THE IMPLICATIONS OF THE ZERO VISION ON BIOMECHANICAL RESEARCH

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ABSTRACT

From the systems approach, road transport is the least error tolerant man-machine environment causing an extreme number of deaths and injuries. Simple mistakes by individuals can lead to a fatality or other severe health losses.

During recent time, future goals on road safety have been set up, to encourage effective safety measures. During 1995, a more final goal has been discussed where no fatalities and other serious health losses are accepted in the road traffic, that is, zero casualties.

The zero goal is not just a political or ethical goal, it is also a way to stress the need for a new approach to what is desired from different fields in the road transport system in order to radically increase the safety level.

In this paper, an approach to the zero goal is presented, built on human biomechanical tolerances. The paper outlines necessary steps to be taken in research and implementation. The paper also, step by step, describes a process that defines questions to be raised and answered.

In summary, it is stated, that the biomechanical tolerance is the most important limiting parameter in the zero vision.

BACKGROUND

The health losses in the road traffic system is an ongoing catastrophe to the public, with no major changes in the number of deaths and injuries during recent years. Approximately 5% of the population is either killed or medically disabled for lifetime due to a road accident. The majority of the casualties occur for people in their most active part of their life. Thanks to changes in transport modes, from unprotected to protected road users, there has been a reduction of risks for a given exposure, combined with reduced risks for car occupants. Generally, the impact of fifty years of traffic safety is disappointing if focusing on the total number of fatalities and injuries, but we have been able to increase mobility with no increase in casualties.

There is, however, a major increase in the knowledge of how and why injuries occur, but only a limited number of measures have been implemented in the road transport system. The explanation might be a lack of a definition of who is responsible for the health losses, and a strategy based on the new knowledge, combined with a general acceptance of the road accident casualties on the political level. More recently, future targets for the number of fatalities and injuries have been decided upon in many countries. These targets are, apart from that they could be questioned from an ethical standpoint, never very radical, or reflect a willingness to cure one of the largest health problem that we have in the society.

Several strategies for traffic safety have been presented, one of them being developed by Haddon. Haddon´s strategy is probably the most comprehensive and used strategy as it takes into account most aspects of prevention.

One area that has not been under discussion to any large degree is the aspect of who is responsible for the systems safety. The normal way to express responsibility is that it is finally the road user, normally the driver of a vehicle, that is responsible for the safety and the consequences of accidents. This is quite different from other areas in the society, where systems safety is gathered to one hand. In occupational safety it is clearly the employer that is responsible for the safety and for any accident taking place.

In Sweden, a new approach to traffic safety has been introduced. This approach, called the "zero vision", defines the final objective of traffic safety to be a road transport system without health losses, and makes the system design responsible for this goal. This radical vision has been taken up by the political level and is supposed to be the new political goal in Sweden.

The "zero vision" is a political as well as an ethical standpoint, but it has also gotten a scientific part. In this paper, only the scientific part is focused.

The aim of this paper is to:

- describe the "zero vision" from the scientific point of view

and,

- briefly outline the biomechanical implications of the "zero vision"

RECENT AND PRESENT PREVENTION STRATEGIES - The very early strategies of prevention focused on the ability, knowledge and psychology of the driver, and were more or less only directed towards accident prevention. By introducing legal limitations, education and changing attitudes to driving, the number of accidents was supposed to diminish.

Systems theories were introduced later, but were only directed towards active safety.

A more integrated concept on traffic safety was introduced by Haddon. In Haddon's concept active and passive safety were applied on the driver, vehicle and environment. This strategy has been generally accepted, but has not been implemented systematically.

Applied passive safety was coming into effect in the 60-ties, and has since then grown in importance. Recent car constructions, and the use of restraints in cars, and helmets by other road user categories have led to a decrease in injury risk and injury severity.

The passive safety of the environment (infrastructure) has also been developed, although not systematically. This process, mainly driven by the society, is today based on economic models, where different political goals are given different weights. There are no absolute targets built into these models.

Active safety is still an important issue, both from the human behavioural as well as the vehicle aspect, but has not decreased the number of accidents to the same degree as the passive safety has reduced injuries. The use of road traffic informatics seems to be mainly directed towards active safety and mobility.

The present safety strategy can be illustrated by a dose-response function, and the distribution of accidents for different doses. The dose, or the accident severity, is one or more variables describing how severe the accident is for the person at risk and exposed. The dose is sometimes measured as change of velocity (delta-v), relative speed, acceleration or deformation. The response is a parameter that describes injuries, fatalities, health losses, etc.

The dose-response function is helpful in that it describes that the risk of injury is not random, but a function of the type and magnitude of the mechanical forces acting on the human body, either directly, or through any filter, like the vehicle, the wearing of restraints, etc. The accident exposure curve describes the distribution of the mechanical forces that typically are many at low levels, and few at high. The number of casualties is the function of the dose-response function and the accident exposure distribution.

The dose-response curve is for most combinations of variables typically exponential, often with an exponent ranging from three to five. The more specified the dose variable is, and the more condensed the population under study is, the more the function is getting tighter. For the whole population, and when mixing restrained and unrestrained occupants, the function is getting more spread out.

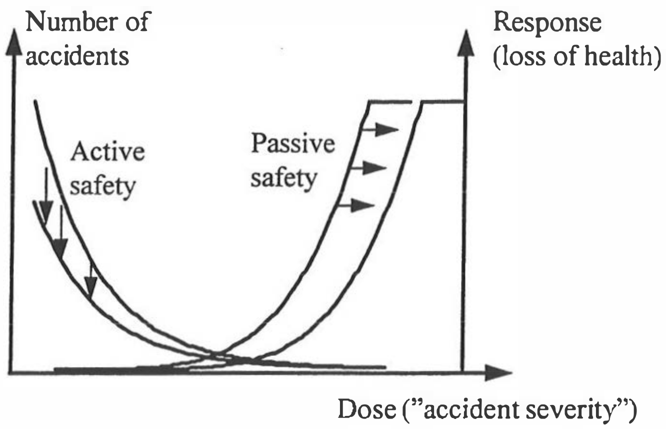

Fig. 1. The safety problem described as dose/response functions. The active safety is traditionally aiming at diminishing the number of accidents and the passive safety is aiming at increasing tolerance at any dose.

The response given a reasonable dose is reduced by mainly increasing the performance of vehicle and restraint systems, while active safety is mainly directed towards all kinds of accidents. Speed limits, though, can be seen as a way to mainly reduce the severity of accidents, thereby acting more among potentially severe accidents.

Still, a large amount of accidents occurs in an area where they are hardly reachable with passive safety.

THE "ZERO VISION"

Unlike more developed man-machine systems, road traffic is built up around the perfect man. The road traffic system is based on individuals following rules, advises and common sense. The individuals are supposed to make the right decisions assuming that all information is clearly understood and that the right conclusions can be drawn from it. If the individual makes wrong decisions, and thereby causes an accident, he or she is by definition offending the law, and can be punished. It is not a surprise that such a system cannot work, the major problem being that the consequences of wrong decisions can be fatal.

A very common conclusion of the fact that people are involved in accidents is that the individuals must be forced to make better decisions. This is an unethical standpoint, if the knowledge on how to change the man- machine system in other ways is reachable and affordable. The good thing is that this knowledge is there, but we are not willing to use it.

Who is not willing to use it? Unlike many others, it can be claimed that it is not the individual road user that is not willing to ask for a better safety. Here, it is claimed that it is the responsible for the system that is not taking the full responsibility, and is acting under no or wrong ethical rules. The first thing to do to change the attitude to the traffic safety problem, is to adopt ethical rules that are based on a much higher responsibility for the professionals in the road systems. People being active in authorities, communities, safety organizations, vehicle industry, road builders, etc. is considered as professionals in this case.

The general ethical rule for those responsible for the road traffic system is "that one should in every situation do ones best to maintain life and health". This ethical rule means that the responsibility for life and health is divided between the road user and those responsible for the system. If the road user is not doing what is asked from him, he should nevertheless be protected from serious injuries. Possible risks must therefore be predicted and diminished.

The general idea behind this approach is to internalize all kinds of mistakes and misjudgements into the design of the system. As long as accidents are not possible to eliminate, it is the consequences that must be held under control. The kind of consequences that should be focused is injuries leading to long term consequences and fatalities. Other types of injuries, minor or even moderate, can be treated as a problem to the individual, but it can be questioned if they should be a part of the "zero vision". The first step of the approach is therefore to define what a "non-acceptable loss of health" is.

The scientific basis of the vision differs from the usual approach to safety in man-machine systems, and also in many views the traditional traffic safety approach. The most common strategy is based on designing the system to minimize the number of events that cause injury. The zero vision takes a different approach. In this, the level of violence is allowed up the point where loss of health might occur.

The loss of health is not distributed randomly over the whole spectrum of accident severity. Instead, the risk of an injury with major health loss is a clear function of the magnitude and forces acting on the human body. As long as there are accidents occurring above the threshold value for this risk, injuries with health losses will occur.

A PREVENTION STRATEGY

If we define a future goal of no health losses in the road transport system, it is of major importance to know if this can be achieved by eliminating accidents. It is, for the moment, neither possible to see what such a solution would look like, and even more so, nor how it could be implemented.

If accidents can occur, the future road transport system must therefore be prepared for limiting the consequences of road accidents. The desired situation is therefore, when possible accidents do not reach a mechanical dose, where road users will be at risk for a serious health loss.

The desired situation is of course trivial - it is when the accident severity, or the dose, distribution is no longer in contact with the dose-response function. The implications are though more complex. In figure two, the areas of importance are given.

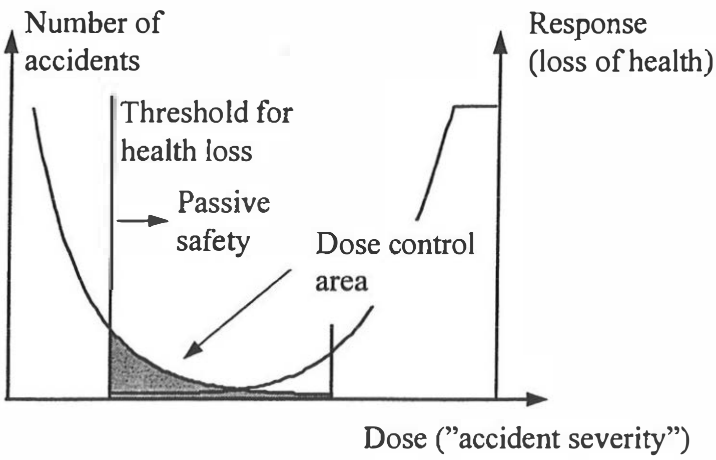

Fig. 2. The "zero vision" safety problem described as dose/response functions. Passive safety aiming at moving the threshold and dose control aiming at elimination accidents with doses higher than the threshold.

Unlike the traditional safety strategy, where common, representative, or "cost effective" dose areas are focused, this strategy focuses on the threshold level for an injury causing health losses. For the area above the threshold, the area of dose control is identified. In this area, accidents must be modified (or eliminated) to fit into the area of where passive safety can act. The threshold is therefore the limit for the whole road transport system.

The threshold level for a pedestrian is fixed, and our only possibility to reach our desired situation is to change the dose-control area - the bullet vehicle or the velocity of the bullet vehicle. This is therefore a trivial area.

The threshold level for the car occupant is a function of the human tolerance and the occupant protection generated by the structure and restraint system of the vehicle. This level can be moved by increasing restraint use, and by developing the vehicle crashworthiness. The highest known threshold level is probably that of a small child sitting in a rearward facing child restraint.

A large part of the accidents will still fall over the threshold level. The dose-control area can be managed in many different ways, not only by reducing speeds, which for many might be the only known way. The infrastructure plays an important role. By using separation of lanes, advanced guard rails, etc. the dose can be held in control without limiting speed. Instead the change of velocity, acceleration and/or deformation is held under control.

BIOMECHANICAL IMPLICATIONS OF THE ZERO VISION

It can be questioned if there are any biomechanical implications just by moving the objective of the future road transport system safety. Looking at the scientific approach, using the dose response control as the regulating parameters there are some areas coming up.

<u>First</u> of all - defining health loss is a challenge. Without doubt, a large proportion of the injuries does not cause any threat to life or the long term health. On the other hand, our instruments to assess the severities of injuries

are not valid in all respects. AIS and its derivatives still lack the ability to predict long term consequences, and there are injuries that are assessed as minor, but still seem to cause a certain risk of leading to disability.

Second - to dimension the road transport system on the human tolerance demands an extreme knowledge on injury mechanisms and tolerance. A challenge is to decide who is the dimensioning person. Taking the "zero vision" seriously means that a person with low tolerance to mechanical forces is dimensioning.

Third - it is of importance to find the balance between change of velocity, acceleration and deformation (intrusion). It is without doubt possible to generate a high degree of safety just by reducing travel speed, but the challenge is to increase the safety without reducing mobility.

Fourth - it is the biomechanical field that must define the interface between the human, the vehicle and the infrastructure (the dose). The tolerance of the human is given - while the interface and the specification put on every component of the system is dynamic.

Fifth - it is the biomechanical field that must develop risk analysis models and simulation based on the human tolerance and that is integrated to the rest of the system. It must be possible to predict the consequences of human behaviour leading to an accident for a all possible kinds of accident situations, vehicles and infrastructure without using people as guinea-pigs.

The conclusion of these statements is that the biomechanical field must expand into the dose-control area. While earlier research and paradigm stop with the vehicle crashworthiness, it must go beyond the given accident severity spectrum and start to put up specifications for the whole road transport system.

SUMMARY

It is the human tolerance to mechanical force that is the absolute dimensioning factor for the future road transport system. As long as we do not have a vision of how to eliminate accidents, it is the outcome of the accident that formulates the limits of risk taking. The road transport system safety is going to handle human mistakes and behaviour beyond rules and regulations for the driver.

When the human tolerance is the dimensioning factor, new demands will be put on the biomechanical field, and biomechanical research must expand in the field of controlling the dose - and not only to in a given frame, do things a little better.

It is the human tolerance that will design roads, crossings, cars, speed limit, etc. Road, vehicles and restraint systems must be designed and dimensioned in an integrated process. If the car industry does not solve the problem with everyone using seat belts, we will have to dimension the system on the unbelted, which is quite a different road transport system than the belted one.

The major problem seems to be how to manage the vision coming into effect, and to create a process where the car industry still has a market for better safety that drives the process.

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