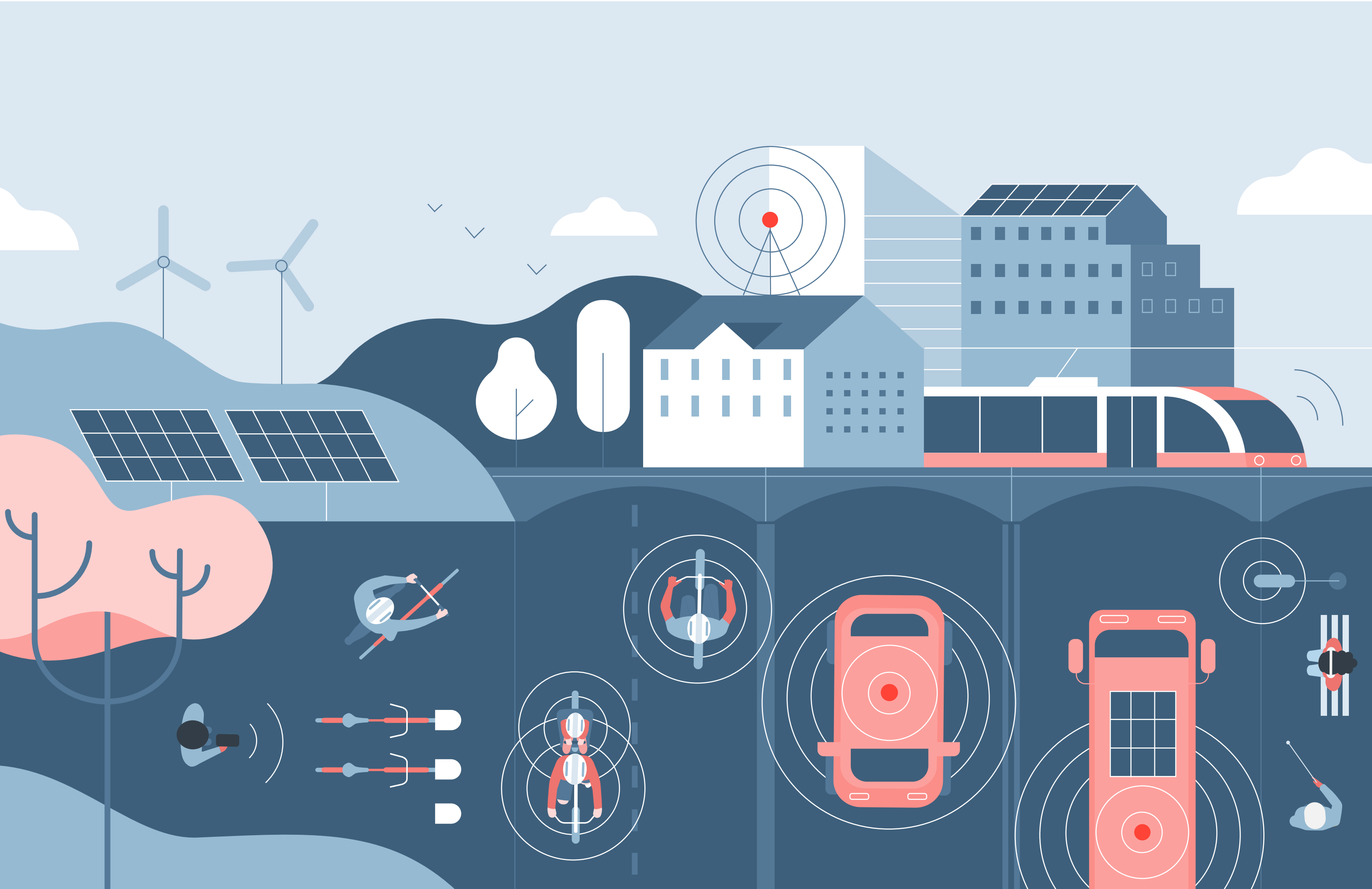
Intelligent Transport Systems *Enable the Decarbonization of Road Transportation*

A whole-system approach to achieve net zero ambitions



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Introduction

Our planet is warming at its fastest pace in history. Securing a world that can support life now and for future generations requires all countries to tackle the urgent global climate change challenge. Immediate and continuous action to nurture planetary health will also improve livelihoods and communities. Reducing greenhouse gas (GHG) emissions demands decarbonization efforts across all sectors. This whitepaper explores how intelligent transport system (ITS) expertise can accelerate the decarbonization of road transportation; the principles discussed also apply to other sectors within the overall transportation system.

Harnessing the collective know-how of our professionals around the world, we have prepared this analysis as a "greenprint" to help make the rapid transition to solutions that minimize and ultimately eliminate carbon impacts; it is also intended to prepare system designers for the many challenges ahead.

The whitepaper proposes a holistic perspective—one that considers people, processes, places, infrastructure, vehicles, technology and associated data—to advance comprehensive change as societies set targets and form pathways to achieve net zero ambitions.

Demystifying the terminology

Net zero

Striking a balance between the GHG emissions going into the atmosphere and the GHG emissions being removed. The Intergovernmental Panel on Climate Change (IPCC) identifies 2050 as a pivotal date to achieve net zero, to limit global warming to 1.5°C above preindustrial levels, consistent with the Paris Agreement.

Decarbonization

The approach needed to achieve net zero and a carbon negative future. Simply put, it means reducing carbon dioxide (CO_2), the primary greenhouse gas emitted through human activities. It is part process and part behaviour, as it requires a "net zero first" mindset to support actionable targets and changes in production, consumption and everyday human practices.

Climate change and global warming

The long-term alteration of temperature and weather conditions across our planet is a result of human activity, primarily burning fossil fuels. Left unchecked, global warming will lead to large-scale environmental and social damage with rising sea levels, increases in temperature, more frequent extreme weather, significantly reduced farming yields and much more. Limiting global warming to well below 2°C is essential to mitigating the impacts of climate change around the world.

The 2021 IPCC report makes clear that without significant global climate action now the impacts will only worsen, with some being irreversible. The dire projection associated with increased global warming requires innovative thinking and immediate, continuous action to reverse the trajectory.

A worldwide commitment to limit global warming to well below 2°C was drafted during the 2015 United Nations Climate Change Conference in Paris, France. To date, 194 countries (plus the European Union) have ratified the treaty and agreed to decarbonize and work towards a net zero society by 2050. Only six countries have not ratified the agreement.

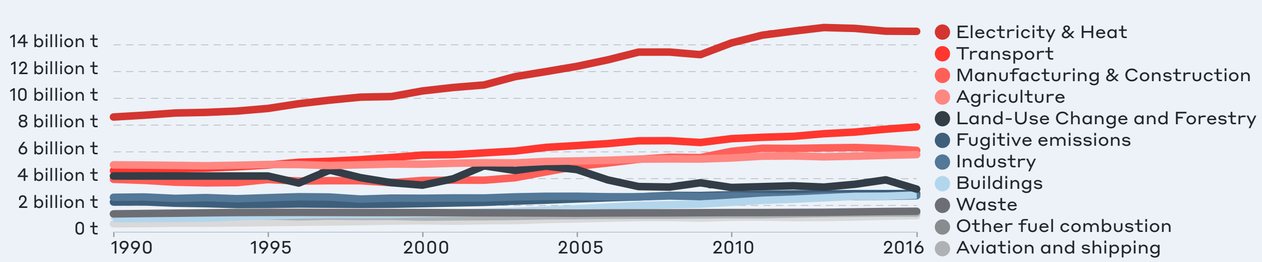
As each country faces unique challenges, the 2015 Paris Agreement does not provide a standard approach to decarbonization. Instead, the treaty outlines a common consensus and a net zero target. Each signatory is required to submit a "nationally determined contribution" (NDC) outlining specific decarbonization strategies and goals. However, following existing NDCs, the UN expects a significant shortfall and anticipates an average global temperature rise of 3.2°C by 2100.[1]

Most NDCs outline transportation decarbonization targets; however, very few commit to achieving a net zero transportation system. Meeting the UN's emissions goals requires commitments to net zero across the transportation sector backed by meaningful action.

The impact of transportation

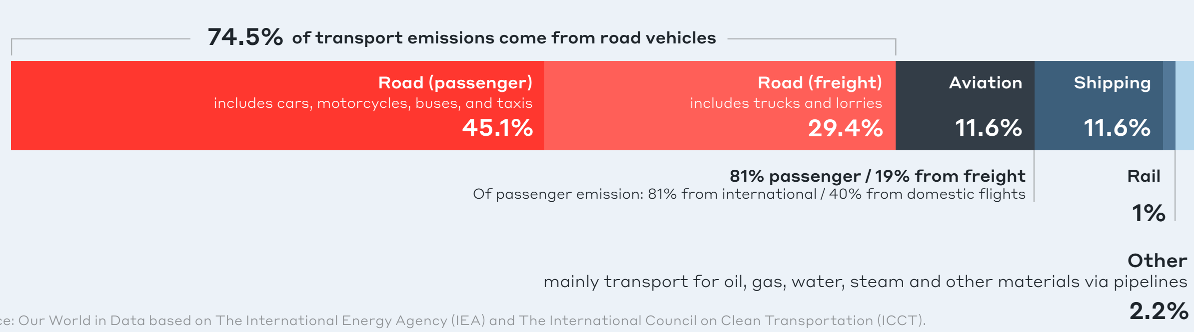
Transportation forms a significant contributor to global CO_2 emissions, being responsible for between 10-15% of all global emissions (see Figure 1) (and 24% of global fuel combustion emissions[2]), making it the second highest industry contributor to climate change.

Within the transportation sector, road transport remains the most significant polluter, with road passenger and freight accounting for 45% and 29% of global transportation emissions respectively. (See Figure 2.) This is largely due to the tailpipe emissions that result from burning petrol/diesel in internal combustion engines (ICEs) and the high number of privately owned ICE vehicles.



Source: CAIT Climate Data Explorer via Climate Watch
Adapted from Ritchie and Roser (2020), CO_2 and Greenhouse Gas Emissions

Figure 1 – Annual global GHG emissions by sector, up to 2016



Source: Our World in Data based on The International Energy Agency (IEA) and The International Council on Clean Transportation (ICCT).
Adapted from Ritchie (2020), Cars, planes, trains: where do CO_2 emissions from transport come from?

Figure 2 – Global CO_2 emissions from transport, 2018

1 United Nations Environment Programme (2020), Emissions Gap Report 2020
2 IEA (2020), Tracking Transport 2020, IEA, Paris

The drive towards net zero through decarbonizing transportation can place roads in a negative light. Roads will continue to play a vital role in society for the foreseeable future (e.g. freight, local and rural connectivity) and therefore in the short-, medium- and longer-term plans of transportation system designers.

The challenge then is to think differently regarding the use of roads, harnessing the positive contributions to mobility that road transportation can continue to make.

System designers

This broad group includes policymakers, politicians/government officials, infrastructure owners and operators, planners, engineers and road designers, vehicle manufacturers, enforcers, plus any others who support the road transportation system. Each contributes important knowledge and expertise to achieve net zero ambitions.

The role of ITS

ITS has evolved into a sophisticated approach, no longer just about the technology; in the course of forming safe and efficient environments for the movement of people and goods, much more attention is given to the setting—or place, which includes physical infrastructure, purpose and social aspects—and the expected outcomes. ITS therefore offers opportunity to revolutionize road networks, delivering transformation that influences travel patterns and demand, reduces congestion, facilitates more efficient planning, and paves the way for greener mobility, leading to achievement of global net zero ambitions.

The ITS whole-system approach considers the interactions between the various elements and seeks to create links that add value and remove barriers that result in inefficiencies. (See Figure 3.) This approach leads to continuous reduction of carbon in the given transportation system.

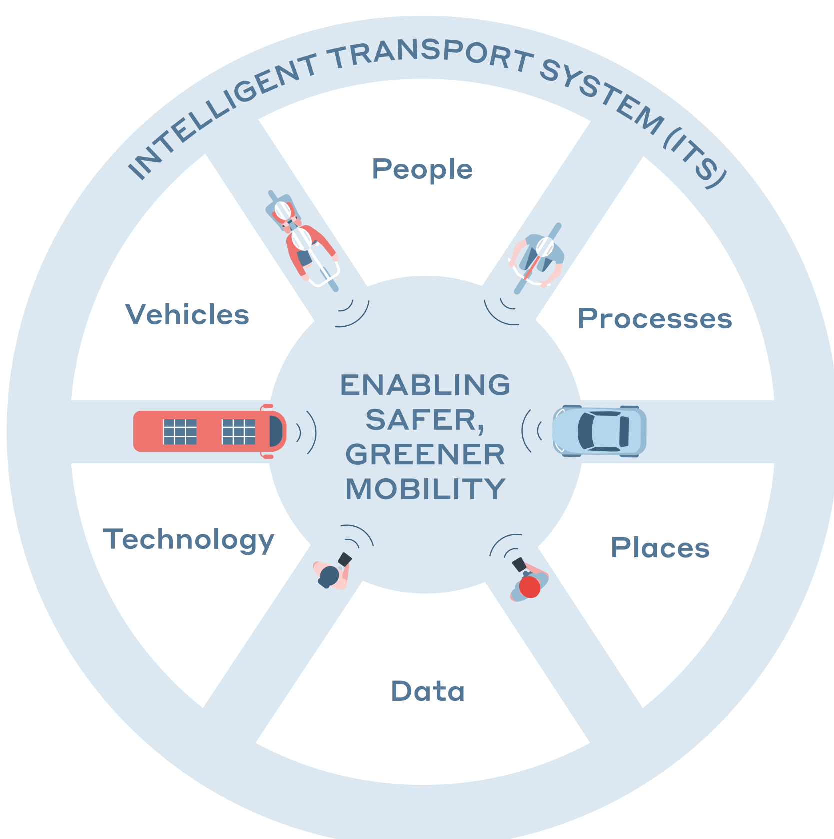
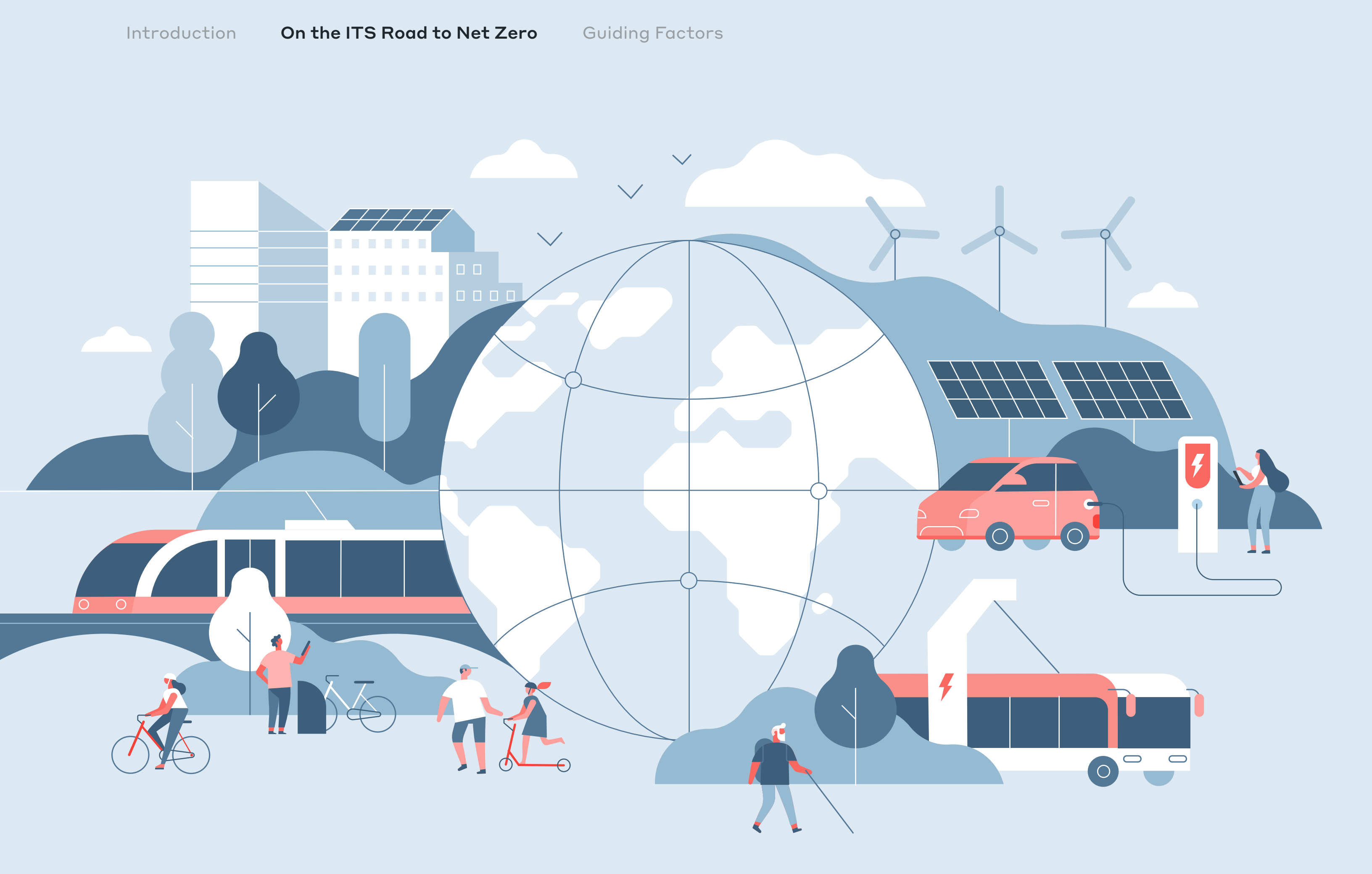


Figure 3 – ITS as the enabler to decarbonize transportation



On the ITS Road to Net Zero

Exploring opportunities brought by ITS to accelerate decarbonization

Leveraging the opportunities of ITS means the transportation decarbonization agenda can be carried out with sustained pace over the next few decades to achieve net zero networks globally by 2050.

We have brought together our global expertise in ITS to present examples of opportunities to decarbonize transportation across three core themes:

ITS decarbonization themes

Efficient use of existing transportation networks

Adapting existing networks to facilitate less movement or more efficient movement of people and goods supports a reduction in the carbon footprint of transportation.

Modal shift to public and active transportation

A shift toward public and active transportation modes (moving away from individual/personal road transportation) supports reduced emissions.

Adoption of zero emission vehicles (ZEVs)

Electrification and other zero emission (ZE) propulsion forms of transportation offer a significant contribution to reduced tailpipe emissions.

Maximizing efficiency across existing networks

Traditionally, poor traffic flow with stop-and-start movements, especially during peak hours of travel, has led to increased fuel consumption and greater GHG emissions. Building more infrastructure has generally been incompatible with decarbonization due to the embodied carbon in the process, or the GHG emissions generated to produce the asset.[3]

ITS allows for better-informed decisions by system designers and road users to make more efficient use of existing networks, easing congestion, improving traffic flow and thereby supporting greener outcomes. Roads in the United Kingdom (UK) are becoming smarter, using roadside technology to adapt speed limits to varying traffic conditions, thereby smoothing flows and improving throughput without the need for carbon intensive widening of existing carriageways.

An ITS holistic approach can increase capacity and adapt systems so less movement is required. From a freight perspective, the use of consolidation centres, integrating journey planning into delivery and servicing plans, and adopting last-mile journeys by bike offer the opportunity to reduce the carbon footprint of goods.

Digital Roads, United Kingdom

The Digital Roads vision in the UK offers insight into how ITS, at a strategic level can integrate people, processes, infrastructure, vehicles, technology and associated data—to enable positive transportation outcomes that will work towards achieving net zero. Through the Digital Roads vision, National Highways aim to transform how England's Strategic Road Network (SRN) is designed, built, operated and used by placing digital transformation at the heart of the future of their network strategy. Data, technology and connectivity will advance a range of benefits: efficiency improvements, greater intelligence in asset management and operational control of the network, lower embodied carbon impact when new infrastructure is needed, a focus on electric infrastructure, and planning that embraces future technological trends. All these outcomes contribute to achieving net zero.

By applying systems thinking, ambitions were created across the whole life of the SRN, from design and construction through to road user/customer experience.

At the beginning of the lifecycle, Digital Roads supports a transition to digital design and construction. Embracing digital twin technology and digital design tools, the modelling of carbon impacts can be better explored and factored into decision making to shape solutions that minimize the environmental impact from the outset. Modular and standardized assets and a more connected approach to modern methods of construction support low-carbon materials to be used consistently and lessen impacts on site.

During operation phases of the lifecycle, Digital Roads embraces a more intelligent approach to asset management. ITS has been incorporated into the vision to offer a more connected solution for assets; use of sensors and aerial survey modes (i.e. drones) allow for better visibility of asset condition; and through integrated data sources a more proactive view of asset condition can be realized. This process supports a lower-carbon approach to maintenance and optimal system performance for smoother flows and reduced carbon emissions.

Future ambitions to embrace connected and autonomous vehicles (CAVs) will enable more efficient traffic flows and a reduction in the requirements for roadside infrastructure, further lowering the carbon footprint of the SRN. Embracing ZEVs through a strategic focus on charging infrastructure will help improve customer confidence and accelerate uptake.

3 World Green Building Council (2019), Bringing Embodied Carbon Upfront

Diverse applications of ITS in WSP projects to maximize efficiency across existing transportation networks

Project

INNOVATE 680

United States

Contra Costa Transportation Authority's (CCTA) INNOVATE 680 program seeks to implement a suite of projects that, when operating together, will address corridor-wide congestion, travel delays, and operational challenges. CCTA has installed a countywide data center that is connected to high-tech infrastructure like integrated corridor management (ICM) and adaptive ramp metering (ARM) throughout Contra Costa County. Operational data, gathered in real time, prompts the dynamic adjustment of traffic signals and can send travelers real-time traffic updates. Smoothing of traffic flow supports an increase in freeway capacity reducing the need for large-scale interventions, with associated embodied carbon, as well as reducing tailpipe emissions from stop/start traffic.

Project

Smart motorways

United Kingdom

The UK road network is increasingly congested and in need of capacity expansion. WSP has worked alongside National Highways in England to develop the concept of smart motorways which maximizes capacity through a more controlled environment and enables opportunities to support operators in better managing traffic conditions. WSP in the UK are now part of a new Alliance that will deliver smart motorways across the SRN reducing the need for new build roads or widening, avoiding the associated embodied carbon, while also supporting smoother traffic conditions and reducing tailpipe emissions. The Alliance will apply a long-term perspective to positive environmental impact, with carbon goals for net zero across emissions and embodied carbon including the design, build and operation of a sustainable motorway - the first of which is a 25% carbon reduction by 2025.

Project

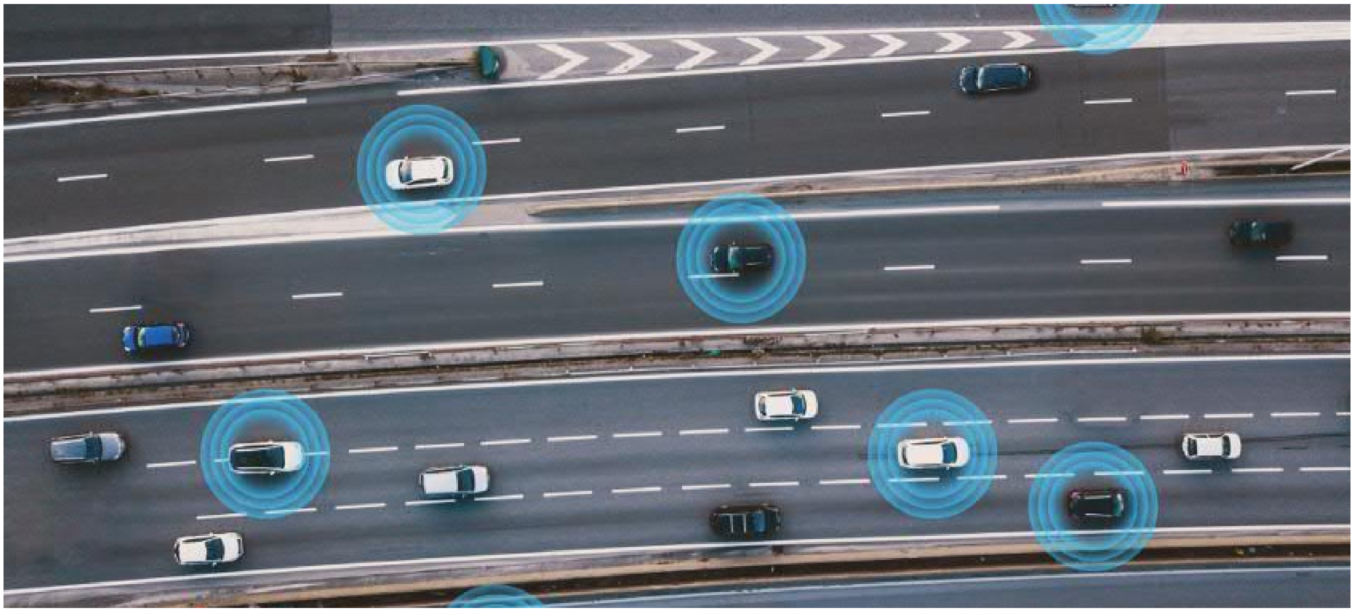
Free-flow tolling

Hong Kong

Tolls can become a significant bottleneck to traffic flows during peak periods as they often require vehicles to join queues, stop and pay before continuing the journey. By utilising on-road technologies such as automated number plate recognition (ANPR), radio frequency identification (RFID) and LiDAR, tolling can become an automatic activity that does not rely on physical barriers.

As a result, traffic flows are not impacted by the tolling procedure allowing journeys to continue as usual improving fuel efficiency, road capacity and user experience.

Diverse applications of ITS in WSP projects to maximize efficiency across existing transportation networks



Project

Tainan CAV-based advanced rapid transit

Taiwan

The Tainan City Government invited WSP to carry out a feasibility study and plan for the advanced rapid transit (ART) line in the east district (blue line, 1st stage). With the fast development of Tainan areas and increasing populations brought by the expanding microchip manufacturing industry, the escalated demands of daily transportation have caused more congested road traffic during peak hours in the downtown. Existing public transportation, buses and regional railway, can no longer suffice to quickly move people around the city.

The Tainan ART project is one of several projects underway to decide whether or not the CAV-based ART system, currently in development, should be adopted in all the public transportation networks of the city. The alternative to adopting the CAV-based ART system is to upgrade the matured guided rapid transit (GRT) systems to cope with public transportation needs. WSP proposed CAV-based ART as the best option for Tainan due to the existing variety of service modes, energy efficiency, less construction time and cost, high adaptation with the mix of road traffic, a better potential for parts-supply localisation, and the least CO_2 emissions during the construction and operation phases.

Other opportunities being explored by WSP

- Platooning
- Ultra-low emission zones
- Traffic management systems
- Digital Twins
- Smart parking
- Data as a service
- Artificial Intelligence and Machine Learning

Facilitating modal shifts to public and active transportation

Public transportation and active modes, such as walking and cycling, provide mobility with far lower environmental impacts compared with driving, when using individual ICE vehicles. Despite significant recent investment in public transportation systems, people continue to choose to travel in private ICE vehicles. By understanding reasons behind transportation mode choice (as explored in the "human-centric solutions" section on page 18), system designers can accelerate the shift towards sustainable public and active transportation modes.

By providing more accurate, timely and useable information, ITS can enable road users to make more informed choices for pre-journey planning, making modal choice decisions easier. This can lead to higher adoption rates for alternative transportation modes and reduce reliance on ICE vehicles. ITS facilitates large-scale modal shifts, including new mobility modes such as micromobility, leading to greener outcomes alongside the benefits for health and wellbeing that active modes bring.

Smart mobility in the West Midlands, United Kingdom

Transport for West Midlands (TfWM) with partners in the region are investing in programmes to improve strategic transportation and economic connections. A regional commitment to deliver net zero is leading to the use of ITS in order to improve the effectiveness, safety and sustainability of initiatives and innovations. Key components involve modal shift with two ITS initiatives being explored to help drive the ambition forward: smart ticketing and mobility as a service (MaaS).

Smart Ticketing

The West Midlands is highly diverse and so is its transportation network. Public transportation systems are often multi-operator and feature differing incompatible payment systems which cause confusion and limit public uptake of sustainable transportation modes. To address this issue and enable effective modal shift, TfWM introduced a simplified integrated payment system (Swift Go) that spans the region, allowing users to make use of all public transportation modes, including trains, trams and buses across any number of operators.

MaaS and Future Transport Zones (FTZs)

TfWM is piloting a FTZ. This introduces a number of innovations that will deepen both the user's understanding of available transportation modes and improve decision maker's understanding of travel behaviour across different groups. The FTZ will allow for targeted introductions of new technologies, systems and services to empower and enable people to make sustainable travel decisions. Data-led MaaS is the core component to the FTZ strategy. By collecting user data on mobility preferences from entertainment to productivity, the service can suggest the most suitable modes of transportation and even alter in-journey information to cater to the user's requirements. Facilitating MaaS through a one-stop mobile application, users will be able to plan, book and pay for their journey across multiple transportation modes as required, including public and active transportation modes.

Diverse applications of ITS in WSP projects to enable modal shift

Project

Congestion Charging Bangkok

Thailand

Congestion charging is a highly effective way to facilitate modal shifts away from privately owned ICEs and towards ZEVs and public transportation modes. By designing congestion charges based on existing geographies of emissions, Bangkok has been able to introduce an effective scheme where revenue is re-invested into green public transportation, further supporting modal shifts.

Considerations are being made for a road pricing scheme to further incentivise modal shifts towards public and active transportation modes.

Project

Future Ready Kerbside

Australia and New Zealand

The kerbside is often viewed as a passive infrastructure asset that takes up valuable land for extended periods. Working alongside Uber Australia, WSP reviewed how we manage and allocate the kerbside with the aim of better managing accessibility, based on shared mobility principles.

Using specialist tools, WSP analyzed the kerbside to maximise on existing space within the transportation system. By allocating new uses to the kerbside, such as holding stations for ZE micromobility scooters, maximum value can be extracted from the kerbside to ensure it provides true benefit to local places and promotes active travel.

Diverse applications of ITS in WSP projects to enable modal shift

Project

Green Light Optimized Speed Advisory (GLOSA)

United Kingdom

One key driver in the uptake of public transportation is the ability to avoid traffic queues and congestion at peak times. To improve the journey experience, GLOSA is being utilized in the UK, supporting prioritisation of public transportation.

By providing visual guidance on when traffic signals are expected to change, drivers can choose the most efficient speed to traverse a traffic signal junction without stopping. This leads to reduced tailpipe emissions due to reductions in fuel use and time spent at a standstill. While this technology can be applicable to all vehicle types, a focus on public transportation is enabling improvements in attractiveness and throughput of public transportation vehicles providing an additional method of stimulating modal shifts away from private vehicles.

Project

Next-Generation Transport Modelling

Norway

Changing mobility patterns along with urbanization, digitalization and emerging megatrends, such as EVs and CAVs, are challenging existing traffic planning in Norway and other countries around the world. These factors are leading to uncertainties that require new techniques to plan for shifts in mobility patterns.

Commissioned by Norwegian Railway Directorate, WSP, in Sweden and Norway, aims to leverage the power of machine learning (ML) to inform Norway's next-generation transportation model. This project is being carried out in a twofold manner, by teaching ML with classical microeconomic choice behaviour and applying ML to understand multidimensional mobility patterns.

The next-generation transportation model is key to preparing strategic railway infrastructure plans for achieving sustainability goals in 2030 and 2050, and realising modal shift.

Other opportunities being explored by WSP

- MaaS
- Integrated multimodal transportation systems
- Travel demand management
- Artificial Intelligence and ML
- On-demand transportation

Accelerating adoption of ZEVs

The traditional ICE is highly energy inefficient and polluting. The emissions are doubly harmful as they contribute to global warming accelerating climate change and pollute the air with harmful toxins leading to chronic ill health and the deaths of millions worldwide. A shift towards ZEVs would reduce and ultimately eliminate these harmful substances, improving both environmental and human health.

ITS plays a pivotal role in encouraging ZEV adoption, supporting transitions as countries strive to meet climate commitments.[4] ITS can improve the uptake of ZEVs by breaking down the barriers for use.

One action is making the charging experience simple, convenient and stress-free so that people can accept ZEVs as viable alternatives to ICE vehicles—pump-and-pay is a relatively straightforward, less time-consuming experience. Another important step is the integration of modes where charging hubs are associated with public transportation interchanges.

Connecting people with infrastructure through the incorporation of asset information into journey planning applications encourages greater confidence in alternative vehicle usage and reduces concerns with challenges such as range anxiety. Dynamic traffic information for charging system availability can assist road users wherever they travel, including city centres, motorway service stations, rest areas on high-speed highways and other locations.

These are a few key measures that support the ability of system designers to address the scope of road user needs and continue the transition to ZEVs.

4 UK Government: DfT and OZEV (2021), The consumer experience at public chargepoints

Electric Transport Stockholm 2030, Sweden

Accelerating the uptake of ZEVs starts with a robust plan and requires collaboration across a range of system designers including vehicle manufacturers.

As part of the Electric Transport Stockholm 2030 project, WSP in Sweden was commissioned by several industry players including Vattenfall, Ellevio, Volkswagen, and Scania, to develop an action plan for the electrification of all mobility in the Swedish capital. The ambitious plan covers all types of mobility, including private cars, commercial transportation, and heavy equipment.

In collaboration with various stakeholders, we mapped out future challenges and opportunities related to transition to a fully electrified transportation system, with economic, environmental and social sustainability factors forming the foundations of the plan's activities and milestones.

Several innovative solutions were proposed for addressing the groundbreaking challenge of electrifying all transportation within a city center as large as Stockholm, including assessments of how logistic centers could be used to transfer goods from conventional vehicles to smaller electric vehicles (EVs).

The action plan identified necessary legislative and regulatory changes, proposed innovations, and outlined the type of infrastructure that the endeavour would require.

Additionally, we identified consequences that various sectors, and society itself, will likely encounter in respect to implementation of the recommended steps of the action plan.

Leveraging global expertise in smart cities, sustainability, and much more, our professionals from Sweden and around the world collaborated on this project to provide a clear understanding of the complexity of future challenges, and to propose new future-ready ideas for capitalizing on the endless possibilities that current and future technology can provide.

Diverse applications of ITS in WSP projects to accelerate ZEV adoption

Project

Midlands Connect Accelerating EV Charging Infrastructure

United Kingdom

It is widely recognized that to achieve the UK's target of being net zero by 2050 more needs to be done to decarbonize the transportation sector. A key pathway to achieving this is shifting from petrol/diesel vehicles to ZEVs.

WSP supported Midlands Connect in establishing guidance for Midlands Connect's partners, such as local transportation authorities, to support and help direct efforts to accelerate the uptake of EV charging infrastructure in the Midlands and help ensure that benefits can be accrued from the delivery of a consistent approach across the Midlands. The project delivered baseline assessments of existing charging provision, future trend analysis and guidance on technical specifications, alongside principles and considerations to deliver accelerated uptake of EVs through a robust charging infrastructure network.

Project

ZEV Feasibility Report, Barrie Transit

Canada

The city of Barrie, a community of approximately 150,000 residents located 100 kilometres north of Toronto, decided to explore the viability of using alternative fuel vehicles for its fleet.

WSP in Canada provided a feasibility study for the city, illustrating the value of non-diesel vehicles, using an ITS whole-system approach considering social, economic and environmental factors.

WSP provided the city with implementation plans for the use of compressed natural gas and EVs over a timeline of 20 years. This included options for a phased-in approach for vehicle purchase or a wholesale vehicle replacement, as well as the associated infrastructure necessary for both technologies based on the community's current transit infrastructure.

The feasibility study included cost-benefit and environment savings analyses, which resulted in a roadmap for transitioning the fleet to alternative fuels.

Diverse applications of ITS in WSP projects to accelerate ZEV adoption

Project

LA County Metro Zero Emission Bus Master Plan

United States

Working on behalf of the Los Angeles Metropolitan Transportation Authority (Metro) and in joint venture with STV, WSP is creating an analysis of Metro's network of 165 bus and bus rapid transit routes and 11 maintenance facilities, making recommendations for the procurement of a new bus fleet, and performing conceptual designs of the modifications at facilities necessary to support the fleet. The master plan will provide a year-by-year schedule that will help Metro achieve a 100-percent zero emission bus (ZEB) fleet by their target of 2035 (five years before the State's mandate). Using the ITS whole-system approach, wider consideration was given to defining recommendations for training, safety planning, disaster planning, and cyber security for the bus fleet.

Project

Lima e-Bus Feasibility Study and Pilot

Peru

WSP was retained by Global Sustainable Electricity Partnership (GSEP) to conduct a feasibility study for introducing electrified urban public transit via battery electric buses (BEBs) in Lima, Peru. The project objective was to study the feasibility of fully incorporating a BEB into a public transit line. WSP analyzed and evaluated the potential for piloting BEBs using its proprietary simulation Battery Optimization and Lifecycle Tool (BOLT). WSP also developed a Total Lifecycle Cost for BEBs comparing the benefits of maintenance and capital costs over the complete lifecycle of the vehicle along with considering socioeconomic and environmental benefits such as emissions and noise reduction.

Diverse applications of ITS in WSP projects to accelerate ZEV adoption

Project

Organizing Charging During the Use of Electric Buses in the Helsinki Region

Finland

Transportation is responsible for about one fifth of Finland's GHG emissions. Road transportation is responsible for almost 95% of these emissions. The path to a carbon-neutral Finland requires strong investments in the development of public transportation and its propulsion choices. Most of Finland's urban public transportation is concentrated in the Helsinki region, where the Helsinki Region Transport (HSL) is responsible for organizing public transportation. HSL's goal is to reduce local emissions that affect air quality and CO_2 emissions more than 90% by 2025. This will be achieved by requiring the use of renewable biofuels from all diesel and gas buses, and by increasing the number of electric buses. The number of electric buses operating in the Helsinki region is expected to increase from 50 to about 175 in 2021. HSL's target for the number of electric buses in 2025 is 30% of all HSL's bus traffic, a total of about 400 electric buses in circulation in 2025.

WSP helped HSL on its path to carbon neutrality in public transportation. As part of its work, WSP developed an overview of electric bus charging in the Helsinki region to serve future traffic planning. In-depth stakeholder interviews were conducted with city officials, bus operators, charging operators, electric grid companies and equipment suppliers. Based on these interviews and as an expert assessment, WSP assessed the pros and cons of electric bus charging methods, their suitability for different locations in the Helsinki region, and a reasoned proposal for organizing bus charging at various locations. In addition, WSP made a long-term assessment of the traffic volume of electric buses and the need for charging during operations in the Helsinki region, and assessed the effects of electric buses and charging during operations on the traffic capacity of bus terminals.

Other opportunities being explored by WSP

- Energy management systems
- Electric micromobility
- Electric first/last mile goods
- New road pricing models
- Hydrogen-fuelled transport

Guiding Factors

Putting a holistic perspective into practice

Realizing the benefits of ITS across the three focus areas for transportation decarbonization requires a structured approach guided by several key factors:

Whole-system approach

The application of technology with associated data is not the complete solution, as this process must be undertaken alongside other elements of transportation systems—such as people, infrastructure and vehicles. This effort forms part of the ITS whole-system approach, to be consistently applied as system designers take steps to deliver targeted outcomes such as Vision Zero road safety and greener mobility.

A whole-system approach supports consideration of all components of the transportation system in decision making. It embraces the interdependencies and interfaces between modes and users that most often lie at the core of any transportation challenge.

Adaptability across the system lifecycle

The requirement to adapt is common across everything human beings do. Adaptability in ITS is not just about adopting the latest technology but recognizing the changing needs of people across the network lifecycle. ITS is unique in its ability to be relevant at all stages, from developing strategic approaches to end-of-life opportunities for reuse/recycling.

Human-centric solutions

A human-centric approach provides system designers with deeper insight into the needs of the road user, to integrate effective solutions that will drive sustainable outcomes.

Whole-system approach

An ITS whole-system approach to develop road transportation—one that considers people, processes, infrastructure, vehicles, technology and associated data—enables system designers to identify and mitigate adverse impacts, creating a safer, more efficient and less environmentally damaging system. Introducing a new technology, for example, may create an unintended negative impact on the environment if it has not been considered holistically. It is when ITS is considered in this manner, rather than focusing solely on the technological aspects, that it achieves the most beneficial outcomes.

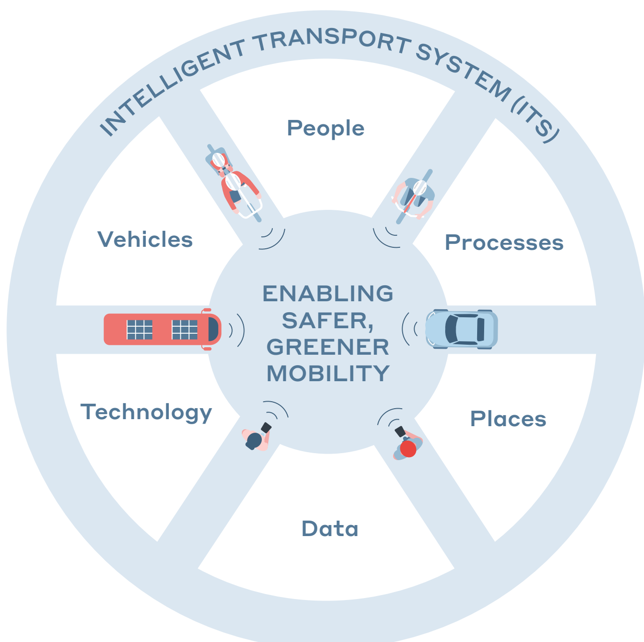


Figure 4 – ITS embracing systems thinking to deliver safer and greener mobility

Mobility in a changing world

Mobility takes place in ever-changing spaces where the needs of the user and the demands on transportation systems are evolving rapidly. It is the interactions within the system that most often lie at the heart of any issue. To address any disruption or suboptimal performance, system designers must consider these interactions and the competition between modes, users and networks, within the context of the whole-system.

On an elemental level, any mobility-transportation system comprises five interdependent areas:

- **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 and Implementers** - the people responsible for creating and building the system
- **Operators and Maintainers** - the people who operate and maintain the system

As countries tackle the climate change challenge, the whole-system perspective becomes increasingly important to achieve more efficient and safer road transportation outcomes—with a concurrent shift to greener mobility, and guidance towards achieving net zero targets.

Simple steps

A whole-system approach supports system designers in maximizing benefits:

1

Create a vision for the outcomes that are to be achieved—in the case of this whitepaper, having a vision for a decarbonized network.

2

Break down the interfaces and interdependencies associated with the transportation network to allow consideration from the outset.

3

Consider the interactions between people, infrastructure, vehicles, technology and associated data throughout each decision in designing, building, operating, maintaining and using the network.

Adaptability across the system lifecycle

Enlisting ITS to guide transportation projects allows system designers to incorporate digital assets alongside physical assets to create a more adaptable system to advance greener travel, all the while supporting safety. ITS has a key part to play through the whole lifecycle of transportation networks.

A strategic approach

Adopting ITS solutions from the outset of projects allows system designers to realize an effective approach to address the key mobility challenges of today and into the future.

Drawing upon ITS once a project has begun can help steer an endeavour in the proper direction and position it for future development.

Introducing ITS as part of design and development

ITS offers a toolbox of solutions to be considered as system designers address transportation challenges, whether congestion management, safety improvements or another issue disrupting transportation system operation. Where new or upgraded infrastructure is required to address a network challenge, a key consideration is the embodied carbon, or all the emissions associated with the materials used—arising from extraction, manufacturing, transportation, installation, maintenance, and disposal. Identifying lower carbon alternatives at the design stage provides the most effective solution for minimizing the associated carbon footprint.

Construction and assembly

A global shift in approach to modern methods of construction—which embraces a production-based philosophy—opens the door to better use of data, technology and connectivity. Threading data through design into construction, alongside a more refined approach to construction, minimizes the need for new assets (generating embodied carbon) and disruption to ecosystems (releasing sequestered carbon).

Continual improvement during operation

Adapting and optimizing performance during the use phase leads to the continual improvement of network operations and a reduction in carbon emissions. As new challenges emerge, ITS offers opportunity (through better use of data) to recognize the source of issues and adapt through technology and connectivity.

Circular economy of ITS

The life of an asset or intervention should not only be thought of in relation to its primary use or purpose; the potential for reuse/recycling materials for a future purpose should be factored into consideration. The ITS whole-system approach, with technology, data and connectivity fortifying the process, opens up opportunities to embrace and extend this circular economy ethos.

Simple steps

Incorporating ITS at any stage in the system lifecycle is possible and can support a transition to greener outcomes.

1

Adopt a systems-thinking approach (an intelligent transport system) from the start; understand the interactions between physical and digital assets and how they can adapt throughout the lifecycle.

2

Think of technology and digital assets as the enabler not the outcome; data, technology and connectivity support the achievement of outcomes.

3

Consider the future today and allow circular economy thinking to help shape solutions; reusing and recycling is essential for achieving greener outcomes.

Human-centric solutions

There are many users of the road system, and this diversity creates complexity; all users must be taken into consideration when designing or developing road systems. A human-centric perspective is necessary to achieve targeted outcomes.

By incorporating human factors into the design process, system designers can shape transportation systems with a deeper understanding of the factors that influence human behaviour; this insight keeps people at the centre of the design process, informs the process with an empathetic approach to comprehending why road users behave the way they do, and also offers greater potential for uptake of low- and zero-carbon mobility.

When transportation system specialists fully consider human behvaiour they are then equipped with better evidence and understanding enabling the delivery of effective, intelligence-led solutions that align with greener outcomes.

Any activity, improvement, development or change that involves a human requires empathy and understanding to create the right perspective in order to arrive at the solution. This thinking applies to decarbonization activities carried out in order to achieve net zero.

Human factors in road transportation

The complexity of road transportation systems can be understood in terms of the people who interact within them, be they drivers, passengers, road workers, pedestrians, cyclists, or others. Each group, and individual within the group, interprets their surroundings through various senses and responds in unique ways; therefore, there is always a level of unpredictability within road networks.

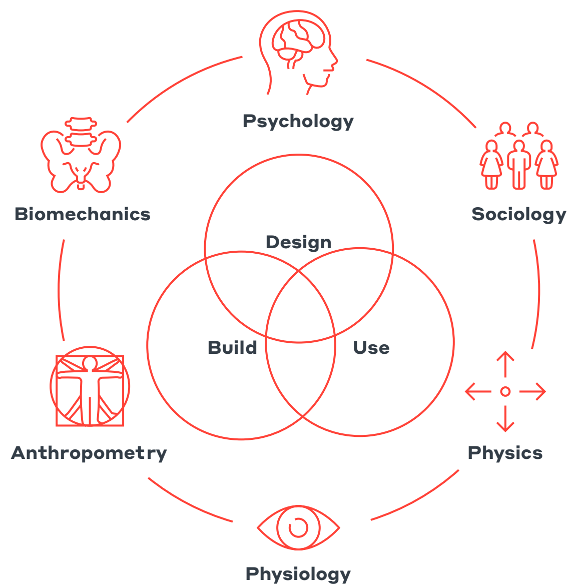
Human factors and net zero

Humans are continuously evolving with ever-increasing requirements and expectations. It is this evolution and the need to develop, adapt and improve that drives the human impact on climate change. To achieve net zero, the natural want and need to adapt and evolve must be catered for in a sustainable manner.

Developing sustainable transportation systems therefore relies on understanding how to incorporate proper consideration of the human factors involved.

Human Factors

Human factors is an interdisciplinary behavioural science that keeps people at the centre of the design process.



Simple steps

Human factors and associated behavioural science will enable/assist system designers to deliver solutions that are suited to the needs of the user.

1

Understand why people do what they do; recognize the mix of societal norms and learned behaviours and how to encourage (nudge) shifts.

2

Understand how and why people respond to/modify their behaviour in response to mitigations—particularly when these may not align with what designers assumed people would do.

3

Go back to the beginning of the development of any solution, then identify and examine all the factors that influenced the outcome.

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