VISION ZERO REQUIRES FIVE STAR ROAD SAFETY SYSTEM

Lal C. Wadhwa
James Cook University, Townsville, Queensland, Australia

ABSTRACT

Vision Zero is aimed at zero fatality or serious injury on our roads. It is a bold concept and presents a challenge to planners, engineers, managers and policy makers. The ramifications of this philosophy are far reaching. It questions the very basis of the traditional economic evaluation methods and the transportation system objectives. Conventional trade-off between safety, mobility, and economics is no longer an option in Vision Zero. All subsystems in road safety must be stretched to their limits of capabilities and beyond. This entails vivid changes in attitude, spectacular advances in technology as well as massive investments. The implications of Vision Zero for road system infrastructure are explored in this study. A concept of prescribing a rating to the road infrastructure is advanced and a framework for determining the rating is proposed. It is postulated that vision zero requires a "five-star" road infrastructure.

Keywords: Vision zero, road infrastructure, road safety, evaluation

Introduction

Vision Zero philosophy is that it can never be ethically acceptable that people are seriously injured or killed when moving within the road transport system (Tingvall, 1998). At the core of the Vision Zero philosophy is the biomechanical tolerance of human beings. It promotes the development of a road system that will ensure that the crash energy cannot exceed human tolerance. It accepts that accidents will occur as people do make errors while moving within the road transport system. It contends that no foreseeable accident should be more severe than the tolerance of the human in order not to receive an injury that causes long-term health loss (Tingvall and Haworth, 1999).

Vision Zero suggests the disbanding of the traditional economic model in which safety is provided at reasonable cost and the traditional transportation model in which safety must be balanced against mobility. It argues that safety must be provided at all costs, and it is unethical to trade health against mobility. It assigns the blame to the system and not the driver. Road and vehicle systems must be designed to tolerate human error. These systems must negate the risk taking behaviour if Vision Zero is to be realised.

The road safety system essentially comprises vehicle, road infrastructure and road user (Figure 1). Each element needs significant changes, modification and improvement to ensure a completely safe system. All elements must be stretched to their limits of capabilities and beyond if Vision Zero is to be realised. Rechnitzer and Grzebieta (1999) argue for a paradigm shift in road safety thinking to achieve Vision Zero. This paper introduces the concept of rating as applied to road safety elements, and employs the concept to the road infrastructure system. It postulates that road safety system elements have to be of "five-star" standard for achieving Vision Zero.

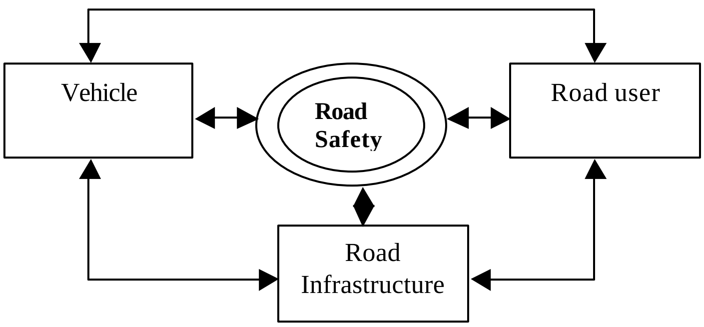

Figure 1: Elements of a road safety system

The Concept of Rating

Star Ratings for Road Safety System Elements

The state or condition of the road safety system elements determine the safety of the road system. It is postulated that to achieve Vision Zero, all system elements must be at their highest standard. The highest standard required for any system element is dependent on the assumed model of star ratings.

Model I: The Trade-off Model

The highest standard required for any system element may be defined as the standard at which the road safety system will attain Vision Zero given the state of other system elements (which may not be at their highest standards). For any road system element, this required standard will depend on the standard of other elements. For example, if the road users could be educated in safe driving and a change in their behaviour was achieved so that they will not be involved in any serious accident, the road users could be classified as "five-star". It is recognised that this may not be achievable. In a similar argument, if vehicles could be designed that will be so safe that no driver would ever be killed or seriously injured (while other subsystems remain at their current standards), the vehicle standard would be designated as "five-star". Road systems could be designed to ensure the achievement of Vision Zero. Such road systems will be designated as five star road infrastructure systems. This is illustrated in Figure 2.

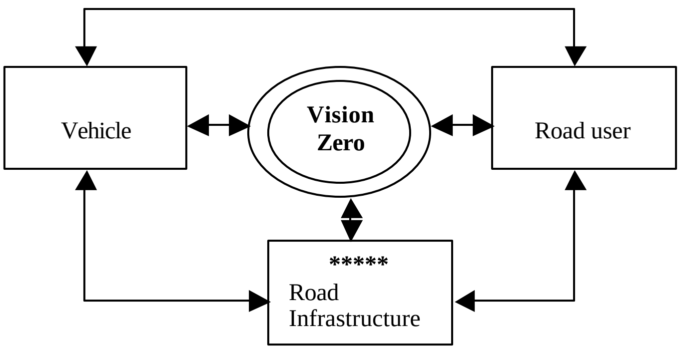

Figure 2: Model 1 – "Five-star" Infrastructure Subsystem for Achieving Vision Zero

When only one subsystem is improved for achieving Vision Zero with other elements being at their current level, its "five-star" standard would be very high indeed. This model suggests that firstly, the highest requirement for any element is dynamic and changes with the condition of other elements and secondly, the highest requirements of any system can be traded off by making improvements in one or both other elements.

Model 2: The Absolute Limit Model

Under this model, each element has to be stretched to its highest standard. All elements must be at "five-star" ratings. The standards required to attain "five-star" rating under this model would not be as stringent as in Model 1. This model is illustrated in Figure 3.

Defining the highest standard required for any element is not easy. Since the Vision Zero philosophy argues for safer roadway and forgiving roadside setting with a view to achieving zero fatality and serious injury victims, the ensuing road infrastructure is designated as having a "five star" standard. If the actual standard is below this level, it is given a lower star rating. The concept of star rating and the approach to assigning star rating to the elements of road safety system is discussed in this paper and is applicable irrespective of the model adopted.

Rating the Road Infrastructure System

The overall rating of a road section is comprised of three major considerations:

a) Design
b) Operations
c) Safety

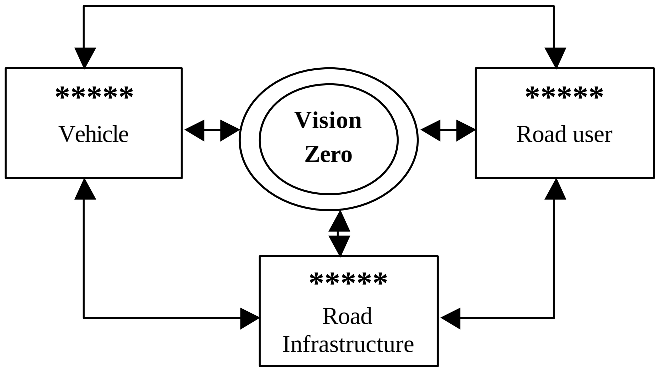

Figure 3: Model 2 – All "Five-star" Subsystem for Achieving Vision Zero

Databases and other information used in assigning rating to the road infrastructure subsystem include

a) Road inventory database
b) Traffic studies including volume counts, and delay and speed studies
c) Crash database
d) Black spot database

Feasibility of "5-star" system elements has to be assessed on the basis of technological feasibility, economic feasibility, and community acceptance

Design Rating

Road design features are important determinants of intrinsic road safety. Divided roads with multiple lanes, wider lane widths and generous shoulders, no sight distance restrictions, gentle or no slopes, large radius horizontal curves (if required), paved or concrete surface in excellent condition and completely forgiving road furniture increase road safety and contribute to Vision Zero. Road inventory database could be used for assigning a rating to each design element. Ratings can be defined for each functional class.

The design elements of a road section include

- Divided/Undivided and number of lanes
- Lane width
- Shoulder width
- Per cent length with sight distance <450m
- Horizontal alignment
- Vertical alignment
- Surface type and condition
- Road furniture/roadside
- Application of ITS

Divided/Undivided and Number of lanes

Divided roads are known to be safer than undivided roads. Multiple lanes allow overtaking function to be performed with relative safety. Divided roads with three or more lanes in each direction are perceived as a high standard road with respect to this criterion (Table 1).

Lane width

Greater lane widths are desirable for comfort and safety. For rural roads, lane widths of 3.7 m are common. On urban roads, widths of 3.3 m are considered adequate. Narrower widths mean lower rating as shown in Table 1.

Shoulder width

Shoulders increase comfort, quality of traffic operations, safety, and sight distances across the inside of horizontal curves. They also provide support for the pavement, space for stationary vehicles and manoeuvring space for erring vehicles. In other words, shoulders are an important element for a safer infrastructure. Suggested ratings based on shoulder width are shown in Table 1.

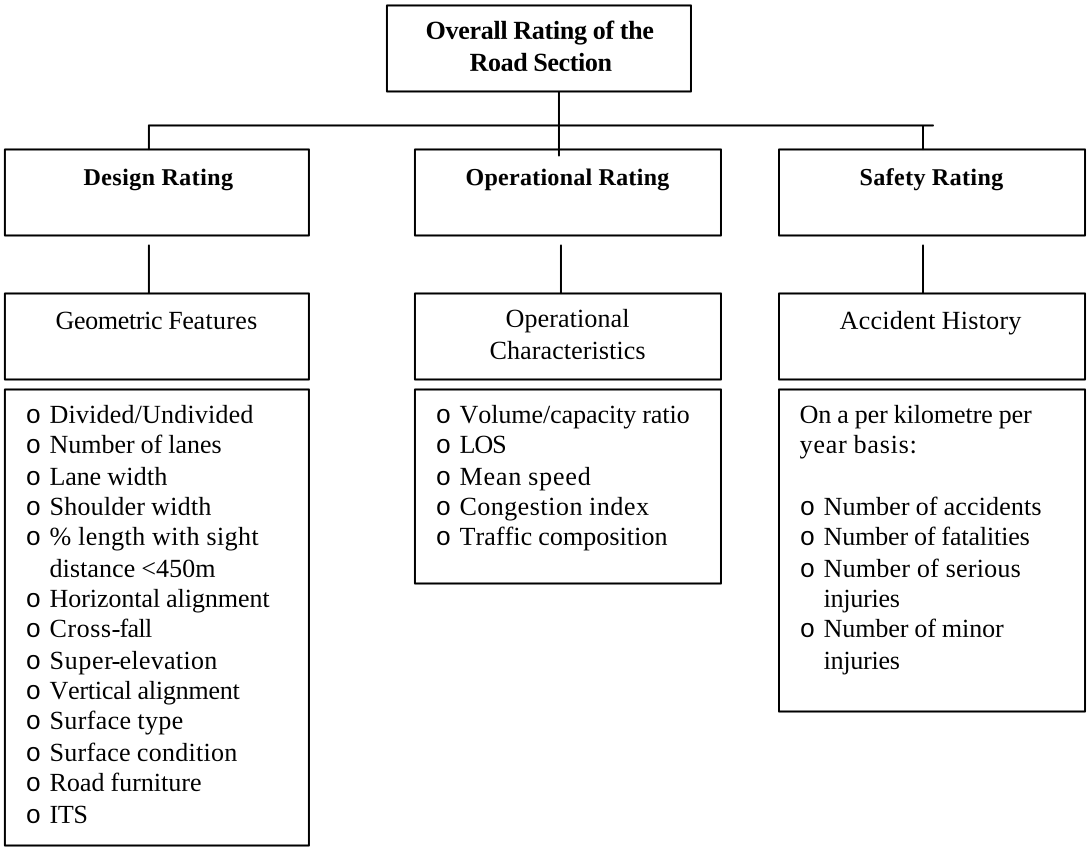

Figure 4: Rating the Road Infrastructure

Per cent length with sight distance <450m

Every section of the road must have sufficient stopping sight distance for the designated speed. For undivided two way two-lane roads, opportunities for overtaking must exist. It is desirable that overtaking sight distance must be available at all times although this is not always possible due to economic and topographical factors. Road sections with no length having sight distance of <450 m would be considered to have the highest rating. Other ratings are proposed as shown in Table 1.

Table 1: Suggested Ratings (Preliminary) based on the Design Features of Road Section

Feature?; Rating?	5	4	3	2	1	0
No. of lanes; and divided/undivided	Divided; =3 lanes in each direction	Divided; 2 lanes each direction	Undivided 2 lanes each direction	Undivided 1 lane each direction	Single lane roads	-
Lane width, m	> 4	3.7 - 4	3.4 - 3.7	3 - 3.4	2.7 – 3	< 2.7
Shoulder width, m	> 3	2 - 3	1.5 - 2	1 - 1.5	< 1	No shoulder
Sight distance (% length with sight distance <450m)	0	1-20	21-40	41-60	61-80	81-100
Min. curve radius, m	> 4600	3500 -4600	2500 - 3500	1500 -2500	900 -1500	< 900
Algebraic sum of grades %	0	< 3	3 - 6	6 - 10	10 - 15	> 15
Surface and condition	Excellent	Very good	Good	Average	< average	Poor
Road furniture, forgiving	Completely	Adequately	Sufficiently	Reasonable	Little	No
Application of ITS	Highest	Reducing ?				None

Horizontal alignment

Horizontal alignment includes circular and transition curves, super-elevation, and lane widening on curves. The most significant element of horizontal alignment is the minimum radius of any horizontal curve on the road sections. It is desired that the radii of all curves should well exceed the minimum radius based on super-elevation, sight distance, comfort and appearance. The required radius of the curve is determined by design speed. Based on this factor, a section with all curves with radius in excess of 4600 m will be given the highest rating. The rating is reduced as the curves become narrower. This is shown in Table 1

Vertical alignment

Steep slopes and vertical curves joining grade changes can reduce sight distances and generate discomforting vertical acceleration thereby compromising safety. The rating based on vertical alignment are suggested as shown in Table 1.

Surface type and condition

Concrete and bitumen paved surfaces in well maintained condition are desirable for improving road safety. Pavement monitoring system data obtained from pavement monitoring equipment can be used to assign a rating to any road section based on the pavement surface, as shown in Table 1.

Road Furniture / Roadside

Road fumiture includes signage, barriers, lighting, etc. Its adequacy for Vision Zero is defined in terms of its forgiveness. At this stage of research, this feature which is composite of several elements, is defined subjectively from most forgiving (rating 5) to least forgiving (rating 0)

Intelligent transportation technologies

The application of intelligent transportation system can make significant contribution to improving road safety. The extent to which driver information systems, automatic highway systems and other ITS systems are introduced in a road section can be represented as a star rating. This requires careful deliberation but is proposed as a factor that should be included in determining the star rating of road infrastructure.

Scoring Models for Composite Rating

A number of evaluation models that use multiple criteria have been developed. Scoring models (unweighted or weighted) can be used to arrive at a composite rating based on various design factors. Unweighted factor scoring models assume that all elements are of equal importance. Weighted factor scoring models allow relative importance of each individual factor to be taken into account.

Operations rating

Operational characteristics are also important determinants of road safety. The operating characteristics of a road section include

- Operating speed
- Level of service
- Volume/capacity ratio
- Congestion index
- Traffic composition

Road inventory data in conjunction with traffic flow data on volumes, speeds, delays and traffic composition are used in assigning operational ratings to the road section. Congestion index is represented in terms of travel time increase (or delay) expressed as per cent of travel time.

Table 2: Suggested Ratings for Operational Characteristics

Rating	Operating speed, % reduction	LOS	V/C ratio	Composition % heavy vehicles	Congestion index (delay as % of travel time)
5	Design or over	A	< 0.4	0	0
4	Within 5%	B	0.4 - 0.6	<2	< 5%
3	Within 10 %	C	0.6 - 0.75	2-5	5 - 10 %
2	Within 15%	D	0.7 5 - 0.9	5-10	10 - 20%
1	Within 20%	E	0.9 – 1.0	10-25	20 - 40%
0	>20%	F	> 1	> 25	>40%

Accident risk (safety) rating

Crash data and black spot database are used to assign accident rating to road sections. The safety features of a road section are represented by the following statistics:

- Accidents per kilometre per year
- Fatalities per kilometre per year
- Serious injuries per kilometre per year
- Minor injuries per kilometre per year
- Property damage only accidents per kilometre per year

These statistics are based on accident data for the past five years. Zero values for each of these statistics will, undoubtedly, earn a "5-star" safety rating to the road section.

Table 3: Suggested Rating (Preliminary) based on Accident Risk

Rating	Fatalities (% all crashes)	Serious injuries (% all crashes)	Minor injuries (% all crashes)	Property damage (% all crashes)	All accidents (fraction of current accidents)
5	0	0	0	0	0
4	0	0	0	All	< 0.25
3	0	0	< 5 %	> 95 %	0.25 – 0.50
2	0	< 5 %	5 – 15 %	80 – 95 %	0.50 – 0.75
1	< 1 %	5 – 15 %	15 – 30 %	< 55 – 80 %	0.75 - 1.0
0	> 1 %	> 15 %	> 30 %	< 55 %	> 1.0

Discussion and Conclusions

Realisation of Vision Zero requires a fresh systems approach and a paradigm shift in road safety thinking. It implies abandonment of traditional economic model and trade-off between mobility and safety. Roads and vehicles must be designed to tolerate human error. This entails new standards for all road safety elements especially road infrastructure which among other improved design features, must be comp letely forgiving.

This research has evoked the concept of rating for road safety system. To illustrate the concept as applied to road infrastructure, preliminary ratings based on design features, operational characteristics and accident risk of a road section have been defined. The number and width of traffic lanes, horizontal alignment, vertical alignment, type and condition of pavement, sight distance, shoulder width, forgiving nature of road furniture etc. have been identified as the design features included in the design rating. The operational rating is based on average speed, level of service, traffic composition, congestion and volume/capacity ratio. Finally, the accident risk is based on the number of accidents of various severity levels and fatalities over last five years. The ratings of various elements included in the design, operations and accident risk can be integrated using weighted or unweighted scoring models.

The aim of this paper has to been to introduce the concept of rating as applied to the elements of road safety system. The overall rating of a road section (star rating - *****, ****, ***, **, * or no star) provides useful information about the safety level of the section and the investment required to bring it to the high standards. A paradigm shift in road safety thinking is needed if Vision Zero is to be realised. Not only are massive investments in road infrastructure system essential to bring it to the best available standards, spectacular advances in technology as well as vivid changes in attitudes are also mandatory to achieve Vision Zero.

References

Rechnitzer, G. and Grzebieta, R.H. (1999), Crashwothiness systems – a paradigm shift in road safety systems, *Transport Engineering in Australia, v 2*

Tingvall, C. (1998), The Swedish "Vision Zero" and how Parliamentary approval was obtained, Keynote Address pp 6-8, Vol. 1, Papers of the Road Safety Research –Policing-Education Conference, Wellington NZ: LTSA

Tingvall, C., and Haworth, N. (1999), "Vision Zero" – An ethical approach to safety and mobility, in Proceedings of the 6th ITE International Conference in Road Safety and Traffic Enforcement: Beyond 2000, Melbourne