CARS ARE DRIVEN ON ROADS, JOINT VISIONS AND MODERN TECHNOLOGIES STRESS THE NEED FOR CO-OPERATION.

Anders Eugensson, Volvo Car Corporation
Jan Ivarsson, Volvo Car Corporation
Anders Lie, Swedish Transport Administration
Claes Tingvall, Swedish Transport Administration
Sweden
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ABSTRACT

Today traffic safety is a major health issue. The numbers of killed and injured in traffic accidents globally every year are staggering. The World Health Organization WHO has estimated the number of fatalities to approximately 1.2 million and the numbers will increase by 65% over the next 20 years. (Peden et al.).

Realizing that this is unacceptable, a number of countries and organizations, among them Sweden and Volvo Car Corporation, have adopted visions aiming towards the goal of no serious injuries and fatalities in traffic (Johansson R, 2009).

The European Commission, in its communication on road safety 2011-2020 to the European Parliament, (SEC (2010) 903) did clearly state the goal of a drastic reduction of the number of fatalities and serious injuries in traffic in line with the visions of reaching zero.

Traffic safety has taken major steps during the last four decades and the risk of being killed or seriously injured as an occupant in a passenger car has been cut down to one third from the early 1970s, (Beckmann, 2009). This has been done basically through separate efforts by each stakeholder in the safety community operating independently (focusing users, roads and vehicles).

Improving road traffic safety towards the target of zero deaths and serious injuries will pose many challenges and obstacles to governments, road authorities and car manufacturers globally. Modern active and integrated safety systems carry a hope of substantially contribute to better safety. However no individual part in society can achieve the demanding goals on its own. Systematic co-operation will be essential to progress. These co-operations need initially to establish shared views on strategies forward, agreements on division of responsibilities, and a shared view on the interfaces between the cars and the infrastructure. A joint view on the demands put on the drivers is also essential. Stringent targets can only be met in an efficient way by a holistic view on road design, vehicle design and user capabilities.

In 2008 the Swedish Transport Administration and Volvo Car Corporation signed an agreement on co-operation. This co-operation rests on the two separate visions of the parties involved, i.e. Vision Zero, for the Swedish government and Vision 2020 for Volvo Cars. An important part of the co-operations is the establishment of quality and demands on the interfaces between the vehicle and the road for instance , road design, road lane markings, road friction measuring, division of responsibility, speed limits etc.

WHAT ARE THE CHALLENGES FACING US?

Mobility is a cornerstone for modern society. In the industrialized parts of the world transportation play a key role in mobility. In developing countries an expansion of the road transport system is foreseen. More cars have in the early days of motorization been linked to higher risks. In the industrialized world that pattern was broken around 1970. Since then a safer road traffic has been achieved even though the amount of traffic has increased.

The challenge is to live up to the modern demand that mobility should be safe and not pose risks to life and health. This has also to apply when using a global perspective. In the future the road transport system must cope with more mobility, more mixed traffic situations, higher demands on safety and demands on lower environmental impact.

It is often stated that the vehicle design changes that would be necessary in order to reduce the environmental footprint of motor vehicles are in conflict with improved road safety. Given the advances in new modern technologies the challenges linked to reduced vehicle size and weight are likely to be overcome. The required performance needed in order to meet the visions of zero fatalities and serious injuries is thus possible to be achieved within the next 10-20 years.

The road transport system is open and complex. No single body has control over it. It is also characterized by its size. Any activity aiming at change of the system must be cost effective and robust.

THE NEED FOR CO-OPERATION BETWEEN THE STAKEHOLDERS RESPONSIBLE FOR TRAFFIC SAFETY.

Ever since the introduction of motor driven vehicles in the early 1900s, manufacturers, responsible for designing and producing the cars and authorities, responsible for designing the infrastructure, have been, to a large degree, working independently. The generic approach has been to redesign cars and roads when needed in response to encountered problems and conflicts.

The road users play an important role to contribute to a safer road transport system. However the demands put on the users in the past have been excessive. Training and information campaigns have been used to make the driver to become 'safe'. The responsibility put on the driver have been formulated as if the drivers never made errors or mistakes. The Swedish Vision Zero approach is stating that road users make mistakes and misjudgements. The human nature cannot be considered to be completely reliable. Humans are sometimes irrational and have spells of distraction and lowered driving task focus. The driving capability of humans also varies considerably in time given different circumstances. A safe system must therefore adapt to the capabilities of the users.

Motor vehicle driver education, traffic education in schools and campaigns are and will continue to be important. Although improved safety training and traffic education can help to reduce the road casualties the potential is limited and the big push towards zero must come from safe vehicles and safer infrastructure.

Society wants the road transport system to be open to the majority of the citizens. It is clear that no significant change in the access to the traffic system, compared to the present situation, will be generally acceptable.

As an effect of modern cars with better road handling and improved crash performance, in combination with gradually improved infrastructure, the numbers of injuries and fatalities have decreased over the last decade.

The societal needs point at one direction, only zero fatalities and zero severely injured in road traffic may be accepted. This is basically already the status of the railway traffic and aviation where any deviation from the present status cannot and will not be accepted by the society. The approach from railroad and aviation safety must therefore also be the aim for all efforts for road traffic. With a beginning in Sweden back in 1997, many countries have today formally adopted a vision aiming at zero fatalities and injuries.

Stakeholders involved realize that new strategies and new technologies need to be developed to achieve stringent targets. Consequently, both new ambitious strategies and advanced technologies are being developed that have the potential of assisting significantly towards the zero target.

The Swedish Vision Zero has lead to changes in the philosophy of road design. The approach is not aiming at zero crashes, it is instead aiming at lowering the number of severe injuries and fatalities. The same approach has led many countries to adopt strategies for replacing in-plane crossings with roundabouts thus reducing the risk for severe injuries in side and rear impacts. Speed limits matching travel speed with crash capabilities of modern cars and speed management has also been used extensively to reduce fatality risks in traffic. This change is in need of good estimates of the future development of cars.

The emergence and market introduction of so called active safety systems for motor vehicles have clearly shown a substantial potential to reduce the number of injuries and fatalities. These systems are, however, in some cases depending on the road infrastructure to perform their tasks well and in a quality assured manner. Features such as lane markings, traffic signs, information displays, etc. have to be designed and constructed in a logical, obvious, detectable and consistent manner. This is essential for technical systems to be able to read and understand the features and information. The road to vehicle interface must also have a predictable and acceptable life-span or follow a maintenance level adapted to the needs and design pre-requisites of the vehicle systems.

If advanced systems are not matched with reliable and available infrastructure features the confidence of users will quickly be eroded and this trust will be difficult re-establish.

In the light of the rapid development and increased market penetration of the advanced systems using the infrastructure features, the pace of efforts to adapt and align both the systems and infrastructure features to each other need to be increased and intensified.

When looking at traffic in a holistic perspective, it is clear that a common view of the division of responsibilities in reaching zero would benefit all involved stakeholders and the society. Such a division could be to assign responsibility to the vehicle for protecting the occupants in a frontal collision up to certain impact speed and then having

the infrastructure responsible for preventing higher impact speeds. Another case can be for side impacts, the vehicle responsible for protecting the occupants up a certain impact speed and the infrastructure preventing side impacts at higher speeds.

A clear and agreed division of responsibilities has the potential of introducing safety measures in the most efficient way and reduce levels of redundancy when applying a holistic approach. For example, a more narrow focus on crash energy when designing a motor vehicle could result in reduced vehicle weight, a more optimized safety system design and more compact vehicles. This in turn could lead to lower CO2 and regulated emissions, lowered vehicle purchase, operational and maintenance costs, lowered societal costs, improved comfort and reduced risk of congestions.

The way ahead for reaching zero fatalities and injuries will be to accept the error and mistake levels of road users and concentrate on the improved performance of other parts of the system. This does not exclude the drivers from responsibility to follow rules and regulations. Operational errors, misjudgements and mistakes, however, should be managed by the system in a way to eliminate harm to life and health.

THE DRIVING PROCESS

Using a common model is one way for stakeholders to better understand and focus the work with safety. A model often used is the model showing phases leading up to a potential crash.

When looking all the sequences leading up to an impact, these can be divided into the preventative, dynamic, avoidance and mitigation phases. After impact there is the post-crash phase where the aspect of quickly locating and in an efficient manner treat accident victims to a avoid fatalities, life-threatening conditions and long-lasting disabilities. See figure 1.

The preventative phase is characterized as a non-conflict phase, whereas the dynamic, avoidance and mitigation phases are conflict phases. The preventative phase is what is considered to be the phase where normal driving occurs, i.e. the vast majority of the time on the road.

The mission of the motor vehicle and the infrastructure must always be to assist the driver to stay within the zone of normal driving, that is in the non-conflict part of driving sequences. Vehicle design, road design and speeds should be optimised to ensure comfortable and safe drive under normal driving conditions. If the car and driver has strayed away from this safe zone and towards a conflict phase the task of the vehicle and the infrastructure is to 'push' the car and its occupants back into the 'normal driving' phase.. This can be done in different ways, e.g. stabilizing the cars, steering away from a threatening object, braking the car thus avoiding an impact, etc.

If the car has passed into a conflict phase and there is no possibility to return it back to the 'normal driving phase' the joint efforts of the vehicle and infrastructure must be to lessen the consequences of an impact by mitigation efforts, for instance, reducing the impact severity, removing hard and stiff objects in the zone of impact, designing forgiving road sides that guides the car to reduce the crash energy in a controlled manner.

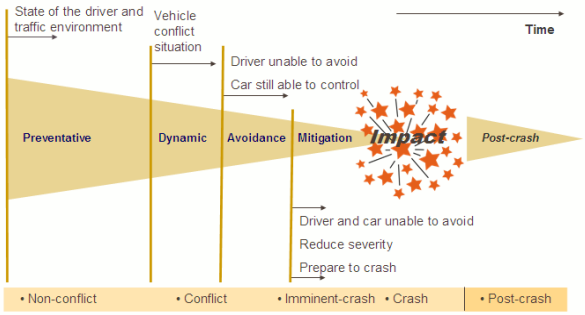

Figure 1. Phases leading up to an impact.

THE AGREEMENT ON CO-OPERATION

The Swedish government and Volvo Car Corporation both have visions with the ultimate goal to eliminate fatalities and severe injuries in the road transport system. As the authority with responsibility for road safety the Swedish Transport Administration (STA) has a good dialogue with many industry partners. Volvo Cars and the STA have signed an agreement to better understand how a modern cars and modern roads best co-operate.

The agreement between the Swedish Transport Administration and Volvo Car Corporation was signed in September 2008 by the STA Administrator Mr. Ingemar Skogö and the Volvo Car Corporation CEO, Mr. Fredrik Arp, at a ceremony linked to the annual road traffic safety conference in Tylösand, Sweden.

Because of the identified need for this co-operation both from the perspective of STA and from Volvo Cars and the expectations from the safety community and the Swedish government the will and determination of the involved parties to produce results were clearly demonstrated already in the beginning of the co-operation.

Principles of the agreement

In the framework of the agreement, a number of areas were identified and in need of being investigated.

One of the main tasks is to establish boundary conditions and interfaces for modern vehicles and modern infrastructure. Other tasks to share are vehicles and legislation and vehicles and other road safety stakeholders. The collected knowledge will enable a common view on the potential division of responsibilities between the traffic safety stakeholders. An agreed division of responsibility will open up the possibilities for more harmonised and optimized vehicle and infrastructures designs. Included in the discussions on establishing boundaries between vehicles and infrastructure are also the aspects of setting the basic requirements and identifying the expectations on the driver's area of responsibility, expected driver performance, and driver limitations. The research findings on the expected levels and span of driver performance will be an important aspect in identifying the levels of responsibilities of the other traffic safety stakeholders.

In designing the infrastructure there are a number of features that play an important role in the interaction with vehicles. Among those are; protective railings, lane markings, street signs and the generic design of streets and adjacent areas.

Field data is to be continuously monitored and shared between the participants.

It is clearly stated that the aim of the co-operation is to strive towards that all driving is done within the safety boundaries of the system. The definition of violations in contrast to misjudgements, mistakes and minor errors is important in the work towards defining the responsibilities of the stakeholders.

STRUCTURE OF THE GOVERNING BODY AND WORKING GROUPS

The co-operation between the Swedish Transport Administration and Volvo Cars has been shaped in a very open and constructive manner. The governing body for the co-operation is a steering group that consists of key traffic safety experts and responsible from both parties involved, in all around ten people. These represent the different areas involved in shaping the strategies for enhancing road traffic safety and also have the authority to make the necessary decision needed in order to move forward towards the common visions of zero injuries and fatalities.

The steering group is setting up and controlling working groups.

The working group on boundary conditions

As discussed earlier, setting the boundary conditions for the division between the responsibility of the infrastructure and the vehicle for different crash types and injury creating mechanisms can potentially mean enhanced and optimized overall traffic safety and fewer redundancies in the design of both vehicles and infrastructures.
In the start-up the working group set out its task by carefully analyzing available data for potential conflict situations. In order to get a more complete and holistic picture of the conflict situations representatives from both heavy vehicle manufacturers and the urban infrastructure were invited to complement the members from Volvo Cars and the road authority. The heavy vehicle side was represented by the staff working with traffic safety and accident analysis at Volvo Truck Corporation and the urban infrastructure side was represented by the local road traffic section at the City of Gothenburg.

The resulting product, once this working group is ready to deliver its analysis and recommendations is expected to be in the form illustrated in figure3.

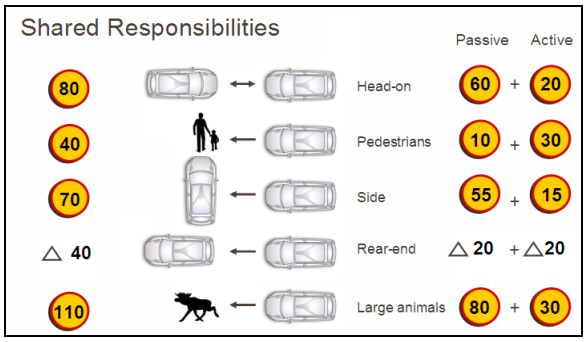

Figure 2. Examples on how the responsibilities can be divided between infrastructure and vehicles.

Figure 3. Road with a wire rope median guard rail to avoid head-on collisions.

The basic concept of this approach is that the speeds illustrated in figure 2 representing a safe speed limit. This illustrates a division of responsibilities between the vehicles and the infrastructure. For the case of head-on collisions this means that below the speed that will be eventually agreed upon, in this example set to 80 km/h, the car will be responsible and the infrastructure design will be responsible for safety above this speed. Any road where it is normally possible to drive above 80 km/h will need to be equipped with measures to avoid frontal-collisions. In the case in the figure 3 this is done by using a wire rope median divider making head-on collisions virtually impossible.

For the vehicle the safety of the occupants can be delivered in different ways. One way is to reduce the speed by before impact. By reducing speed the crash protection will be sufficient. The car can also steer away from the potential conflict.

For conflicts between pedestrians and vehicles the proposed boundary conditions in the working group is set at a speed of 40 km/h, i.e. above this speed the pedestrians need to be separated from the traffic. Up to 40 km/h the car can manage the impact with the pedestrian either by passive protection using soft and energy absorbing structure or devices creating no serious injuries to the pedestrians at this speed or by first reducing the impact severity and then creating no harm at the remaining speed. In the example in Figure 2 the speed change for reducing energy by braking before hitting the pedestrian is set at 10 km/h and the remaining speed thus becoming 30 km/h.

The work in this working group is continuing with the goal of reaching an agreed set of boundary conditions that is to be used as a base standard for future road and street designs in Sweden and for the design of the future Volvo vehicles.

Working group for interfaces cars/ infrastructure

Traditionally, lane markings, rumble strips, road signs (such as speed limit signs, directional signs, restriction signs and information signs) all have been designed in ways suitable for driver recognition and what is practicable when applying them to the infrastructure. Very limited considerations have been given to the interfaces with the vehicle system since they have not appeared until the five to ten years. There are already vehicle systems that are depending on certain features in the infrastructure to perform their task. In the future there be even more vehicle systems needing support from road features. Examples of such systems are Lane Departure Warnings systems (LDW), driver drowsiness systems, lane keeping aid systems and speed limit sign recognition systems. The usability of these systems is depending on a number of factors linked to the design of the infrastructure features. For instance, for systems depending on lane markings for their performance the contrast to the road surface, the spacing between the dashed lines, the link up between lanes and exits are essential and could decide if a lane departure system will be an efficient driver support aid or will be practically unavailable for the majority of the road usage.

The outcome of the discussions in this working group so far has been a set of recommendations on the contrast, shape and spacing of the road lane markings. Once implemented, this will potentially have an effect on the availability and performance of a number of systems that are depending on the lane markings.

Discussions are also ongoing on the shape and placement of road signs. One strategic decision taken in Sweden is that speed limits will always be posted by a circular shaped speed limit sign. Some countries have adopted principles for advertising speed limits in towns and cities by posting special signs for urban areas when entering a town, which

does imply a speed limit of 50 km/h. This strategy will be problematic for road sign recognition systems looking specifically for signs with a rounded shape which is the shape commonly used for indicating restrictions in many parts of the world. A recommendation from the group is that any change in the set speed limit should always be indicated by a speed limit sign.

Working group on violations

A basic philosophy both in the Vision Zero as adopted by the Swedish Transport Administration and the Volvo Vision 2020, is that the road traffic system should be tolerant to errors caused by what can be referred to as normal human behaviour. This means that those who are playing by the rules and doing their best to use the system should be offered a safe journey.

Obviously, there are, however, some road users that are deliberately breaking the rules and regulations of the system. It is essential that a clear definition is made to distinguish between these violations of the system and the 'normal' or 'ordinary' errors, mistakes and misjudgements.

Involved in the task of setting the targets for zero deaths and serious injuries is the discussion on if zero is truly in all respects zero regardless of if the road users have stepped over a clear boundary into the area of severe violation. Although it has not been ultimately decided, setting the target also to zero for the case of serious violations does appear to be neither logical nor realistic. A violation is characterized in that it is:

- Deliberate and is following a strategic decision
- Breaking the legal rules of the system

Errors, mistakes and misjudgements are:

- Random and not planned
- Independent of the legal rules

One issue that will pose an interesting and onerous task in deciding on the violation issue is how to categorize non-belt usage. Obviously, seat belt usage laws for front seat passengers exist in most countries and it is considered to be the 'normal' driver behaviour to buckle up. All governments and safety organizations around the world strongly recommend using the seat belts. Still we know that, in many countries, the belt usage rate for drivers is 80 percent or even lower. We also know that the properties for protecting the occupants improve significantly for belted occupants. It cannot be considered optimal for any society to adopt rules requiring protection for un-belted occupants to the same level as for belted occupants. However, is non-belt usage to be considered as a violation to the same degree as excessive speeding? Logically, a somewhat lower safety level need to be considered but non-belt usage must still be part of the analysis and performance setting when designing for protecting the occupants.
However, disconnecting a seat belt reminder system should be considered a violation.

NEXT STEPS IN THE CO-OPERATION.

The work in the three working groups will continue towards a common view of the issues discussed and the responsibilities, The working group discussing interfaces, i.e. lane markings, street signs, etc., is closest in its tasks of finalizing a recommendation. The working group dealing with violations is gaining momentum and will be monitored closely by the parties in the agreement. The discussions in this group are challenging and can have implications on a number of areas, e.g. restraint designs, road speed designs, etc.

The co-operation, as it exists today, mainly includes the national government agency, Swedish Transport Administration and one representative from the passenger vehicle manufacturer side. In one group Volvo Trucks and the City of Gothenburg, are represented. Desired would be to expand the entire co-operation to include more parties when relevant.

An expansion to other parties outside of Sweden would also be desired. An international perspective will give an added merit to any recommendations from the working groups. Better co-operation between vehicle manufacturers and road authorities is recommended by the European Council in their communication on road safety.

DISCUSSION

In this paper the societal demands of lowered emissions, improved fuel economy, reduced congestion, improved comfort *and* zero severe injuries and fatalities have been stated as inevitable and necessary. The obvious question is: will the transportation sector be able to meet the demands of the society and will this be met in an acceptable time frame.

When analyzing the traffic safety it becomes clear that the low-hanging fruits of actions already have in many countries been managed and what now remains to reach the goals are much more onerous tasks requiring advanced engineering, new approaches and new ways of thinking.

Efforts are needed aiming at cutting away unnecessary redundancies and adapting all elements into one common model where the borderlines for the responsibilities of all stakeholders are easily identified and decided in the, for the society, most optimal way. This is the basic view point of and the reasoning behind the co-operation between Swedish Transport Administration and Volvo Car Corporation.

The approach of dividing the responsibilities is shaped around the belief that once divided, the stakeholders will base and adapt the development according to the agreements. There is an apparent risk, however, that the adaptation to the area of responsibilities for the car and the infrastructure will not go hand in hand and thus, there exists a risk that there will be a misalignment in the design approach over time between the two stakeholders.

Even if the standards for design of roads to avoid frontal crashes are adopted and in effect, the risk is that the actual building of the measures necessary will be delayed and take time. It can then be argued that the reduction of road casualties would be more rapid if there would be an overlap in the responsibilities between infrastructure and the vehicles. Vehicle design, road design and timing should be aligned.

There are also voices raised claiming that road users will adapt to a more protective road environment and will be less careful and observant and depend too much on the technologies. Substantial research and many strategic decisions are therefore needed in order to give proper consideration to these aspects and the steep learning curves in the paths towards zero need to be climbed in small steps, each step carefully evaluated and adjustments should be made according to lessons learned.

CONCLUSIONS AND RECOMMENDATIONS

The challenges of finding a widely accepted strategy for road traffic with zero serious injuries and fatalities at the same time as meeting the demands on increased mobility, improved comfort, reduced emissions and improved fuel economy will necessitate more close co-operations between the different road safety stakeholders.

One of the goals for this kind of co-operation will be to will be to define interfaces and division of responsibilities between vehicles and the infrastructure.

In order to facilitate this in Sweden the Swedish Transport Administration and Volvo Car Corporation in 2008 signed an agreement on such a co-operation. The work is governed by a steering group which has three working groups dealing with the different aspects as defined in the agreement. Although progress has been made more efforts are needed in order to reach the desired results.

Expansion of the work to both heavy vehicles and also more international co-operation would contribute towards a more wide spread and holistic perspective.

REFERENCES

Johansson R. Vision Zero – Implementing a policy for traffic safety. Safety Science, Vol. 47, No. 6. (July 2009), pp. 826-831.

Peden M, Scurfield R, Sleet D, Mohan D, Hyder A, Jarawan E, Mathers C (2004) World report on road traffic injury prevention, World Health Organization, Geneva.

Volvo Car Corporation. 2008/09 Corporate report with sustainability. Volvo Car Corporation PA/PV 501252801-09 EN. Göteborg 2009

Beckmann J. Ranking Nr 1. Null Verkehrstote: ist das möglich?

European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions, Towards a European Road Safety Area; policy orientations on road safety 2011-2020. (SEC (2010) 903).