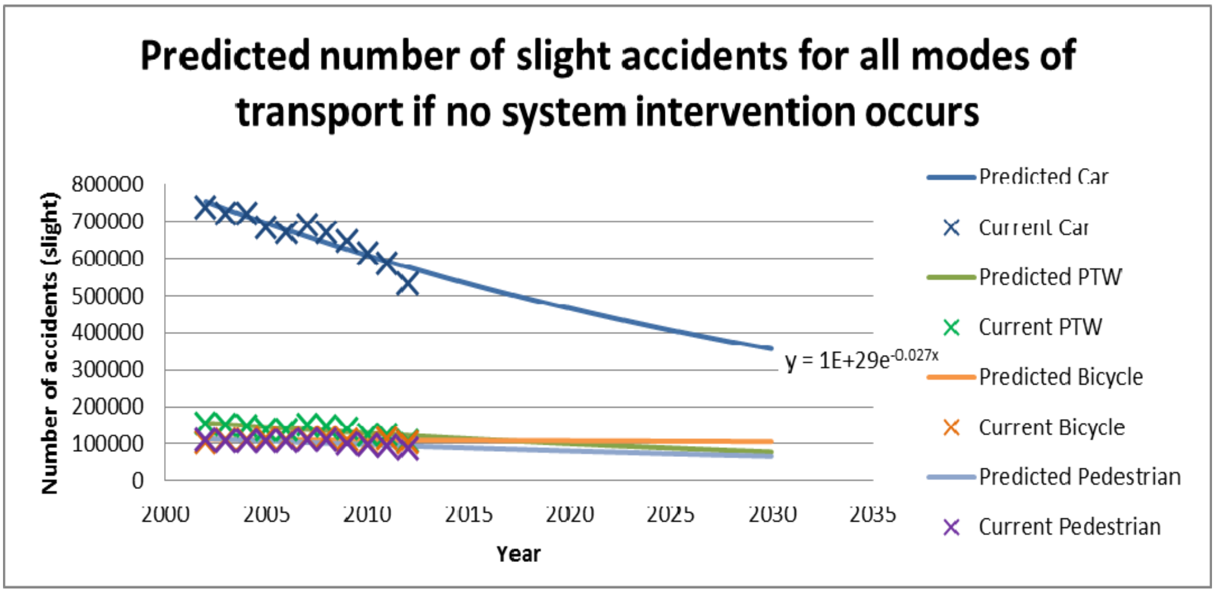

Figure 10 – Predicted Numbers of 'Slight' Road Accidents by 2030

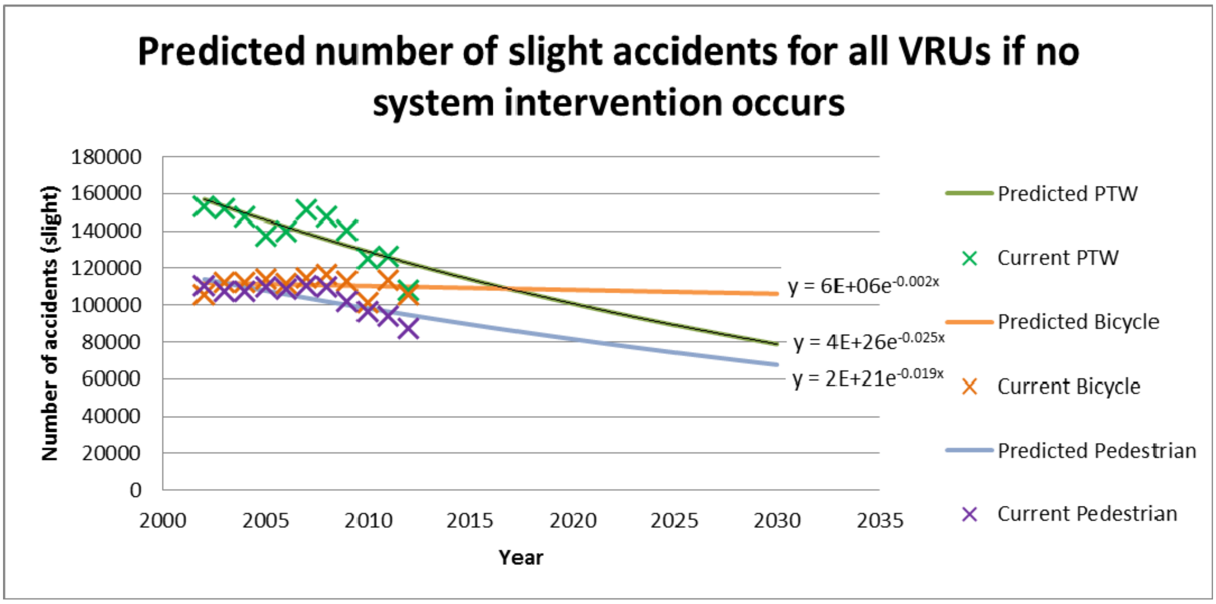

Figure 11 – Predicted Numbers of 'Serious' Road Accidents by 2030 for the VRU Group

Discussion

Current Accident Trends

Figures 1, 2, 3 and 4 contain details of historical data from 2002 to 2012. The trend in accident numbers of all severities is shown in figure 1. As can be seen, there is a significant decline in the numbers of accidents overall with car occupant casualties showing a modest decrease. However the decline in accident numbers for the VRU's is much less pronounced with bicycle and pedestrian casualties remaining relatively constant.

The trends in fatalities from 2002 to 2012 are shown in figure 2. This shows passenger car fatalities have declined steeply over the period whereas the decline for the VRU groups is again much less pronounced, and bicycle fatalities showing a negligible decline. The trend in fatalities is similar to that for Serious Injuries (figure 3) although the rate of decline is perhaps not as pronounced for passenger car users whilst the numbers of VRUs who are Seriously Injured does not change between 2002 and 2012. The trend for 'Slightly Injured' casualties (figure 4) is similar to those observed for Fatal and Seriously Injured road-users, although bicycle and pedestrian casualties appear to have increased slightly during the period. The number of accidents for all VRU types is seen to be fairly similar with PTWs having the highest incidence for all but fatalities, where pedestrians rank the highest.

The observed dramatic drop in the number of passenger car fatalities is likely a result of the vast increases in both active and passive safety technology which has been developed and implemented in recent years. This is demonstrated by the number of car accidents falling but the number of fatal accidents dropping quite considerably more so. On the whole VRU accidents were also seen to decline, though clearly not to the same extent as those observed for cars. Generally speaking, the number of VRU accidents is a function of the number of potential conflicts (the VRU encountering a vehicle or other potentially dangerous situation), the probability that a potential conflict leads to accident, and the severity of its consequences. Thus, this VRU accident reduction can possibly be explained by a combination of factors such as: improved cycle facilities and road infrastructure; decrease in speed limits; increased safety campaigns and the resulting increase in driver awareness towards VRU presence and increased cyclist helmet use and conspicuity efforts. Furthermore, improvements in vehicle technology, such as brake performance and sensors may also have had an effect. Improvements in medical care may have contributed to a reduction in accident severity. Kopits and Cropper (2005) correlate a decline in pedestrian fatality rates to an increase in per capita income (which may in turn be correlated to variables like car ownership, travel and mode preferences, and medical facilities), a decline in the proportion of young drivers, a decline in alcohol abuse and an increase in the number of vehicles, but there are still unexplained factors. They observe that increased urbanization and an increase in the proportion of elderly actually correlate to an increase in pedestrian fatality rate. No single factor can be pinpointed as the cause in this accident rate improvement but all the factors combine to have an impact on VRU safety. However, the fact that pedestrian and PTW fatal accident rates did not reduce to anywhere near the same level as cars did, and that bicycle accidents barely reduced at all is a good demonstration of the need for far more research and investment into VRU accidents. If research into infrastructure and ITS solutions for this group is made a priority then it may be possible to help ensure VRU accident trends in the next ten years mirror those already demonstrated for passenger cars more closely.

Accident Trend Forecasts

Exponential regression was used to predict the future accident and fatality numbers for different road users in the year 2030 if the same trends as for 2002-2012 continue.

Interesting trends are depicted in figure 9 which shows the predicted number of accidents for each VRU group. As can be seen PTW accidents are predicted to decrease dramatically whilst alarmingly the numbers of bicycle accidents are actually expected to increase slightly.

Figure 10 shows the likely trend in all road-user fatalities, as can be seen from the figure, car occupant fatalities will fall to just around 6,000 from the 2002 figure of 35,000 which represents a dramatic decrease. However, the predicted fatality decrease for the VRU groups is not so dramatic. The VRU numbers are shown in greater detail in figure 11 where the trends for pedestrian and PTW user groups are predicted to be similar to one another, whilst the trend for the bicycle users shows a decrease to a lesser extent as the other road-users. Even despite these decreases, the model predicts that over 5,000 VRUs will be fatally injured during 2030 assuming that no effective countermeasure is introduced, this figure is almost comparable to those of predicted fatal car accidents (6000) in the same year.

Conclusions

Overall this paper has determined the current accident numbers for VRUs between the years 2002 and 2012 in Europe using a European wide road accident database (CARE). It showed that currently the number of car accidents and fatalities are far higher than those of VRUs but are also in a more rapid rate of decline than those of any VRU group. Accident forecasting was also used to predict future accident and fatality numbers if the current trends continue and this showed the number of VRU fatalities in 2030 to be almost comparable to those of car accidents due to car fatality rates reducing at a far increased proportion compared to VRUs. This demonstrates the need for further investigation into reducing VRU accidents and fatalities. The critical accident scenarios identified within the VRUITS study reported in an earlier paper from the VRUITS study (Scholliers et al, 2014) give a good starting point for highlighting the scenarios which ITS solutions could be implemented to have the greatest impact. It is clear that future ITS applications are central to making transportation of VRUs both safer and more comfortable.

Acknowledgements

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