Intelligent Transport Systems *Advance Vision Zero Road Safety*

Adopting whole-system approaches enables safe and sustainable mobility for all.

The following article introduces a series exploring how intelligent transport systems can be applied to progress toward the goal of Vision Zero—zero fatalities and serious injuries within the worldwide road transportation system. The Swedish Parliament adopted Vision Zero in 1997, recognizing that death and serious injury are not acceptable consequences of mobility.

Viewing each intelligent transport system (ITS) within the broad context of a transport system—considering people, processes, infrastructure, vehicles, technology and associated data—is already standard practice in some parts of the world but a relatively new concept in others. This article explores the ITS whole-system approach in the United Kingdom (UK), where it was established more than two decades ago. The UK approach and use cases from the United Kingdom and Australia provide guidance for application, as countries, cities and communities of all sizes seek to implement road safety according to Vision Zero. ITS can become part of the Vision Zero road safety solution.

The six-part series also includes the following article topics: an effective assessment framework, crash review and response, safe people, safe vehicles, and safe spaces.

Society is facing significant issues: the impacts of climate change, increasing levels of congestion and the health consequences of COVID-19. All of these issues affect mobility—why, when and how people move about in their daily lives. Communities around the world must also continue to address another global public-health issue affecting both human life and mobility: Today, more than 1.35 million people die on the world's roads each year from traffic crashes; another 20 million to 50 million people are seriously injured.[1]

As communities increasingly seek to reshape transport systems to provide accessible, affordable and environment-friendly options, there is greater opportunity to focus on the fundamental human need for effective road safety. Transport infrastructure networks that facilitate the safe movement of people and goods will also enable communities to thrive and prosper.

How can we—all those responsible for planning, designing, operating and maintaining transport and infrastructure—use this period of upheaval to create safe and sustainable roads and mobility for everyone? The answer begins by considering how the benefits of the rapidly growing intelligent transport system (ITS) market can support a paradigm shift to the Vision Zero road-safety approach (Figure 1). Vision Zero's main message is that death and serious injury on the world's roads are preventable.

Effective intelligent transport systems integrate people, processes, infrastructure, vehicles, technology and associated data to form safe and efficient environments for the movement of people and goods. It is when ITS is considered in this holistic manner—rather than focusing solely on the technological aspects—that it achieves the most beneficial outcomes. Without this system-based approach, potentially positive changes to individual aspects can have adverse impacts on other parts, and therefore on the overall system. Introducing a new technology, for example, may create an unintended negative effect on safety if it has not been considered holistically.

Road Safety Urgency

1.35 million people die on the world's roads each year; another 20 million to 50 million people are seriously injured.

Vulnerable Road Users
More than half of all road traffic deaths are among pedestrians, cyclists and motorcyclists.

Source: World Health Organization

PARADIGM SHIFT

	Traditional/Prevailing	Vision Zero
Issue	Preventing all crashes	Preventing fatalities and serious injuries
Premise	Deaths are inevitable	Deaths are preventable
Focus	Perfecting human behavior	Designing a road system that takes into account human error
Responsibility	Individual road users	Shared: road users and system designers

Figure 1 — Principles of Vision Zero

1 World Health Organization

Powerful Partnership

Providing infrastructure for 21st-century mobility is a multifaceted undertaking that requires contributions from diverse stakeholders. The Vision Zero approach embraces these key stakeholders—known as system designers[2]—who apply their knowledge and expertise to make and keep roads safe for all users—including pedestrians, cyclists, motorcyclists, drivers, passengers and those for whom the transport network is their workplace. The Vision Zero framework considers all users, modes and interfaces—and prioritises consideration of the safe passage of vulnerable road users who comprise more than half of all road fatalities.

Road safety approaches have tended to focus on perfecting human behaviour rather than designing a road system that accounts for human error. Vision Zero views safety in the context of the entire road system and accounts for human error.

The Vision Zero paradigm is based on shared responsibility among the road transport system users and system designers (Figure 2). Road users should follow the rules; system designers are responsible for preventing severe injury and death on urban and rural roads. If users fail to comply with these rules—due to a lack of knowledge, acceptance or ability—the system designers are required to take the necessary further steps to counteract people being killed or seriously injured.

If the road users fail, the system should not; all parts of the system need to be considered so that if one part falls short other parts will protect users.

A fundamental tool in creating a Safe System—including safe people, safe spaces and safe vehicles—is speed management, or managing the speed of vehicles according to what is appropriate for the environment. The Safe System approach ensures that the impact energy of an incident remains below the threshold likely to result in death or serious injury.

Intelligent transport systems can have a key role in enabling the achievement of a safe transport system. To be effective, it is essential that the whole system is considered, not just the technology. Aligning this holistic approach to ITS with Vision Zero proven practices has led to a reduction in fatalities and serious injuries.

Automated Speed Enforcement, *Sweden*

The installation of "life-saving cameras" in Sweden has reduced fatalities by 50% and all injuries by 20%.[3]

Figure 2 — Responsibility for safety is shared in the Vision Zero approach. (adapted from the Swedish Transport Administration)

2 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.

3 *The Handbook of Road Safety Measures*, chapter 8.2, Institute of Transport Economics (TØI)

The controlled motorway, introduced on the M25 West of London in 1995, used speed-management technology to smooth traffic flows, reduce congestion, reduce harmful emissions and create more reliable journey times. The smoothing of traffic flows and reduction in journey times considerably reduced driver stress and impatience, directly contributing to a reduction in collisions. The smoother flow of traffic also reduced noise and air pollution resulting in a benefit to public health. Controlled motorways now cover 220 kilometres (137 miles) of the English motorway network and carried 7 billion miles of traffic by the end of 2018; the overall safety benefit has been a reduction of 13 percent in fatal and weighted injury rates.[4]

The controlled motorway demonstrated that creating a controlled environment led to more compliant behaviour so that when lower speed limits were displayed, they were obeyed. Driver education was an integral part of the scheme and resulted in motorists understanding that by obeying the variable speed limits they would experience less stressful and safer journeys. The actual number of speed cameras required to achieve the outcomes was relatively low.

Prioritising speed management, a cornerstone of Vision Zero, can be facilitated using ITS technologies and processes—which include education alongside engineering and enforcement-compliance. This holistic approach brings the ability to provide different solutions; in some locations, for example, installing speed cameras will likely result in injury reduction, which, in other contexts requires further measures.

The development of smart motorways in England, starting with the Active Traffic Management (ATM) Pilot in 2006, has relied upon the alignment of ITS with the Safe System approach of shared responsibility that lies at the heart of Vision Zero. The assessment framework developed for the ATM Pilot was used to identify, assess and mitigate the impacts of the (over 100) potential hazards within the operational system, and used to frame the design. Examples of the hazards defined include events such as 'Driver drives too fast' and 'Vehicle stops in traffic lane'.

A paradigm shift in road safety to Vision Zero will continue to lead to meaningful reductions in road traffic deaths.[5] Aligning ITS with a Vision Zero mindset and methodology creates a powerful partnership—full of opportunities to transform the design, operation and management of road transport networks and achieve meaningful outcomes.

Active Traffic Management (ATM) Pilot, *England*

The ATM Pilot combined technology, people, process and infrastructure to create a new operational transport system.

The pilot demonstrated the following safety, health and environmental benefits:

26% reduction in average journey time

50% reduction in personal injury accident rate

80% of the benefit for 20% of the cost (compared to widening)

4% reduction in fuel consumption

30% reduction in noise levels

7.5% reduction in level of harmful pollutants

Variable Speed Limit Operations *Queensland, Australia*

In the first year of smart motorways, motorists experienced a nearly 50% drop in rear-end crashes with variable speed-limit signs on the Bruce Highway. The severity of crashes also reduced, with the percentage of hospitalisation crashes dropping from 43% to 20% since the implementation of variable speed-limit signs on the Bruce Highway.

4 *Smart Motorway Safety, Evidence Stocktake and Action Plan*, Department for Transport (DfT), United Kingdom, 2020

5 *Vision Zero: Setting a Higher Standard for Road Safety*, WSP, pp. 12-13

Mobility in a Changing World

While the achievement of Vision Zero is a complex effort, cities and countries are rising to meet the challenges that come with a commitment to develop safe roads and safe mobility. International organisations—including the United Nations, the World Health Organization, World Resources Institute, and the Organisation for Economic Co-operation and Development—have endorsed the Safe System approach to road safety.

Working in sync, ITS and Vision Zero can embrace change and implement appropriate practices. Both are based on strategic, evidence-based, whole-system approaches that improve road safety.

The mobility landscape is constantly evolving—responding to and preparing for demographic, economic, environmental and technological developments. Whole-system approaches consider influential dimensions—of developments individually and in combination.

Significant dimensions for consideration include:

- **Climate Emergency** – The transport sector needs to be decarbonised if the globally agreed safety threshold of a 2°C increase in average temperature is to be achieved. Fundamental changes to the transport system will be required to attain this goal—including infrastructure design and construction, shared mobility, propulsion/fuel—all of which impact the types, mix and profile of risk within the system.
- **Congestion** – Demand for mobility and use of the transport system fluctuates according to economic growth. Greater demand for mobility increases traffic volumes and congestion and therefore the risk of injury and death. No one should be excluded from safe, affordable and reliable transport; adapting the system to become more inclusive changes the risk profile and introduces new challenges and opportunities.
- **Health** – Transport can also negatively affect public health due to vehicle emissions, noise and brake dust. These undesired consequences adversely affect air quality and can create health issues. A holistic approach needs to be taken, as improved access to transport can also support improved health. New risks and opportunities continue to emerge. For example, the COVID-19 global pandemic fundamentally changed how people, commerce and places function. COVID-19 has accelerated some positive societal changes and responses as well as introducing new risk-reducing behaviours and reactions.

These and other factors will continue to affect decision-making. The key is appreciating that transport is a system with multiple dependencies and interfaces. Any change or disruption needs to be recognised and managed within the context of the system, rather than in isolation. A single change in one part of the system can have unintended consequences elsewhere—hence the need to consider the system holistically.

For example, the removal of the hard shoulder on motorways in England to increase capacity was considered in a holistic way to maintain a safe network. This shift represented a new operational regime for motorways and needed to be approached in the context of an operational system. The overall system design took account of the interfaces and dependencies between road infrastructure, people and vehicles. An evidence-based hazard analysis was used to

Bruce Highway Road Operations Improvements Project (BHROIP) *Queensland, Australia*

The BHROIP provides increased situational awareness across 1700 km of rural highway, using bespoke technology for incident detection, flood monitoring and traveller information provision to create a safe operating system.

Smart Motorway (All Lane Running, ALR) development in *England*

The Smart Motorway Programme for English motorways is based on the conversion of the hard shoulder into a traffic lane, using physical infrastructure, technology, people and processes to create a safe operating system.

The DfT Stocktake found:

- Fatal and weighted injury (FWI) rates on ALR roads were lower (0.35 per hundred million vehicle miles (hmvm) than on conventional motorways (0.38).
- Overall, the collision risk declined after ALR was introduced, which was consistent with earlier modelling.

determine the overall safety and risk profile for the new operational regime. Using the Safe System approach developed for the ATM Pilot, it was determined that safety could be improved compared to a baseline of a standard motorway. This was confirmed by post-opening monitoring studies and tested during the Department for Transport's *Smart Motorway Safety Evidence Stocktake and Action Plan*.[6]

Traffic Officer Procedures

Highways England's Traffic Officer Service helps to keep road users safe and to keep traffic moving on the strategic road network (SRN) of motorways and all-purpose trunk roads. They attend to incidents, provide rolling road blocks and many other customer-facing services that enable the safe operation of the SRN.

Traffic Officers form an essential part of the overall Safe System, linking technology and infrastructure with people and process. They work according to procedures designed to form part of that overall Safe System.

Traffic Officers have attended almost 1 million incidents since 2015.

Transport Systems from the ITS Perspective

Transport systems comprise dependent and interacting elements. At a system level, any disruption or sub-optimal performance leads to inefficiency. When the system is managed safely, it also becomes more efficient.

On an elemental level, any mobility-transport system comprises five interdependent areas:[7]

- **Physical Space**
  the infrastructure, including technology, signs, lining, etc.
- **Users**
  the people who use and access the system
- **Vehicles**
  cars, buses, trucks, motorcycles, etc.
- **Designers & Implementers**
  the people responsible for creating and building the system
- **Operators & Maintainers**
  the people who operate and maintain the system.

The users of the system are diverse and complex—from drivers and passengers to pedestrians and cyclists—each with their own needs and vulnerabilities that need to be considered.

Within a transport system, competition exists between modes, users and network types. It is the interfaces and interactions within the system that most often lie at the heart of any issue. The whole system therefore needs to be designed and operated to achieve the required outcomes—with the Safe System approach guiding the process.

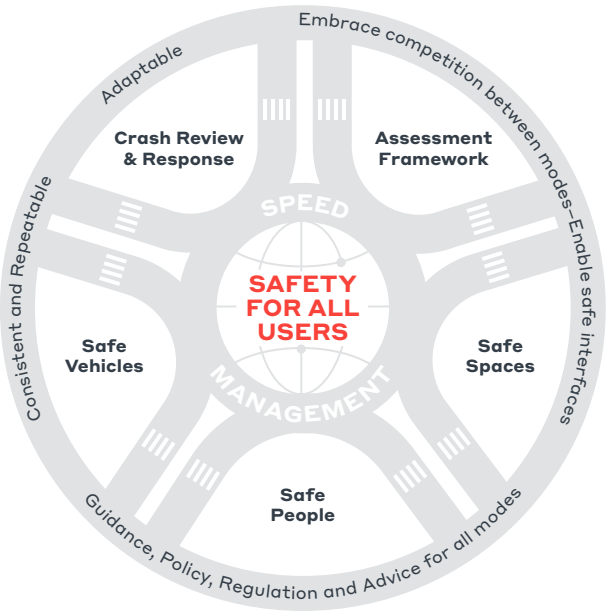

Figure 3 — Re-imagining the transport system and aligning with the Safe System approach will create sustainable outcomes.

6 *Evidence Stocktake and Action Plan*, DfT, United Kingdom, 2020

7 Noting - According to the Vision Zero approach, system designers include designers, implementers, maintainers and operators as described in the text and referred to in Figure 1 and Figure 2.

Safety at the Centre

Most serious traffic incidents are both predictable and preventable. Adding ITS, with its data-led ethos, to Vision Zero practices creates greater ability to prevent serious injuries and fatalities.

The Safe System approach manages the interactions between system components throughout the whole lifecycle of a network—taking full account of human vulnerability and resulting in a system that has been designed to be forgiving of human error. It is based on understanding and considering the needs of all users.

By placing safety at the centre of the system, those involved in designing, managing and operating the system can clearly see how their decisions and actions impact safety and their contribution towards achieving Vision Zero. An evidence-led approach, using both qualitative and quantitative data, enables system designers to get to the root causes of the failures that lead to death and serious injury. Understanding and dealing with the root causes, rather than the symptoms or presenting issues, leads to safer systems. ITS can be an enabler within the overall system that supports safe and efficient operation.

ITS solutions range from a simple, fixed-plate speed-limit sign, for example, to an all-encompassing system that links together vehicles, infrastructure and customers. The A2M2 Connected Vehicle Corridor Trial tested systems that connect motorway signalling with displays in test vehicles to demonstrate the potential benefits of providing variable speed limit and roadworks information directly into in-vehicle displays.

Figure 4 — A2M2 Connected Vehicle Corridor trial of in-vehicle 'virtual gantries'

The Future Role of ITS

It could be argued that technology has been used to manage mobility since the introduction of the first traffic signals in London in 1868. The manually operated gas-lit signal exploded less than a month after it was implemented, injuring the police officer operating it—an example of a non-holistic approach, where the introduction of one element in the system had an adverse impact on another part of that system (the human operator). The use of technology within transport has evolved significantly since those early pioneering attempts, which makes the evidence-based Safe System approach even more important as systems become increasingly complex.

It is essential that ITS is viewed as, and within, a holistic system that enables mobility, and one that considers the whole transport system and its interfaces rather than focusing on the individual devices or the technology in isolation. Just as with Vision Zero, all aspects need to work in harmony with each other for the system to operate safely and efficiently. When considered and used properly from the outset, ITS can therefore become part of the Vision Zero road safety solution.

Moving Forward Together

Transport systems are an intrinsic part of any society, enabling mobility, which in turn facilitates access to activities—education, employment, social interaction—that create vibrant and healthy communities. While increasing reliance on technology presents both opportunities and challenges for ITS, there is a timely opportunity to integrate ITS into socially acceptable solutions and practices that support Vision Zero. It is imperative that the benefits of technology and digital advances are brought into a whole-system approach to continuously reduce the number of deaths and injuries in transport.

Using leading safety indicators creates a more proactive method and culture of decision-making that embraces safety, inclusivity, health and wellbeing as fundamental components of thriving transport-mobility systems. Looking backwards at what has happened and why provides valuable evidence and understanding of how and where a system has failed; looking forward requires the desired outcome to be articulated. The Vision Zero approach combined with data-led ITS solutions enables a sustainable route towards the desired and essential outcome—no deaths or serious injuries on the world's roads.

Leading safety indicator examples:

- Reporting of near misses enables action to be taken to prevent injury: Reporting instances of scalding or near misses with hot water and kettles in offices led to the use of taps that dispense boiling water, removing the hazard.
- Reports of tyre scuffs on kerbs indicate that drivers are not cornering safely—leading potentially to a reduced speed limit, preventing more serious incidents.

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