Creating Safe Road Ecosystems

Considering how the physical space contributes to the safe design and use of road transport systems

Article No. 6 in the six-part series addressing how intelligent transport systems can become part of the Vision Zero road safety solution. A link to the all the articles is provided at the end of this article.

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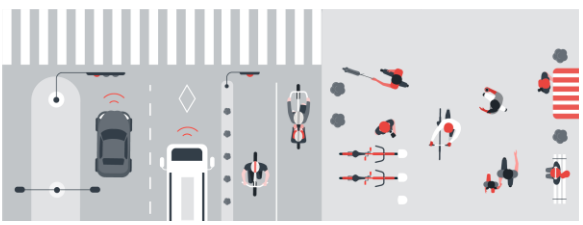
Vision Zero is rooted in the position that death and serious injury are not acceptable consequences of mobility. Death and serious injury are preventable within the worldwide road transportation system.



Road transport systems are integral to the form and function of communities. They facilitate the movement of people and goods, thereby connecting people to places and supporting commerce. Within these systems, spaces are used for mobility and local activity. Safety should consider both of these purposes. For system designers[1] to create safe road systems, they must understand and manage the interdependencies and interactions between the people, vehicles and space (Figure 1) comprising each road ecosystem.

The users of road systems are diverse, each with their own needs and vulnerability[2] that must be taken into consideration. They include drivers and passengers, road workers, pedestrians, transit passengers, motorcyclists, cyclists, people using emerging micromobility options such as electric scooters, and, in some contexts, horse riders/horse-drawn carriages. The Safe System approach to achieving Vision Zero embraces all users and modes of transport and the places where activity occurs. Similarly, the intelligent transport system (ITS) whole-system approach considers people, processes, infrastructure, vehicles, technology and associated data to develop safe and efficient operational environments for all users.

To form safe ecosystems, system designers consider the physical features and operational factors and their purpose within the system toward enabling mobility and placemaking. Safely connecting the elements of space—the road itself, curbsides, roadsides, and adjacent land use—is essential to creating the context to achieve a Safe System.

Figure 1 – Designing and Maintaining a Safe System - Interdependent Elements

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[1] System designers–according to the Vision Zero approach–include policymakers, politicians/government officials, infrastructure owners and operators, planners, engineers and road designers, vehicle manufacturers, trauma and hospital care providers, enforcers, plus any others who provide for the road transport system. Each contributes important knowledge and expertise to help make and keep roads safe.

[2] While vulnerability exists in relation to all road users, Vision Zero characterizes "vulnerable" users as those most at risk in traffic, as they do not have an outside shield to protect them from the force of impact in a crash. *See the brochure: Vision Zero, Setting a higher standard for road safety*, WSP, p. *7*

Different Spaces, Same Vision

With the Vision Zero approach, road users and system designers share the responsibility for achieving safe outcomes. System designers apply their knowledge and expertise to make and keep roads safe for all users. Road users are responsible for following the rules. If users fail to comply with road rules—due to a lack of knowledge, acceptance or ability—system designers must take the necessary further steps to prevent death and serious injury.

Worldwide, more than 1.35 million people die on roads each year, and another 20 million to 50 million people are seriously injured.[3] Vision Zero is rooted in the position that death and serious injury are not acceptable consequences of mobility, and strives to achieve optimal safety for all users on roads. Similarly, the intelligent transport system (ITS) whole-system approach, established in England over two decades ago, uses a formal assessment framework[4] that focuses attention on those areas that fundamentally advance safety for everyone using the transport system. The ITS whole-system approach aligns with the Vision Zero principle of shared responsibility.

The responsibility for providing road systems that are safe for all users rests with the system designers. System designers have the greatest influence over the design of the physical space—creating a system that works by design within which road users intuitively understand how to use roads safely. The guidance from Highways England for good road design[5] states, "Good road design places people and their safety at the heart of the design process."

Speed Management

The design techniques required to achieve safety vary according to the type of road being considered. System designers must evaluate the influential factors affecting the environment of each road and understand how to manage them within their spheres of control and influence. For example, an inter-urban road, such as a motorway,[6] operates within a different context compared to a street.

Common to achieving safety in all road spaces is the need for speed management to maintain speeds appropriate for the environment. Excessive speed is a toxin within the system. Sometimes, speed limits are reduced due to the weather, road-side activity, traffic conditions, and/or other factors affecting a road's context.[7] Speed contributes significantly to the severity of injury resulting from a crash—for car occupants in a crash with an impact speed of 80 kilometres per hour (km/h) the likelihood of death is 20 times greater than at an impact speed of 30 km/h.[8] The consequences for pedestrians are even greater—when involved in a collision with a car travelling at 30 km/h the chances of survival are 90 percent, at 45 km/h less than 50 percent and at 80 km/h virtually zero.[9]

Effective speed management comprises a range of measures that include the design of the space and how users operate within it, setting and enforcing appropriate speed limits for the context, education of users, understanding the effects of speed in crashes and using technology to encourage behaviour change. Technology,

[3] World Health Organization, road traffic injuries
[4] This assessment framework is explored in "On the 'ITS' Road Toward Vision Zero," article No. 2 in the WSP ITS-Vision Zero series. It explains how the hazards are identified within each environment and assessed objectively to inform the design toward achieving Vision Zero.
[5] Highways England, The road to good design, 2018

[6] The words "motorway" and "freeway" are used interchangeably throughout the article.
[7] World Health Organization, from World report on road traffic injury prevention, Road Safety, Speed, 2004
[8] ibid.
[9] Ibid.

using connectivity and additional sensors applied to infrastructure and in vehicles, such as advanced driver assistance systems, offers significant opportunity to reduce harm and create safer ecosystems through better awareness and levels of driver support.[10]

Tailored Design

One design feature of motorways/freeways to support safety is the control of access—in the United Kingdom, for example, motorway regulations prohibit some types of vehicle and user, including non-motorised users, learner drivers and motorcycles with engines smaller than 50 cubic centimetres. The combination of infrastructure design features suited to high speeds—such as grade-separated junctions—with the prohibition of slow-moving vehicles and pedestrians allows an appropriate speed limit of 110 km/h.

Designers of urban spaces, however, have little or no ability to control user access, resulting in the need for much lower speed limits and consideration of all types of user and forms of mobility—both established and emerging forms. If city roads were designed to eliminate access in a similar manner to motorways, this would severely limit the functionality of the system and the space to achieve its purpose—mobility and placemaking.

Linking land use planning and the design of roads is a critical step in achieving Vision Zero. To create safer ecosystems, system designers must identify the purpose of a road, what activities will be occurring on the road, who will be utilising the public space, and then design the road accordingly,[11] rather than applying standardised vehicle-centric designs regardless of context. Designing communities where people can live close to the amenities they need to access for work, shopping, leisure activities, and social and education purposes reduces and potentially eliminates the need for car travel.

Figure 2 - A “pop-up” demonstration project as part of a public involvement campaign supporting implementation of the Armour Road Complete Street Plan (North Kansas City, Missouri, United States). Phase 1 improvements have now been constructed, and since completion no serious injury or fatal crashes have occurred.[12]

Forgiving Ecosystems

The concept of forgiving roadside design[13] acknowledges that hazardous objects within the road space increase the risk of fatality and severe injury when a crash occurs. The standards or alignment—horizontal and vertical—for high-speed roads take speed into account and are designed to accommodate the higher operating speeds. The forgiving roadside removes potential hazards that could lead to fatality or severe injury; where it is not possible to remove a hazard, the potential for harm is reduced by design—following the ERIC-PD principles.[14] There are numerous examples of forgiving-design features:

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[10] Technology, using connectivity and additional sensors, is discussed “Adopting the ‘ITS’ Holistic View to Progress Road Vehicle Safety, article No. 4 in the WSP ITS-Vision Zero series.

[11] sustrans, UK walking and cycling organization

[12] See the brochure: *Vision Zero, Setting a higher standard for road safety*, WSP, p. 23

[13] Forgiving roadsides design guide, Conference of European Directors of Roads, Ref: CEDR report 2013/09

[14] “Designing Out Flaws Within Road Transportation Systems,” article No. 5 in the WSP ITS-Vision Zero series

- Shoulder width – where land is available, a wider shoulder provides a greater recovery area in the case where a vehicle leaves the road.
- Roadside barriers – protect a vehicle from striking a hazard, absorb the energy of impact, and, in many cases, allow the vehicle to come safely to its stop without significant harm to the occupants of the vehicle
- Barrier terminals – designed to deflect a vehicle or absorb the energy of impact (Figure 3)
- Rumble strips at the edge of carriageway – to alert a driver and allow corrective action to be taken
- Passively safe sign supports – to absorb the energy from a vehicle

Figure 3 - Energy-absorbing barrier terminal (photo: courtesy of Highway Care)

A self-explaining, or intuitive, road space seeks to prevent driver error; a well-designed vista or field of view enables drivers to focus their attention on the driving task and not be distracted. A forgiving design minimises the consequences of driver error. Design features can "nudge"/encourage the right behaviours—hard barriers alongside cycle lanes increase the severity of injury in a collision, whereas a gravel edge is more forgiving.

As advanced driver assistance systems become more prevalent in the vehicle fleet, opportunities to improve road safety will increasingly arise from the co-design of road space and vehicles—for example, designing signs and road markings that can clearly be seen and interpreted by drivers and machine vision systems such as automated lane-keeping assist functions. WSP in Australia recently tested characteristics of road markings to support functions of advanced driver assistance systems, noting substantial benefits to drivers of all vehicles through setting minimum widths, reflectivity and contrast to the surrounding pavement surface.[15]

The concept of creating forgiving ecosystems must be contextualized within the complex road system. Forgiving roads design elements/measures can improve safety for high-speed roads. However, as a forgiving road environment can lead to increased motorist speeds, incorporating forgiving design elements may be counterproductive to achieving Vision Zero in urban contexts with more roadside activity and diverse road users.

Coordinated traffic calming treatments including intentional vertical and horizontal deflection of motor vehicles, such as speed humps, chicanes, and curb extensions/bump-outs, are effective for reducing motorists' speeds through villages, towns and suburban areas, and can result in a safer environment for all users of the transportation ecosystem in these areas.

[15] Austroads, Connected and automated vehicles

Figure 4 – speed hump on a local street in Gothenberg. Sweden

Managing the Interfaces

Creating safe ecosystems requires system designers to acknowledge and embrace the competition between modes and between users, and create safe interfaces. The crash review and response process[16] enables designers to understand where and how to change the design of spaces to create a Safe System.

Managing the interfaces is a key factor in creating safe ecosystems—reducing the potential to fail by designing for conflicts at:

- Interfaces between modes
- Interfaces between modes and infrastructure – a forgiving space

Urban spaces are characterised by an increasingly complex set of interfaces—with the introduction of new modes, such as electric-scooters, electric cargo bikes and autonomous delivery pods, as well as greater provision for active modes alongside automobiles and motorcycles. The design of the physical space must take account of the potential for serious harm that these interactions introduce. Physical separation between each mode minimizes the risks associated with harmful interaction between modes—for example, cyclists and pedestrians, cyclists and motorised vehicles—but does not reduce the potential for "within-mode" harm (cyclists colliding with each other) unless there is separation between individual users travelling by a particular mode. Innovative design is required, as the physical separation of modes for movement within an urban space has the potential to compromise the infrastructure, access and activity required to support placemaking (Figure 5). Given that the potential for crashes resulting in fatalities and serious injuries reduces with lower speeds, measures that control speed create the greatest potential for achieving Vision Zero.

Figure 5 - WSP representation - a vision of a future street

Applying Technology

Technology can play a significant role in managing speed—on all categories of road—to reduce the likelihood and severity of crashes. On rural roads and in urban spaces, the use of vehicle-activated signs (Figure 6) has become more prevalent. When an approaching vehicle exceeds a pre-set speed, the sign will illuminate, providing the driver with a targeted reminder of the speed limit and/or the presence of a hazard ahead.

[16] "Designing Out Flaws Within Road Transportation Systems," wsp.com

Figure 6 - Vehicle-activated sign to encourage compliance with speed limits (photo: courtesy of Swarco)

Managed freeways and smart motorways use speed management to manage congestion and to achieve greater compliance with speed limits—to reduce crashes resulting in fatalities and serious injuries. These speed management systems rely on enforcement systems to support compliance—variable speed limits are displayed on signals either at the roadside or on gantries above the road. The enforcement equipment—radar detectors and cameras—are also located on structures. Active management of freeways and motorways can also include the use of dynamic signals to close lanes—to protect vehicles and people involved in a crash, for example, or to isolate debris on the road (Figure 7).

The design of a safe ecosystem in this context requires consideration of the mounting structures and their contribution to a forgiving and safe environment—mounting poles and gantries present obstructions, and the design of these structures must not create additional hazards. A cluttered space will not only introduce hazards that can increase the potential for, and severity of, harm but can also serve to distract the attention of drivers, increasing the risk of crashes. The design of the messaging, placement and operation of these signals must also be informed by the consideration of human factors—how drivers will understand and interact with the devices.[17]

Figure 7 - Automatic lane closure and enforcement system, United Kingdom (photo: courtesy of Redflex)

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To improve safety as communities progress toward Vision Zero, the designers of physical spaces, whether in an urban context, a rural area, suburban neighbourhood or on a freeway/motorway, must take a holistic view of roads—embracing the interdependencies and interactions between people, vehicles and space. This perspective also involves an understanding of the features, users and modes particular to each road/street space, as well as the road's purpose.

Figure 8 - A WSP project (current road - before possible design modifications) in Hutchinson, Kansas, United States noted six transportation modes at one intersection: pedestrian, cyclist, bus/transit, car/truck, tractor and horse & buggy (horse-drawn carriage).

Context-specific design is integral to the ITS whole-system approach and crucial for the creation of safe road ecosystems to achieve Vision Zero, which seeks to eliminate death and serious injury from road transport systems

[17] "Effective Intelligent Transport Systems Integrate Human Factors," article No. 3 in the WSP ITS-Vision Zero series

around the world. Safe road systems underpin mobility and are essential to the development of communities where people can and want to live, work, learn, socialize and thrive.

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