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Net Zero x Vision Zero: integrated through ITS

T Grahamslaw[1], M Bray[2], A Kappeler[3], M van der Sanden[4]

1. Associate, WSP, 8 First Street, Manchester, M15 4RP, UK, +447525083068, thomas.grahamslaw@wsp.com
2. Senior Consultant, WSP, 1st Floor, Exchange Station, Tithebarn Street, Liverpool, L2 2QP, UK, +447584337407, michael.bray@wsp.com
3. Associate Director, WSP, 62-64 Hills Road, Cambridge, CB2 1LA, UK, +447500884351, axel.kappeler@wsp.com
4. Graduate Consultant, WSP, 8 First Street, Manchester, M15 4RP, UK, michael.vandersanden@wsp.com

Abstract

As a global society we face unprecedented challenges, from climate change to the economic, health and social effects of a pandemic. These are refocusing our attitudes and acceptance of many aspects of life, and mobility forms an integral part in these discussions. Global transport strategies are reacting to these challenges and aiming towards safer and more sustainable systems. Net Zero and Vision Zero are two future outcomes that frame the opportunities; combating climate change and delivering transport systems where nobody is killed or seriously injured are now key focus areas for society.

Successful delivery requires integration of both 'zeros'. Without a whole system approach the two have the potential to diverge and compete, creating challenges that may prevent outcomes being achieved. This paper explores how digital transformation, driven through intelligent transport systems (ITS), enables transport to embrace data, technology and connectivity to work towards a common path to delivery of strategic outcomes of Net Zero and Vision Zero.

Keywords: Net Zero, Vision Zero, digital, intelligent transport systems, whole system approach.

Introduction

Society is faced with unprecedented global challenges including the impacts of climate change and the economic, health and social effects of a pandemic. These have and will continue to impact transport and mobility.

Climate change is the most significant challenge facing humanity. Left unchecked, global warming will lead to largescale environmental and social damage with rising sea levels, increases in temperature, more frequent extreme weather, reduced farming yields and much more. Limiting global warming to well below 2^{o}C is essential to mitigating the impact these changes will bring.

A commitment to limit global warming to well below 2^{o}C was drafted during the 2015 United Nations Climate Change Conference in Paris, France (UNFCCC, 2015). In total, 196 countries have adopted the treaty known as the Paris Agreement and agreed to decarbonise and work towards a Net Zero carbon society by 2050. As each country faces unique challenges, the 2015 Paris Agreement does not provide a standard approach to decarbonisation. Instead, the treaty outlines a common consensus and a Net Zero target. Each signatory is required to outline their own decarbonisation strategies in a 'nationally

determined contribution' (NDC). Following existing commitments, the UN expects a significant shortfall and anticipates an average global temperature rise of 3.2°C by 2100 (UNEP, 2019). Transport forms a significant contributor to global CO_2 emissions, being responsible for between 10-15% of all global emissions (and 24% of global fuel combustion emissions), making it the second highest industry contributor to climate change (Ritchie, 2020). Within the transport sector road transportation (both passenger and freight) remains the most significant polluter, accounting for 45% and 29% of global transport emissions respectively (Ritchie, 2020). This is largely due to the vast tailpipe emissions that result from burning petrol / diesel in internal combustion engines (ICEs) and the sheer quantity of privately owned ICE vehicles.

The world continues 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 collisions; another 20 to 50 million people are seriously injured (WHO, 2018). This demonstrates the scale of the challenge surrounding road safety and ambitions to eliminate fatal and serious injuries.

These two key global challenges surrounding safety and decarbonisation are at the forefront of transport policy and global infrastructure strategies. Improving safety (Vision Zero) and decarbonising transport (Net Zero) are recognised as essential components to achieving a sustainable global system. The response in the UK has been to set ambitious targets (refreshed in the recent 'greenprint' by the Department for Transport (DfT, 2021) for reducing greenhouse gas (GHG) emissions and achieving Net Zero (by 2050) and for some road network operators such as Highways England, reducing road deaths and serious injuries to zero (by 2040). At present the two targets are on separate paths but it is clear the two need to be integrated and not treated as mutually exclusive, as the two are key outcomes from transport interventions and use.

Society is embracing technology across all aspects of life; be this the way we shop or the way we travel. In a transport environment, these outcomes have traditionally applied technology to improve safety, customer experience and efficiency in delivery, however there is growing recognition of the wider benefits that intelligent transport systems (ITS) can provide. With a global focus on climate change, could ITS be the key to integrating and delivering the desired safety and decarbonisation outcomes for transport?

Effective ITS combine people, processes, infrastructure, vehicles, technology and associated data to form efficient and safe 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 beneficial changes to individual aspects can have adverse impacts on other parts, and therefore on the overall system.

Figure 1: Whole system thinking requires consideration of all parts of the transport ecosystem (source: Patey, I et al, 2020)

This paper explores the opportunities on offer to integrate and achieve both goals of Net Zero and Vision Zero, in a transport setting, with ITS as the enabler. This paper also explores how these opportunities can be viewed holistically applying a whole system approach to maximise the benefits of ITS.

Net Zero: an overview

Net Zero is the common goal of governments and society to combat climate change by 2050 or sooner. It's about striking a balance between the carbon emissions going into the atmosphere and those being removed; recognising the ultimate objective to eliminate emissions altogether. Mitigating climate change is essential to slowing down global temperature rise and the associated social and environmental impacts. By striving for Net Zero we can limit the harm to future generations.

The UK Department for Transport's recent publication, 'Decarbonising Transport: setting the challenge' (2020), identified that transport became the largest emitting UK sector of GHGs in 2016, responsible for 451 million tonnes of CO_2e, equalling 28% of all UK emissions (Figure 2). This firmly places transport in the spotlight of the decarbonisation agenda. Whilst this paper speaks to transport as an industry, we must recognise that over 85% of domestic transport emissions come from roads (DfT, 2020), the examples are therefore focused on this mode.

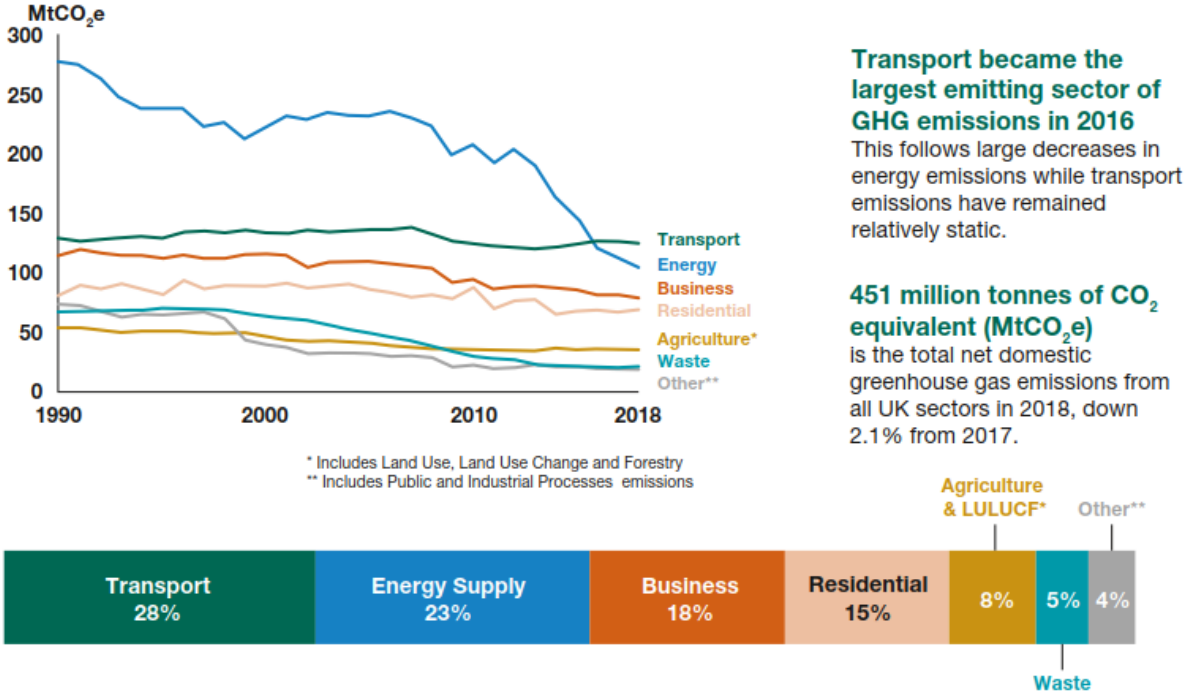

Figure 2: GHG emissions by sector showing transport as the largest (source: DfT, 2020)

Decarbonisation forms the means of reducing and eliminating carbon emissions. From a transport perspective this means considering how carbon can be eliminated from: construction materials in transport projects (embodied carbon), transport operations e.g. use of transport networks (operational carbon) or disruptive construction activities e.g. releasing carbon locked in the ground (sequestered carbon).

Vision Zero: an overview

Vision Zero seeks to eliminate fatalities and serious injuries within the worldwide road transportation system. The Swedish Parliament adopted Vision Zero in 1997 recognising that death and serious injury are not acceptable consequences of mobility. Today, countries and cities around the world continue their journeys toward achieving a higher level of road safety, applying the Vision Zero philosophy and evidenced-based approach to designing safe road systems (WSP, 2018).

Vision Zero is a paradigm shift that requires an open and transformative mindset and approach to eliminate all road related fatalities and serious injuries. moving away from what is possible to what is necessary (Figure 3). Vision Zero's principles are shown in Figure 4.

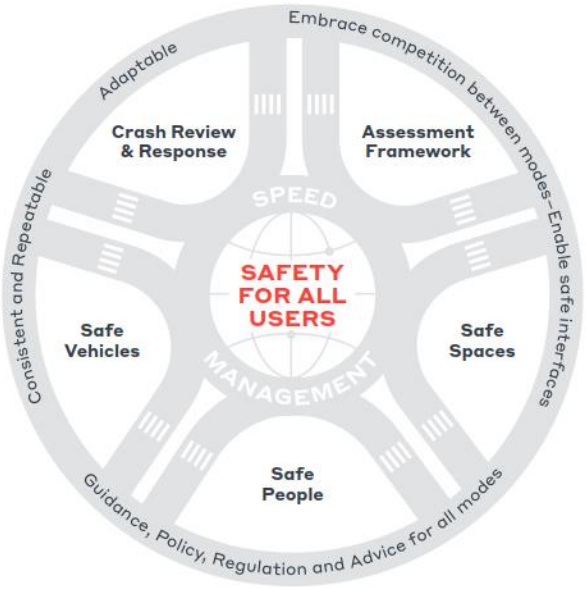

Figure 3: Re-imagining the transport system and aligning with the Safe System approach will create sustainable outcomes (source: WSP, 2018)

	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 4: Principles of Vision Zero (source: WSP, 2018)

This paradigm shift in building a safe system is a holistic exercise relying on collaboration and shared responsibility (Figure 5) between various levels of government, public services, private industries and other road managers. The Vision Zero approach embraces these key stakeholders known as system designers[1] 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.

[1] *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. (WSP, 2018)*

Figure 5: Responsibility for safety is shared in the Vision Zero approach (source: WSP, 2018)

This shared responsibility among system users and system designers recognises; 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 paradigm shift in road safety to Vision Zero will continue to lead to meaningful reductions in road traffic deaths. 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.

Opportunities for integrating Net Zero and Vision Zero through ITS

How can we, all those responsible for planning, designing, operating and maintaining transport and infrastructure, create safe and sustainable roads and mobility for everyone? The answer begins by considering how the benefits of the rapidly growing ITS market can support a shift in approach and mindset to elevate safety and decarbonisation to the top of the policy and strategy agenda. Embracing digital as a catalyst for change provides a unique opportunity to support delivery of safety and sustainability ambitions.

Currently, transport strategies focus on safety and decarbonisation separately creating potential challenges in creating solutions that help us achieve both outcomes, as achieving both can end up more by luck than judgement. Focus should be on achieving outcomes, considering the linkages and interdependencies across interventions, rather than solutions in isolation. This starts to change the mindset when dealing with complex global challenges such as improving safety and decarbonising transport.

This offers us an opportunity to improve the link between safety and decarbonisation through ITS interventions, working to achieve both outcomes through better use of data, technology and connectivity. The recognition of the change required is however gaining more strategic focus with major infrastructure clients considering how best to adopt ITS to improve the way networks are designed, built, operated and used. Opportunities to deliver long term benefits whilst creating a safe and sustainable network should be considered across the whole lifecycle. This paper explores the opportunities to integrate ambitions using three themes where ITS forms a key role.

Table 1: ITS themes where alignment of Net Zero and Vision Zero can be achieved

#	Theme	Summary
1	**Making best use of existing assets**	ITS and the application of technology can support network operators in making the best use of their existing assets, be this use of sensors to gain better understanding of traffic conditions or asset health, through to roadside infrastructure that supports smoothing of traffic and more controlled networks.
2	**Modal shift**	Data, collected from roadside technology, can support network operators in providing better information provision to their customers. In turn this allows the customer to make more informed decisions on routes and modes for travel, or whether to travel at all.
3	**Connectivity and automation**	ITS are the driving force behind making future mobility happen. Connected and autonomous vehicles are at the centre of the ITS industry's future and evidence of increasing connectivity is already underway across the transport sector, this forms a great opportunity to improve safety and improve network performance and decarbonising transport.

Each of the above are explored in more detail demonstrating the ITS opportunities that offer the ability to provide both safety and decarbonisation benefits alongside an integrated approach.

Making best use of existing assets

Maximising the use of existing road networks prevents new roads being built or traditional widening schemes from being constructed to increase capacity. ITS offers the ability to make better use of data to inform more accurate interventions, integrate technology to maximise flow and improve control of traffic and introduce connectivity and automation to unlock new operating models. These options in turn create systems that minimise the significant embodied carbon impacts of new build roads whilst enabling smooth flows from an operational carbon perspective. Safety is enhanced through greater control of traffic, smoother traffic flows and the ability to dynamically adapt to incidents and other heightened situations.

Information about incidents and disruptions can be communicated to customers through on road systems, in-vehicle systems, mobile applications and other means. This helps customers make informed travel decisions including alternative routes, use of alternative transport options or deciding not to travel helping to reduce carbon emissions from sitting in traffic jams or improving safety through reduced conflicts. An example of this is smart motorways which convert the hard shoulder of traditional motorways in the UK to a permanent running lane and utilise technology to enable operational performance to be maximised and delivered safely. Increasing capacity by 33% without the need to build additional lanes significantly reduces the carbon footprint of new road schemes. The use of ITS through overhead signs and signals, detection systems and CCTV support the reduction in congestion, both improving safety and lowering tailpipe emissions associated with queuing or stop/start traffic conditions. Speed management with use of the technology also supports the reduction in severity of incidents, contributing to Vision Zero ambitions, and enables reductions in speed limits that can respond to air quality monitoring and environmental impacts.

Improved integration of data into decision making around enhancements to existing networks, brought about by roadside technology and digital twin capabilities, aids a better understanding of the needs of the network and of those using it. By understanding challenges and constraints better, we can improve the targeting of interventions and new assets to deliver a more refined holistic ITS solution. If we consider the design of emergency areas as an example, there is the requirement for various data sets to inform the network operational performance, i.e. breakdown locations, traffic flows, gradients etc. These data streams are brought together through a digital twin, offering the ability to generate intelligence to support design. Digital design tools then enable the balancing of varying parameters (i.e.

operational performance, geometry, carbon impact) in the design of future emergency area locations enabling an operational focused outcome to improve safety, that also works towards delivering other key client objectives i.e. Net Zero. Further to this the virtual design environment allows for different options to be assessed for both safety and carbon impacts and digital rehearsals further testing construction impacts.

Technology allows for increased value through better use of data to create information and ultimately intelligence. In the context of network operation and asset management, this creates an opportunity to increase predictive maintenance and targeted network interventions. For example, self-healing materials and roadside technology with remote diagnostics and repair capabilities reduce the need for workers on site, and reduces network downtime. This enables operators to minimise the disruptive impacts of roadworks leading to improved network performance and reduced emissions. By removing disruption, we can also improve safety with fewer hazards for workers and users, resulting from less stressful driving and working conditions.

Modal shift

Modal shift provides a significant opportunity to decarbonise transport networks and digital transformation is key to enabling it. It also allows users to transition to safer means of travel, in respect of public transport comparative to personal car use per mile travelled, and to a more active and healthier way to travel when walking or cycling compared to sitting in a car. During the COVID-19 pandemic, the shift to active travel has been considered in Copenhagen, Denmark where plans to embed LED road markings into the road pavement have been proposed to enable alternative use of space, including cyclists, depending on the time of day. In addition, the 'Green wave' development in Copenhagen promotes the use of existing space for cyclists and supports safety in the urban environment. The use of sensors and LED markings aim to reduce the number of stops cyclists need to make based on a measurement of their average speed.

Through improved information provision to customers about the operational performance of transport networks, ITS can support proactive modal choices before journeys begin. For example, through improved use of data and information streams customers can have access to real-time congestion data enabling proactive decisions to switch modes for an improved journey experience. With targeted digital transformation in active travel (i.e. to walking and cycling) such as geofencing, allowing the protection of vulnerable users in a connected environment, individuals will find it easier to shift to low carbon transport modes leading to meaningful reductions in emissions. Through better uptake and investment these options can be made safer through segregation, for some modes, and integrated for full end-to-end journey coverage providing a robust alternative to personal car use.

It has been shown that improving safety in active travel positively impacts the modal shift from motor vehicles to active travel, especially for cycling (Ton et al., 2019). ITS enabled vehicle to everything (V2X) technologies are being expanded to include bicycles and cycling peripherals. An example of this is seen in Australia where Telstra and Arenburg are developing 5G connected cycle helmets that feed in to V2X devices enabling cyclist-detection based automatic braking and priority access at junctions (Brown, 2021).

Connectivity and automation

While the physical design of vehicles is outside the scope of the intelligent transport system field of work, there are vehicle-focused technologies, either specific to the vehicle itself or as part of the broader data-led ITS whole-system approach, that have an impact on the overall safety and sustainability of the transportation ecosystem.

In the longer term, the widespread use of connected, automated and ultimately autonomous, vehicles will provide further opportunities to improve network performance and offer greater intelligence for

journey planning, ride sharing and optimal vehicle performance. Each has a significant part to play in enhancing the customer experience and the integrated approach required to decarbonise our transport networks. Further to this, in an autonomous world, we would expect to see significant reductions in network assets, an example is the concept of 'Naked Highways' where no roadside assets are required, reducing the embodied carbon and construction/maintenance related emissions.

Improving operational capability through automation is an opportunity that network operators are embracing. Using data and technology to gain a better understand of what is happening across a network provides a foundation which when built upon with automation and machine learning enables more predictive actions to be undertaken and enhanced capabilities for proactive network management. This provides significant opportunities to optimise traffic flows and contribute to the decarbonisation agenda through reducing emissions.

Trials of Intelligent Speed Adaptation (ISA) have been carried out in numerous countries, including Sweden and the Netherlands. ISA is an in-vehicle system that supports driver compliance with speed limits (European Commission). ISA is predicted to save up to 33% of accidents on urban roads, particularly those killed or seriously injured of which speed is a major contribution, and to reduce CO_2 emissions by up to 5.8% on 70 mph roads (Lai et al., 2012).

Wider opportunities

The accelerated transformation in the way we work, brought about by COVID-19 is a prime example of how flexible working can reduce the demand for transport. Whilst it is too early to tell whether this trend will continue, trends suggest reduction in demand has led to significant reductions in emissions as well as fewer road deaths. Longer term changes across transport will not be so easy and as the globe starts to move into a new normal, we will need to look at more gradual ways to decarbonise our transport networks as well as making it safer for all to use.

Applying whole system approach to deliver outcomes

Effective intelligent transport systems combine 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.

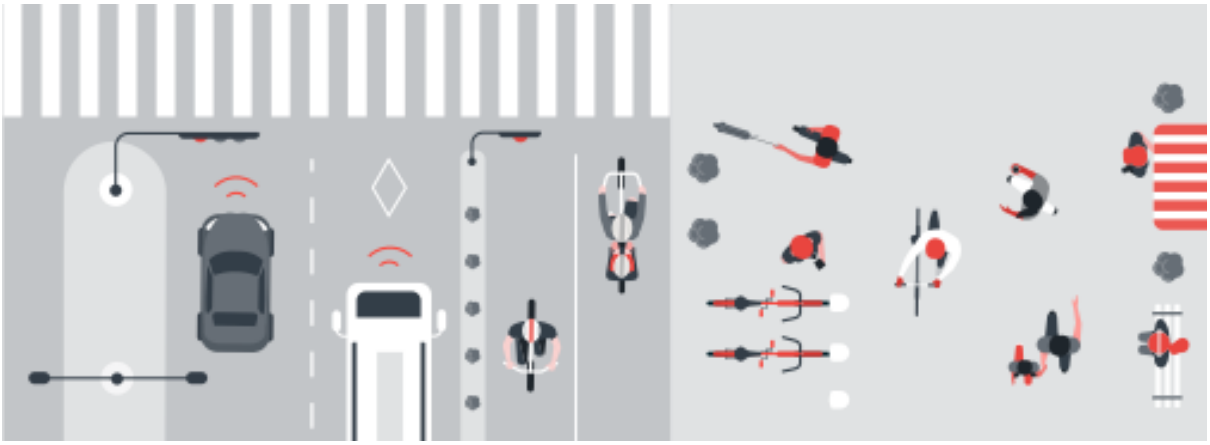

Figure 6: ITS considered holistically supports a safer and more efficient transport system (source: Patey, I et al, 2020)

Without this system-based approach, potentially beneficial 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 impact on the environment if it has not been considered holistically (Patey et al., 2020).

Traditional road transport interventions have been developed and delivered seemingly in silo, with the integration of varying modes an afterthought in most cases. Thinking about the whole system becomes a fundamental requirement when approaching transport strategy for the longer term and delivering ITS interventions that aim to better connect and facilitate changes in behaviour and outcomes.

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 and improvements in environmental factors. Transport infrastructure networks that facilitate the safe and sustainable movement of people and goods will also enable communities to thrive and prosper.

Elevating Net Zero alongside a safety-first approach allows for a decarbonisation related step change quicker than would traditionally have been achieved. A holistic perspective of transport systems, working towards both Vision Zero and Net Zero, will facilitate improvements leading to the ultimate prevention of death and serious injuries and decarbonisation within the worldwide road transportation system. To further explore these opportunities, it is important for transport policy makers and network operators to integrate their digital transformation and Net Zero strategies, identifying synergies and opportunities to align and realise benefits across both.

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