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Vision Zero – Implementing a policy for traffic safety

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ABSTRACT

The scope of this paper is to outline, in a general way, the safety philosophy inherent in present road- and street design, trace the origin of this philosophy, and to present the principles for a new design of streets and roads. It will be argued that deficiencies in the present road design philosophy are the main cause of the global road safety crisis, clearly indicating its man-made nature. A brief description is made of the decision process leading to the establishment of Vision Zero as Sweden's Traffic Safety Policy in 1997.

Following an analysis of the problem, suggestions are made for finding solutions. The solutions are based on some of the principles in Vision Zero. They include a new basic mechanism for creating error-tolerance in the road system, and new design principles for road- and street design.

The tradition of "blaming the victim" is hereby questioned and focus is put on the need for professionals to act based on these new standards. During the last 10 years the fatalities in Sweden have dropped from approximately 550/year to 450/year. Roads redesigned with median barriers have an 80% reduction in fatalities. Streets with 30 km/h design speed show similar results. This indicates that measures derived from Vision Zero strategy are effective but that large scale implementation has not yet been done.

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1. The process

The Swedish Road Administration (SRA) had an overall responsibility for Road Traffic Safety in Sweden since 1993. This responsibility was further clarified by the Government in 1996. Sweden has very small Ministries (number of personnel). As a consequence Administrations like the SRA often have semi-political tasks like development of policies and targets. Decisions on policy, long term targets and overall budgets are made by the Government or the Parliament but development is made in the Administration.

Following the elections in the autumn 1994 Sweden got a new Minister for Transportation. The Minister declared that traffic safety would be one of her priorities. A dialog was started between the Minister's Staff and the SRA on how the Minister could make traffic safety a prioritized subject.

In the spring of 1994 the SRA together with the major stakeholders for traffic safety had presented a short term program for action for the years of 1994–2000. It had the character of continuing earlier work but with more emphasis on cooperation between key actors and focus on results. Directly after this program was launched the SRA started to develop some basic ideas for a long term strategy for traffic safety. It had been recognised for some time that the contemporary traffic safety paradigm had some problems (Johansson, 1991). Part of this problem was a lack of expected benefits of many measures, something that was recognised by among others Gerald Wilde (best described in Wilde, 2001). A comprehensive overview can be found in OECD (1990).

The new safety paradigm, Vision Zero is built around the basic idea that even if not all crashes or collisions can be avoided, all severe injuries can, in principle, be avoided. The basic idea was to build a "safe system" where all predicted crashes and collisions had tolerable health losses.

The Minister and her Staff recognised that it was possible to work with the ideas behind Vision Zero in a political setting and quickly adopted the basic ideas, developed a text (translated in Belin et al., 1997), and took it to the Parliament in 1997, where it was accepted by all political parties (Tingvall, 1998). Since then, the Parliament has repeated this decision on a number of occasions. The notion of "Vision Zero" has become synonymous with the concept of "high political ambitions" in a number of other areas as well. The Government in 2008 took a decision on a Vision Zero for suicide.

Much of the political debate on Vision Zero between 1995 and the Parliament's decision in 1997 was concentrated on the question "How many fatalities can we accept?" At this time Sweden had around 500 fatalities in road traffic per year. Comparisons where made with the safety level for other transport modes, (clearly a zero fatality goal), occupational safety (about 50 fatalities annually), electricity (about five fatalities annually). From this political analysis it was concluded that a zero fatality target was the only justifiable target for road traffic.

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During the same time period SRA and its network concentrated work on developing strategies for radically lowering fatality risks in road traffic, typically aiming at reducing fatality risks with a factor 10. Examples follow later in this paper.

2. Vision Zero

In 1997 the Swedish Parliament passed a bill on Traffic Safety where it was stated that:

"Vision Zero means that eventually no one will be killed or seriously injured within the road transport system."

Vision Zero does not presume that all accidents that result in personal property damage or in less serious injuries must be eliminated. These occurrences are not considered to be an essential element in the road traffic safety problem even if they can entail large costs for the State, county councils, municipalities and individuals. Rather, focus shall be placed on those incidents that lead to a person being killed or seriously injured. Vision Zero also proposes an ethical approach to the health problems associated with road traffic:

"It can never be ethically acceptable that people are killed or seriously injured when moving within the road transport system."

Vision Zero is said to be a long-term goal for the design and functioning of the road transport system. What is important is to realise that the Vision Zero approach will alter the aim of the work on road traffic safety; i.e., from attempting to reduce the number of accidents to the formulation of an explicit goal: to *eliminate the risk of chronic health impairment caused by a traffic accident*. This new approach will also alter the question from "what can we do?" to "what must we do?"

Vision Zero presumes a new division of responsibility for road traffic safety within the road transport system. The responsibility for road traffic safety should be introduced along the following lines.

1. The designers of the system are always ultimately responsible for the design, operations and use of the road transport system and are thereby responsible for the level of safety within the entire system.
2. Road users are responsible for following the rules for using the road transport system set by the system designers.
3. If road users fail to obey these rules due to a lack of knowledge, acceptance or ability, or if injuries do occur, the system designers are required to take the necessary further steps to counteract people being killed and seriously injured.

Taking the Vision Zero approach means that paying attention to human life and health is an absolute requirement in the design and functioning of the road transport system. This implies that road traffic safety issues, in similarity to environmental issues, must be clearly integrated in all the processes that affect road traffic safety in the road transport system and be based on the following:

"The level of violence that the human body can tolerate without being killed or seriously injured shall be the basic parameter in the design of the road transport system."

It is upon this principle that the future society with safe road traffic can develop: through designing and constructing roads, vehicles and transport services so that the level of violence that can be tolerated by the human being is not exceeded; and through the effective contribution of different support systems such as rules and regulations, education, information, surveillance, rescue services, care and rehabilitation. With this as the basis, there will be a positive demand for new and effective solutions that can contribute to a road transport system where human needs, prerequisites and demands are in focus.

"It is true, that 95% of all crashes or collisions depend on human error, but according to Vision Zero philosophy, 95% of the solutions are in changing roads, streets or vehicles."Some simple examples follow:

(1) Drivers in Sweden used to have a 92% seat-belt wearing rate. Good but not good enough. EuroNCaP[1] established a protocol for seat-belt reminders a couple of years ago having the effect that 70% of new cars sold in Sweden 2005 had seat-belt reminders. The drivers of these cars have a seat-belt wearing rate of 99%. Hence, the problem of seat-belt wearing will gradually be solved at a very low cost.

(2) Alcohol: All over the world alcohol and traffic is a big problem, even if improvements can be made with strict legislation and enforcement. By demonstrating a demand for safe transport primarily by professional transporters a demand for "proven sober" transports has risen. In Sweden about 50% of all school buses have alcohol interlocks (a device that checks if the driver is sober). A new generation of Alco locks are coming on the market (at least four competitors in Europe/USA) reducing price and improving performance.

In this way a car that reminds you to use your seat-belt, and checks your breath for alcohol, or otherwise checks your performance, and assists you to be a better, safer driver. Different aspects of the Vision Zero philosophy can be found in (Tingvall et al., 1996, 1997; Tingvall, 1998, 2007; Belin et al., 1997).

3. Traditional road design philosophy

The traditional road-oriented safety philosophy has as its starting point the "accident". Accident statistics are normally based on police reports made up on traffic accidents known to the police. These statistics have been used by road authorities world-wide for describing and analysing the road safety problem associated with roads and road design. It is important to notice that the concepts of traffic accidents and (bad) road safety are not synonymous. Many accidents could be an indicator of (bad) safety, but if the accidents do not lead to personal injuries they are not. Road safety is a 'loss of health' problem. A crash or accident without loss of health is no safety problem, only a cost. But the thesis put forward in this paper is another, namely that by choosing the "accident" perspective, you get a safety philosophy that at its best reduces accidents, not necessarily personal injuries. And, as all modern definitions of the traffic safety problem define it as a health problem (health loss) the accident perspective misses the target.

Accident analysis shows typically that 90–95% of all accidents are caused by road users. Society's most fundamental response to accident prevention has been rules and regulations for road user behaviour. The purpose of traffic legislation is mainly to simplify the tasks for road users, making the risk of accident lower. In many cases this works as intended. But if focus is shifted to the effect of the traffic regulation on health loss, the pattern is less clear. Examples could be, for instance, traffic lights and pedestrian crossings. Installing traffic lights typically results in fewer crashes, but more severe injuries. Pedestrian crossings generally do not lead to a safer crossing for pedestrians; they facilitate crossing a street but provide no safety in themselves.

When it comes to road- and street design the dominant safety strategy overall has been to *increase space for drivers and vehicles*. That is, wider lanes, wider roads, straighter roads, larger crossings etc. The reasoning behind this is straightforward and logical; if drivers run off the road, make the road a little bit wider so there

[1] EuroNCAP = European New Car Assessment Programme.

is room for manoeuvring the vehicle back into the lane and keeping the vehicle on the road; if drivers run off the road in bends, try making the road a little bit straighter thereby avoiding accidents in bends. This strategy has had some success in reducing the number of accidents, but even the effect on the accident risk has been questioned (Hauer, 1999). *The strategy to create space for evasive action has not been successful in reducing fatalities and other severe injuries.* In fact, everything else considered, this strategy increases fatalities and other health losses. A wide, strait road has more fatalities than a narrow road with many curves if everything else is the same. The reason is simple: the most predominant effect of creating more space is an increase in driving speed, which means higher levels of kinetic energy in crashes. Higher energy levels lead to more severe health losses, all other things being equal. This increase in speed has two reasons; first road administrations normally set a higher speed limit on roads that are wide and straight because they are said to have a higher safety standard, and drivers tend to drive faster anyway on these roads.

This safety philosophy to build wide, straight roads and streets is one of the main contributions to the present global road safety crisis. The result is an increase, by one or two factors of 10, in the risks of severe personal injury or fatality, compared to the Vision Zero design philosophy described later in this paper. No other design parameter has an impact of this magnitude. As an example Swedish 2-lane highways with a speed limit of 110 km/h had one of the most severe injury pattern recorded ever; out of three persons injured on these roads, one was killed. Relatively new Chinese highways produce more than 1 killed/km/year. The main difference between the Swedish rural roads and the Chinese highways is that the latter have a large quantity of vulnerable road users, who are "separated" from motorised vehicles only by the "wideness" of the roads and traffic regulations e.g. pedestrian crossings (Fig. 1). It has been shown on the Swedish roads mentioned in the example that the fatalities can be reduced by 85–90% by applying mid- and side barriers. The Chinese highways mentioned above could, at least in principle, be rebuilt reducing fatalities with up to 99%.

A note must be made on motorisation and its effect on overall safety in a country. Sweden has approximately 0.5 cars/inhabitant whereas China is only in its beginning as a motorised country with 0.04 cars/inhabitant. The World Bank has noted that the number of persons killed in a country turns from an increasing trend to a decreasing trend when the GNP/capita reaches approximately 8000 US$ (Kopits and Kropper, 2003). A hypothesis based on this data could be that the change in composition of traffic, that is, the mixture of protected/unprotected road users reaches a critical limit at that stage of economic development. That is, the separation between vehicles and unprotected road users reaches a certain level which has an overall good effect on road safety. It should also be noted that this separation in (most) societies is spontaneous and not engineered. It is a function of more and more people becoming motorised (car or bus) and the number of vulnerable road users decreasing, especially on rural roads. *The challenge in a developing country is of course to engineer this separation at an early stage of motorisation.*

4. Design principles in Vision Zero

The human tolerance for biomechanical forces is in this perspective the starting point for the design of a safe traffic system. This tolerance is a given factor – it cannot be affected to any significant extent. For instance if cars hits pedestrians at 25–30 km/h most of them survive. However, if the cars instead do 50 km/h, most pedestrians will die (Fig. 2).

The trick from an engineering point of view is to design and construct a traffic system where this human tolerance is not exceeded. Whereas the general strategy for safe road design from the accident perspective was to *increase space for drivers and vehicles*, the corresponding strategy from a Vision Zero perspective is to *manage kinetic energy in crashes and collisions.* It is kinetic energy that kills and injures the road user – not the accident. *By managing the crash in terms of the energy that is transferred to the human body, an error tolerance can be built into the traffic system.* In fact, an error tolerance was also the intention behind the idea to give drivers

Fig. 1. A road (Highway 204, China), where *space* is thought to be the safety feature resulting in more than 1 killed/km/year.

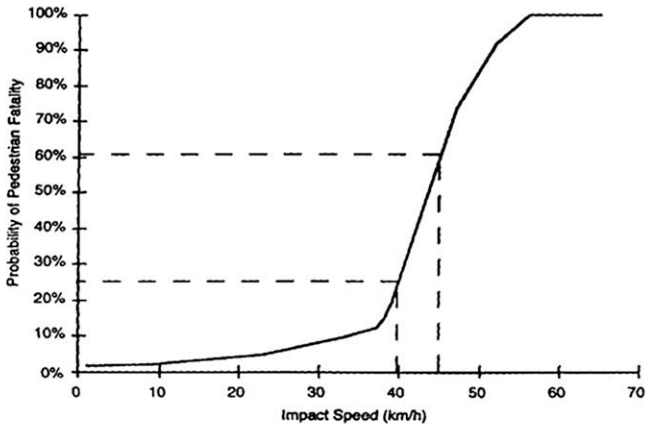

Fig. 2. The probability of pedestrian fatality as a function of impact speed (Anderson et al., 1997).

space in the traditional safety paradigm. Space would give room for evasive manoeuvres thus avoiding the accident; the problem was that it never worked the way it was intended.

The management of kinetic energy in crashes and collisions can be broken down to the following principle for road and street design; 'Integration and Separation': kinetic energy is managed by integrating compatible traffic elements and by separating incompatible ones. Here are some boundary values:

1. Vulnerable road users should not be exposed to motorised vehicles at speeds exceeding 30 km/h.
2. If 1. cannot be satisfied then separate or reduce the vehicle speed to 30 km/h.
3. Car occupants should not be exposed to other motorised vehicles at speeds exceeding 50 km/h in 90° crossings.
4. If 3. cannot be satisfied then separate, or reduce the angle, or reduce the speed to 50 km/h.
5. Car occupants should not be exposed to oncoming traffic (other vehicles of approximately same weight) at speeds exceeding 70 km/h or 50 km/h if oncoming vehicles are of considerably different weight (Fig. 3).
6. If 5. cannot be satisfied then separate, homogenise weights or reduce speeds to 70 (50) km/h.
7. Car occupants should not be exposed to the road side at speeds exceeding 70 km/h, or 50 km/h if the road side contains trees or other narrow objects (Fig. 4).
8. If 7. cannot be satisfied separate or reduce speed to 70 (50) km/h.

It should be noted that a separation is always a physical separation (typically a barrier) and never a temporal one (e.g. traffic lights). Spatial separations could be tunnels, bridges or other crossings at different levels, crash barriers or barriers for pedestrians or different roads for different traffic elements (e.g. bicycle roads, Fig. 5). A space of up to a few meters is *not* to be considered as a separation.

The result of an application of these principles to the design of roads and streets can be described in many ways. One is to look upon the road and street environment from the perspective of the road user. From the perspective of the driver the following can be observed:

- In areas with many vulnerable road users, the maximum speed is 30 km/h. Expect narrow lanes, speed bumps and vulnerable road users crossing the streets even in between crossings.

Fig. 3. A redesigned rural road in Sweden with 2 + 1 lanes and mid-barrier, resulting in a reduction of fatalities by 80–90%.

Fig. 4. A simulated collision into a tree. The picture shows the approximately position of the tree after a 70 km/h crash.

- Where driving speeds are 50 km/h lanes are still narrow, pedestrians and bicyclists do not cross between crossings due to mid-street pedestrian fences and speeds are reduced to 30 km/h where vulnerable road users cross.
- For all roads and streets with speeds higher than 50 km/h drivers should expect barriers both to the right and to the left of their car (Fig. 6). In 50+ km/h environment vulnerable road users are never mixed with cars.

Fig. 5. Narrow lanes for cars and busses, vulnerable road users on parallel roads, roundabouts as crossings in city of Borlänge, Sweden. This type of design reduces fatalities by 80–90%.

The general solutions for crossings are roundabouts. If capacity is a problem, add traffic lights. If vulnerable road users are present, canalise and lower car speeds to 30 km/h in crossings.

Pedestrians and bicyclists generally have their own "roads" (Fig. 7). Cars are separated from this network by their crash barriers in 50+ km/h environments.

In 30–50 km/h environments pedestrians are if necessary prevented from crossing the streets by use of pedestrian fence in mid-street.

Always when pedestrians and bicyclists share space with cars, the car speed is a maximum of 30 km/h.

If we try to summarise some of the characteristics of these design principles and their consequences for vulnerable road users and for street- and road design:

- You should never mix vulnerable road users and cars at speeds exceeding 30 km/h. When speeds are higher, you should always separate vulnerable road users from cars. In built-up areas this is rather straightforward (just a little bit of discipline is needed from the designers) but in rural settings the change is larger

Fig. 6. Different cable-barriers used as side barriers.

Fig. 7. Dedicated motorcycle lane in Malaysia. Motorcycle fatalities were reduced by 83% (Umar Radin, 2007).

compared to tradition. This requires continuous, dedicated pedestrian and bicycle lanes (or motorcycle-) with physical barriers separating them from cars. These are, however not very costly. Bridges or tunnels should be used for crossing the roads if speed cannot be reduced to 30 km/h. These are more costly.
- Pedestrian crossings (the white lines) are not a safety device in themselves. They should be seen as a device for regulating priority. The safety is decided by the speed of cars at the crossing. If the speed is below 30 km/h, safety is acceptable – if higher then unacceptable.

5. Developments in fatality rates

In 1997, when Sweden started to implement the principles of Vision Zero the fatality rate was about six killed/100,000 inhabitants. In 2006, the fatality rate was 4.7 killed/100,000 inhabitants and falling. But the distribution of fatality risk is not homogenous. Where large scale attempts have been made to implement these design principles, mainly in built-up areas and along major rural roads, fatalities have been reduced to a tenth of the initial risk. Where no such improvements have been made, risks have typically been reduced by some 2–3% annually, mainly due to safety improvements of the vehicle fleet. We have thus concluded that the principles work, they can be implemented on a large scale and the costs are reasonable.

6. Discussion

The principles of 'integration and separation' are universal, that is, they are valid in any country, independent of its level of development. What differs is both what types of changes are necessary and how changes are introduced and implemented. The best situation is, of course, if you have the possibility to do the right thing from the beginning, that is, if you start with a narrow gravel road and a budget for building a new one or improving the existing road. The full implementation of these principles both for vulnerable road users and for cars and buses probably costs less (budget) than building in a traditional fashion, the reason being primarily the reduced cost for less width and side areas. Costs for maintenance will increase, mainly due to repairs of barriers, but the reduced costs for fatalities and injuries may well compensate this. These costs are, however, on another budget.

How you implement these principles are dependent on traditions and local culture. Road- and street designers tend to be educated in similar traditions worldwide. The key to their culture is guidelines or manuals. If you change these you will be able to change safety relevant properties. But generally, thorough knowledge of local tradition and culture is always needed.

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References

Anderson, R.W.G., McLean, A.J., Farmer, M.J.B., Lee, B.H., Brooks, C.G., 1997. Vehicle travel speeds and the incidence of fatal pedestrian crashes. Accident Analysis and Prevention 29 (5), 667–674.

Belin, M.Å., Johansson, R., Lindberg, J., Tingvall, C., 1997. The Vision Zero and its consequences. In: Proceedings of the 4th International Conference on Safety and Environment in the 21st Century, Tel Aviv., Isarael, Berlin, pp. 1–14.

Hauer, E., 1999. Safety in geometric design standards. <http://roadsafetyresearch.com/hauer@civ.utoronto.ca>.

Johansson, 1991. Safety research in an individual and societal perspective – a look at the future. In: Proceedings of Third European Workshop on Recent Developments in Road Safety Research, April 26–27, 1990, VTI Report 366A, 1991, Linköping, Sweden.

Kopits, E., Kropper, M., 2003. Traffic fatalities and economic growth. World Bank Policy Research Working Paper 3035, April 2003.

OECD (Organization for Economic Cooperation and Development), 1990. Behavioural Adaptations to Changes in the Road Transport System. OECD Road Research Group, Paris.

Tingvall, C., 1998. The Swedish 'Vision Zero' and how parliamentary approval was obtained. Keynote address at Researchers Conference, NZ, and 'Road Safety Summit', Canberra 1998, pp. 57–61.

Tingvall, C., 2007. Vision Zero and The New Paradigm for Road Safety (Emphasizing Critical Lessons For Infrastructure Design). Second UN Stakeholder Forum on Global Road Safety, Geneva.

Tingvall, C., Johansson, R., Stenborg, L., Lie, A., 1996. How to reach the non-fatality road transport system. Presented and commented by Michael Griffiths, Road Transport Authority New South Wales. Third International Injury Conference in Melbourne.

Tingvall, C., Johansson, R., Lie, A., 1997. Traffic safety in planning – a multidimensional model for the zero vision. In: Manuscript for Second Conference on Traffic, Mobility and Health, Brussels.

Umar Radin, 2007. Personal communication.

Wilde, J.S. Gerald, 2001. Target Risk 2: A New Psychology of Safety and Health. PDE Publications.