# The Digitisation of Transport

## Think Different

Ryan Hood
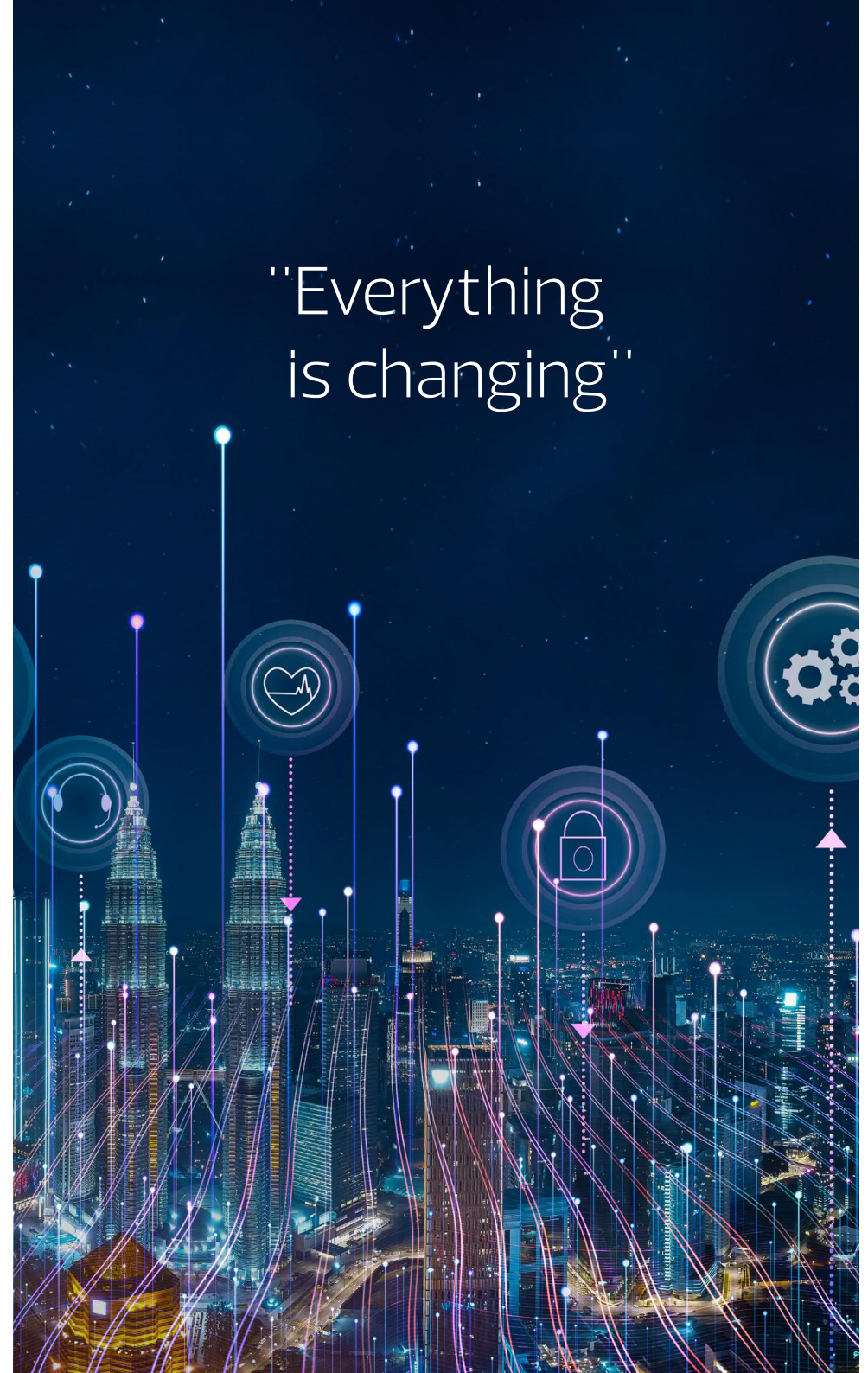
2021

# Contents

''Everything
is changing''

# Executive summary

**Everything is changing.** The Global Centre for Digital Business Transformation states that the transport domain has experienced the largest jump in vulnerability to digital disruption of any sector. Unprecedented investment by private capital into the transport sector has seen the emergence of some 2000 start-ups, bringing new ideas and business models, and challenging traditional norms. This pace of change is increasing.

Growth in connected devices was estimated at 22Bn devices in 2018 and is expected to double over the next decade. The rise in Location-Based Services, growing at 30% CAGR, is enabling a future where almost everything can be located, communicated with, monitored, and tracked in real-time. Every moving device has the potential to act as a sensor, providing real-time information about itself, and the environment. These changes provide significant opportunities to 'think different' about the future of transport.

TRL's vision is for a transport system that is safe, clean, and efficient. Fully interconnected, seamlessly integrated, fair, and accessible to everyone. A system that is decarbonised, resilient and supports UN Sustainability Goals. A transport network that is the backbone of our economies, enabling innovation, progress, and growth. A system underpinned by intelligence. Digitisation is a key enabler for this vision.

By applying data and technology correctly, the journeys we make could be smarter, safer, greener, and more efficient. Pilots of connected corridors — where users, vehicles and operators co-operate to share data and information in real-time — have shown the potential for reductions of 34% in accidents, 13% in journey times, and 22% in CO2 emissions. The performance of transport infrastructure could also be optimised leading to higher throughputs, better availability, and higher returns to the economy. In particular, the application of crowd-sourced data, 'vehicle as a mobile sensor' and Infrastructure IoT, show promise for improving asset management, network operation and availability. The progressive use of these new data sources, alongside Government commitments to Open Data, is creating a new transport data economy, with data increasingly available through open data platforms and data exchange hubs.

Challenges to this future persist such as managing the speed and scale of digital innovation, and assessing, de-risking and unlocking the use of new technologies and data sources to provide real benefits to transport stakeholders.

TRL's strategic research capabilities, data-driven software products, and world class facilities such as the Smart Mobility Living Lab (SMLL), provide a platform to support accelerated change in the sector through:

- **Innovation Management:** By applying strategic research capabilities, advanced tools, and processes, we help understand and manage the impact of digital disruption within transport, ensuring that organisations are hyper-aware and adapt intelligently to emerging trends.

- **Digital Lab Services:** By applying new data sources, digital technologies, data science and simulation capabilities we provide solutions, insights and advice that enables safer, greener, and more efficient transport outcomes.

- **Synergistic Partnerships:** By combining our world class transport domain specific expertise with digital methods, new technology, and services from across the technology sector, we help ensure organisations within the transport sector are ready for the digital age.
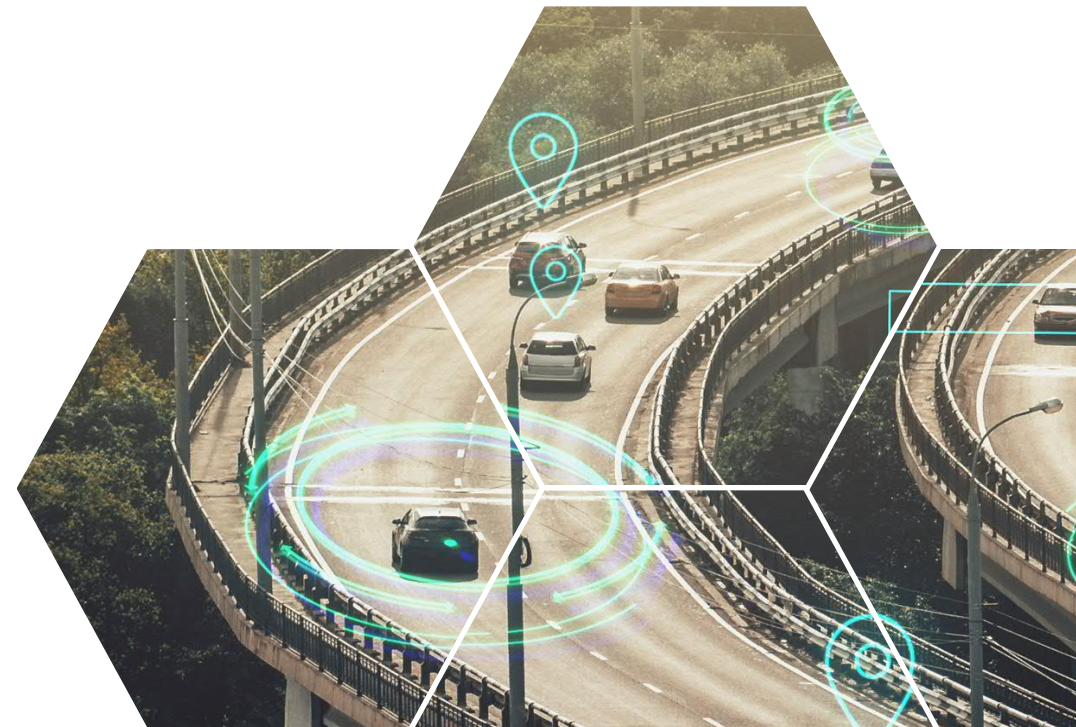
# The current landscape

Transport departments and authorities, such as the UK Department for Transport (DfT), Highways England, Network Rail, Transport for London (TfL), Innovate UK and the European Commission, have recognised the challenges and opportunities related to digitisation, and have initiated programmes linked with unlocking its potential.

The DfT Road Investment Strategy 2 Government Objectives document highlights the potential for disruptive change, and the need to respond with innovation, open architectures and flexibility, making allowances for changes related to the wider availability of data, connectivity between vehicles and their surroundings, and increasing automation of vehicles[1]. Through a related document, 'Connecting the Country – Planning for the Long–Term', Highways England sets out 5 areas for transformation, enabled by digitisation, to guide future investment:

· Design, Construction and Maintenance
· Connected and Self Driving Vehicles
· Customer Mobility
· Energy and Environment
· Operations[2]

Recent 'Digital Roads' strategy communications have further refined this with an emphasis on 'Digital Design and Construction', 'Digital for Customer', and 'Digital Operations', whilst highlighting six characteristics that should be considered in the transition to Digital Roads:

· Connected
· Protected
· Naked
· Personalised
· Integrated
· Twinned

Highways England's Connected and Automated Vehicle strategy and implementation work that TRL continues to support, has a strong focus on connected and co–operative services given the uncertainty in market adoption timescales for truly driverless vehicles.

Our railways are also undergoing digital transformation. Findings from the digitisation of numerous metro and mainline rail schemes have demonstrated 30% capacity improvements at peak times, and the Digital Railway programme is implementing new operational technology that will increase capacity, enhance driver and passenger journey experience, and improve safety[3]. Digital Twins are also under consideration to support digital rehearsals to ensure implementations of these new solutions are right first time and minimise impact on the travelling public. There are also plans to implement an intelligent mobile monitoring service that collects, analyses, and delivers increased asset intelligence, reducing the need for human inspection of track[4].

Through the DfT and Innovate UK Transport Technology Forum (TTF) State of the Connected Nation reports[5] and related documents, a number of focus areas are emerging, spread over three horizons:

### Now
Moving from paper-based to digital traffic regulations, opening up data in many more towns and cities, and making the whole roads maintenance chain able to use data from vehicles.

### Next
Investment in 7 priority connected vehicle data use cases: asset management, smarter parking, probe vehicle data, in-vehicle messaging, connected junctions, vulnerable road users, and public transport.

### Future
A potential regional scale 'Talking Traffic' initiative, similar to the national initiative TRL has previously supported in the Netherlands and aligned with TRL's work on Open SCOOT UTC with Transport for Greater Manchester. During this trial, GLOSA operation has been successfully demonstrated with minimal additional infrastructure.

More recently, the TTF has advocated the use of Horizon Scanning and the potential for more dynamic and adaptable infrastructure as areas of focus for Local Highway Authorities[6]. In addition, the Geospatial Commission and Innovate UK have invested in 27 transport location data projects in four areas:

1. **Mobility as a service** to help better integration of transport types
2. **Active travel** creating safer ways to enable active travel
3. **Supply chains** helping better distribution, storage and delivery
4. **Boosting capacity** increasing efficiency of transport networks[7]

Many forums and programmes across Europe are also looking at the digitisation of transport. In line with the EU's first two priorities – Jobs, Growth and Investment, and A Digital Single Market, the European Commission has recognised the potential for digitisation, new technologies and big data to change the way cargo and traffic flows. Key opportunities include real–time management of traffic and cargo and better use of infrastructure thereby increasing efficiency and lowering costs[8]. The EU POLIS network, a leading network of cities and regions across Europe looking at innovative policies and solutions for local transport, has increased its focus on digitisation, with topic areas looking at data, innovation and disruption, C–ITS and smart cities[9].

Further, and by way of example of the potential benefits, one recent Connected Corridor trial co–funded by the Connecting Europe Facility (CEF), showed a decrease of 34% in the number of accidents, of 13% in average journey duration, and of 22% in $CO_2$ emissions[10]. The benefits of using sensors, communications and data to support better transport outcomes are very real.

There is also a significant focus on improving safety. The Data Task Force, a pan European public private partnership founded by Transport Ministers, has been investigating real–time data exchange for improvements in road safety[11]. TRL has also worked in partnership with the EC and the European automotive industry to quantify the costs and benefits of new automotive technology, culminating in the introduction of new legislation, the General Safety Regulations, including numerous Connected and Automated Vehicle (CAV) functions, which from 2022 are expected to save 25000 lives across 27 countries over the next 16 years[12]. In addition, TRL is assisting the EC with strategic research on access to 'in–vehicle data', identifying what data is available and how it can be best accessed and shared for the benefit of consumers[13].

Digital Twins are also emerging as a potential tool to support the transformation of our transport system. The UK National Digital Twin programme is exploring how data can improve how infrastructure is built, managed, and operated[14]. Within the Confederation of European Directors of Roads (CEDR), TRL is building a digital twin of an existing highways assets to provide guidance to the industry on how to use digital twins for asset management[15]. In addition, within the Smart Mobility Living Lab we have built a town–scale digital twin to support accelerated testing of connected and automated vehicles[16].
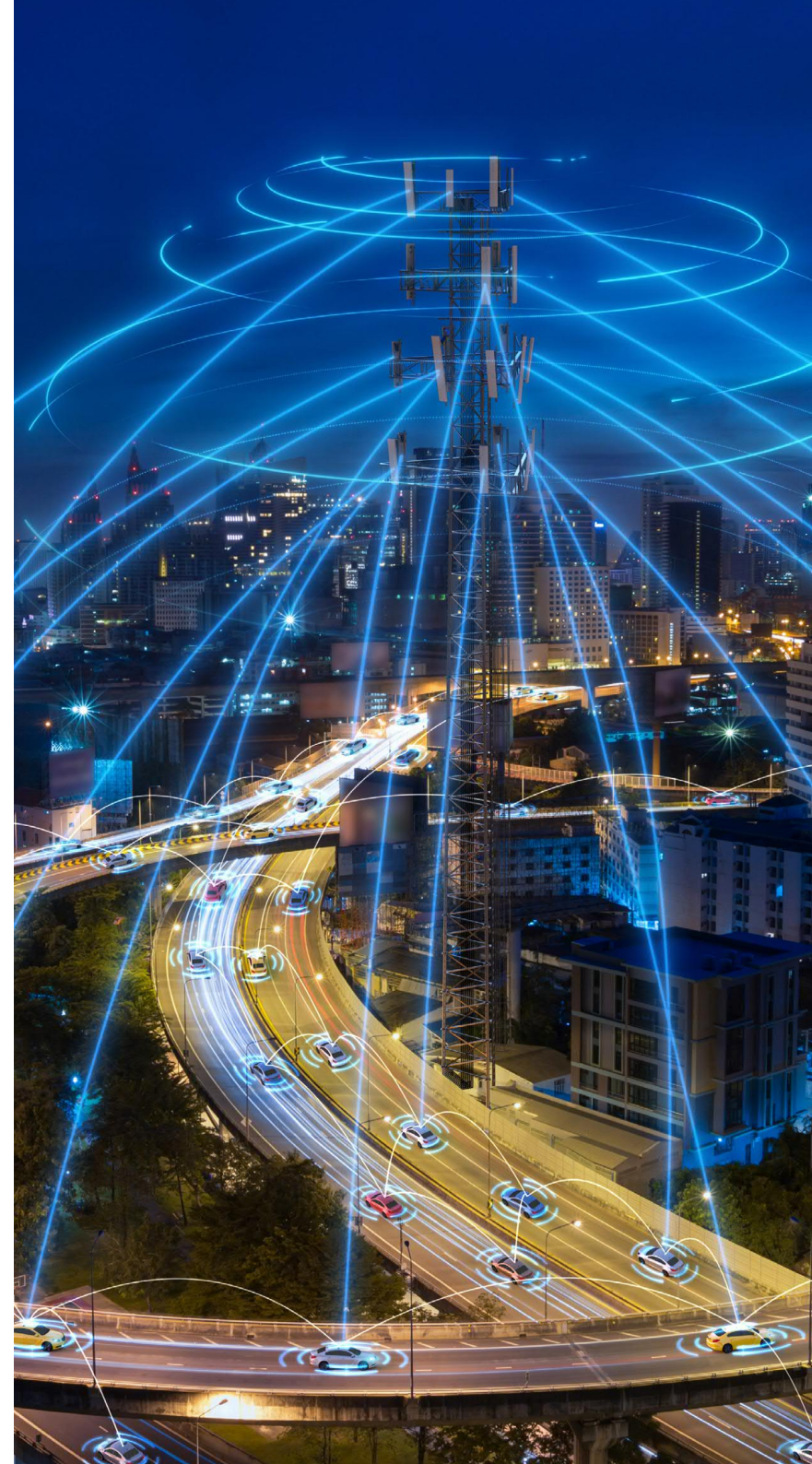
> **"** Our ability to predict future demand can no longer simply be linked with historical patterns **"**

# The challenge

Digitisation is affecting every part of our lives. To each of us, this brings challenges and opportunities, from more efficient ways to access the goods and services we use every day, such as online banking and retail, to the challenges of simply keeping pace with the rate of technological change, and threats to our security and privacy. In a similar way, digitisation is changing transport – from the impact of wider digital trends on transport, to how we can apply digital technologies and solutions to improve transport outcomes, through to the changes the transport sector needs to make to be fit for purpose in a digital age.

From a business perspective, the transport environment is seeing unprecedented investment from private capital, with significant advances into the sector by a wave of start–ups, scale–ups, and large technology organisations, bringing new technologies, new approaches and new business models. Recent reports have identified over 2000 start–ups impacting the mobility sector[17]. The Global Centre for Digital Business Transformation states that organisations within the transportation sector have experienced the largest jump in vulnerability to digital disruption of any sector, in part due to the 'Amazon effect'[18].

From a transport user's perspective, we see how digitisation is influencing demand, from whether we travel and how we get from A to B, to the transport choices we make, how we pay, and the service we receive. The rapid shift to remote working, for some sectors of society, is a great example of how digital technologies have enabled 'virtual mobility', compressing space and time, and changing our need to travel. Revitalised concepts, such as the 15 min city, will also change our views.

As a transport planner, these changes mean that our ability to predict future demand can no longer simply be linked with historical patterns, requiring fresh approaches and the ability to 'think different' about the future. With this, we are seeing the introduction of new approaches to strategic planning that help us manage future uncertainty, such as horizon scanning and scenario planning, the use of new data sources to provide fresh insight, and the emergence of 'Big World' simulation capabilities to simulate, experiment with and stress test new policies and concepts.

From a technological perspective, the proliferation of sensors and communication technologies across our road network, along our railways, in our towns and cities, on vehicles and on our person (e.g. mobile phones) is providing an explosion in data — data is everywhere. Advances in data–driven tools are enabling the more efficient design, construction and maintenance of our transport infrastructure, such as Rapid Engineering Models for automated design, so called 'smart factories' where off–site manufacture of modular components and on–site assembly will increase productivity, and where new sources of asset data, such as 'vehicle as a mobile sensor' show promise for driving increases in asset performance.

Digital tools and communications are enabling us to understand customer journeys in more fidelity, provide more journey information, and directly communicate with customers supplying information increasingly personalised to our individual needs. Data from roadside sensors and mobile probes (e.g. people and vehicles) is increasing our real–time situational awareness of transport network operations, enabling new control strategies, and providing vast amounts of data from which to model, simulate, experiment with and optimise future plans. And broader technological trends such as open data, data science techniques such as machine learning, drones, data from space–borne assets and use of digital twins will all impact transport in the future.
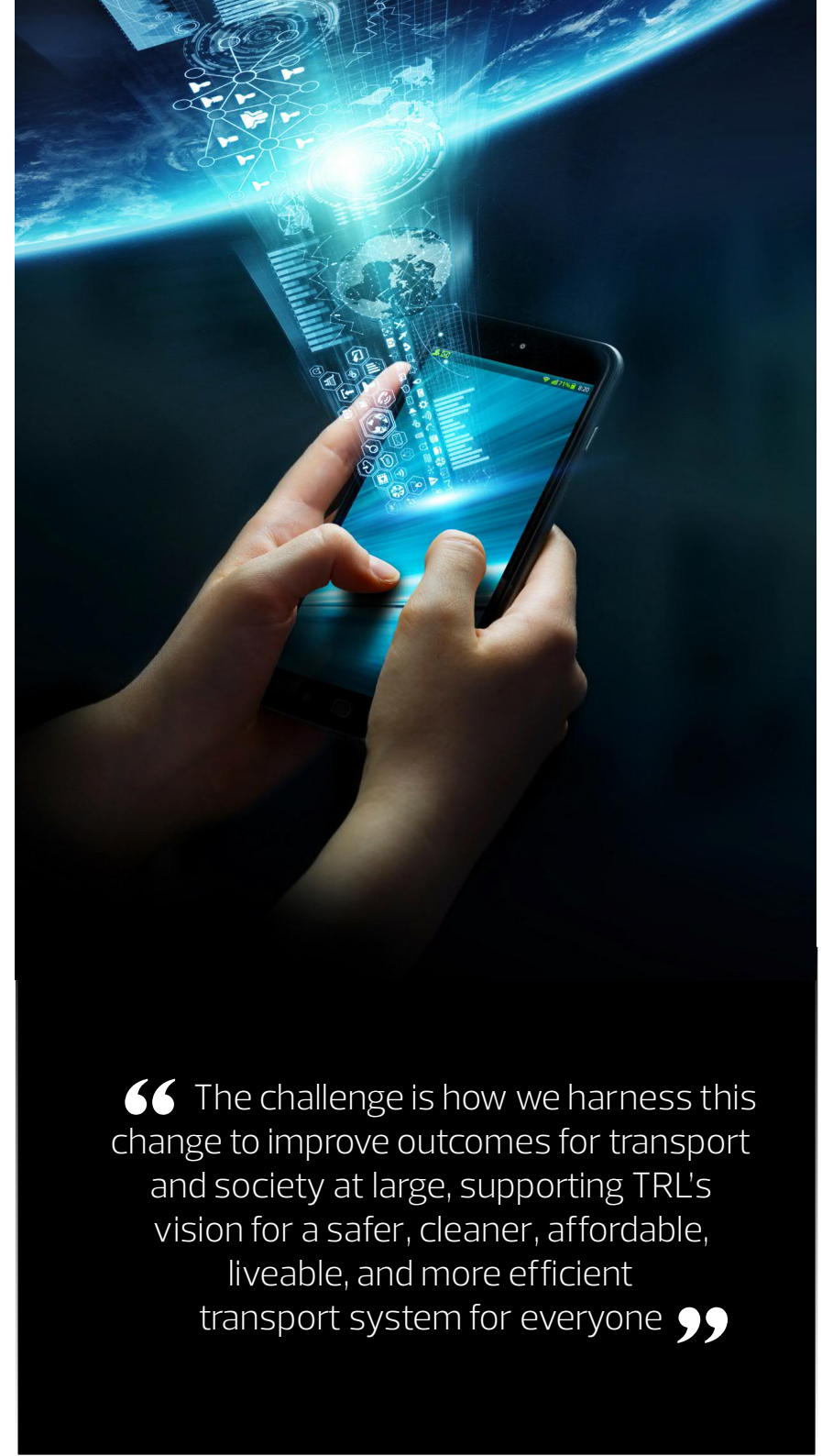
66 The challenge is how we harness this change to improve outcomes for transport and society at large, supporting TRL's vision for a safer, cleaner, affordable, liveable, and more efficient transport system for everyone 99

# TRL in the digital age

TRL's direct involvement in many of these initiatives provides us with great opportunity to shape the future of transport. Our Smart Mobility Living Lab, digital twins and driving simulation, provide real and virtual platforms to demonstrate and experiment with new and future concepts and technology. Our SMLL innovation partners provide community intelligence on the art of the possible and emerging needs. Through our strategic research for partners such as the EC, Highways England and DfT we are helping to understand how we can open-up vehicle data, how vehicles can co-operate, and what transport will require from digital infrastructure.

Our capabilities with network-level digital asset data and asset management provide us with a basis from which to incorporate new sources of data to improve asset performance, such as condition and safety, and our skills in data science and visualisation provides a capability to derive insight from data and provide interventions that will succeed. In addition, TRL data driven products like IMAAP, IROADS, and UTC all provide tangible assets that can be leveraged to improve safety, asset performance, and traffic operations.

"The future of transport
is different"

# Our priorities

The future of transport is different. At TRL, we have and are investing in the capabilities, products, and services to support this new future. Our 10–point plan for the digitisation of transport outlines key focus areas to support this transition. We see this plan through 3 broad themes:

1. **DIGITAL DISRUPTION**
   Managing the impact of digital disruption in the Transport sector

2. **DIGITAL LABS**
   Harnessing digital technologies to provide better transport outcomes

3. **FIT FOR DIGITAL**
   How to make the Transport sector fit for the digital age.

# DIGITAL DISRUPTION

*Managing the impact of wider digital trends on the Transport sector*

1. Innovation and disruption
2. Adaptable Infrastructure

## 1. Innovation and disruption

The transport sector must become hyper–aware, more agile and more strongly influence the wider digital trends that are impacting how and why we move.

We believe that the pace and scale of change in the transport sector will continue to increase, with disruptive innovations occurring external to the direct control of many transport authorities, and at a rate that is an order of magnitude shorter than strategic planning cycles, typically measured in years, and two orders of magnitude shorter than the lifecycle of major transport infrastructure, typically measured in decades. This will lead to significant uncertainty, concerns and delays with where to prioritise investment, and the potential for investment in rigid transport infrastructure solutions that may become obsolete or extremely costly to change.

Two strategic responses are needed: 1 – increases in the agility of transport organisations to align with the pace of change in the market; and 2 – the creation of more flexible and adaptable transport solutions.

To increase agility in planning and decision making, organisations need to:
a.  become 'hyper–aware' of advances external to their organisation
b.  introduce iterative processes that support accelerated intelligent decision–making
c.  adopt approaches that enable fast execution to changes in the market

To support this, the transport industry needs to make increased use of Futures Thinking and Horizon Scanning as promoted by the Government Office for Science[19], linked with strategic innovation management processes. TRL can assist with this by providing 'Innovation–as–a–Service' – demonstrated by the innovate, simulate, test approach utilised within our Smart Mobility Living Lab in London[20].

## 2. Adaptable infrastructure

The planning, construction and operation of our transport infrastructure must become more flexible and easier to adapt to embrace change.

To facilitate change, we see a need for fresh thinking around flexible and adaptable transport infrastructure and systems, and by this we mean the ability to adapt the infrastructure cost-effectively to support evolving needs, such as changes in policy, environmental factors, technology, and use. This is not new thinking; however, it requires fresh impetus. For example, research undertaken through the EU Forever Open Road programme looked at The Adaptable Road[21].

We currently see the application of advanced concepts to the building of transport infrastructure, such as modular off-site fabrication and product assembly line approaches to the construction of major transport infrastructure, to increase the speed, and reduce costs of build and impact on users.

> We believe now is the time for the development and deployment of advanced concepts for how our transport infrastructure and systems can more dynamically flex and adapt to changes in need over time. To support this, we propose the creation of a Centre for Adaptable Transport Infrastructure. This centre would enable Government, Industry and Academia to work in partnership to understand how our transport system should evolve.
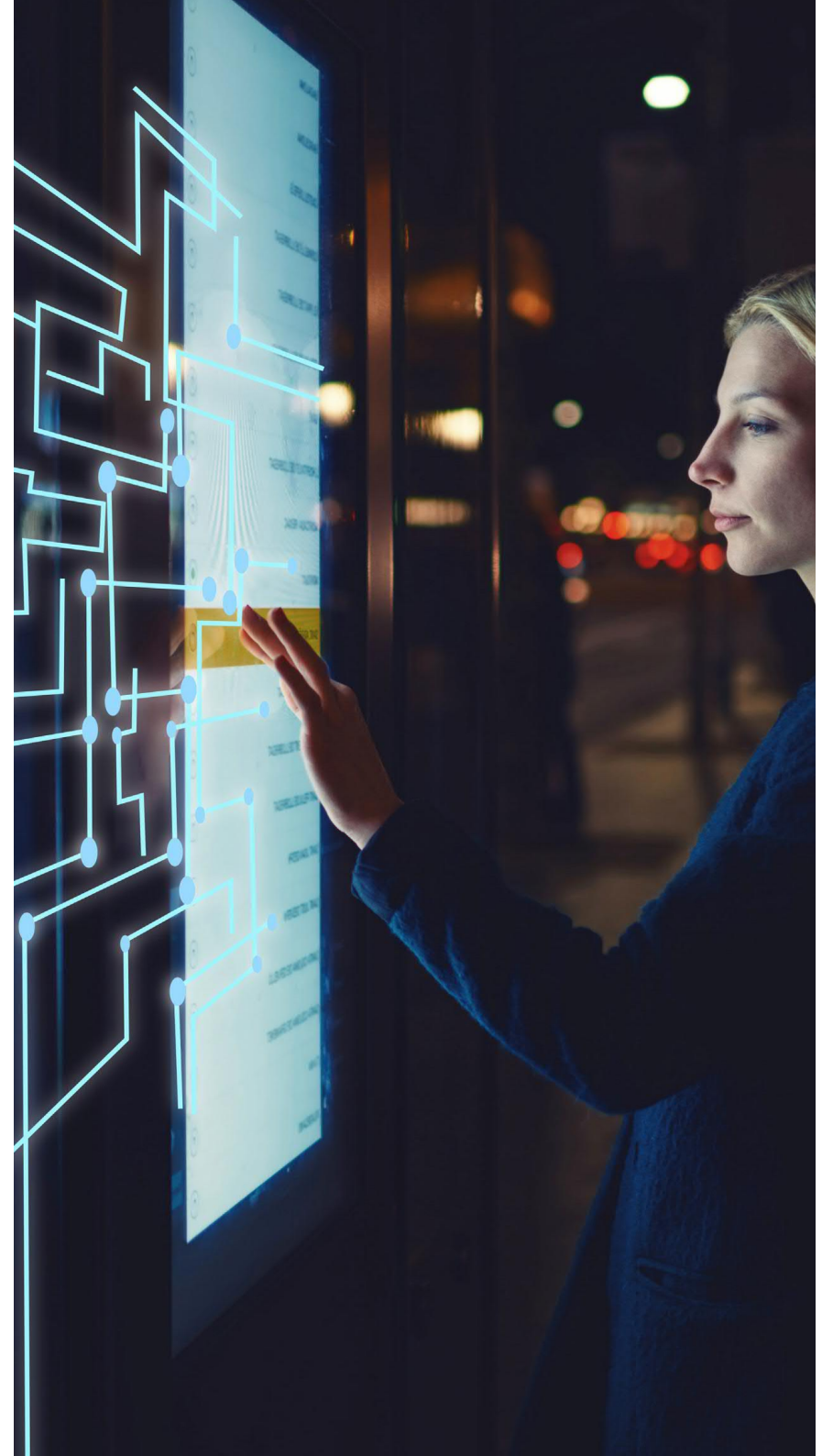
# DIGITAL LABS

*Harnessing digital technologies to optimise transport outcomes*

3.  Real-time geo-analytics
4.  The internet of mobile things and infrasturcture IoT
5.  Ubiquitous mobile connectivity
6.  Open or acessible data
7.  Big world simulation
8.  Digital twins

## 3.  Real-time geo-analytics

What has really changed?

Our world is fast moving towards a future where almost everything can be located, communicated with, monitored, and tracked in real-time, enabled by GPS, cellular networks, mobile computing, the internet, and cloud infrastructure. As of 2018, there were approximately 22Bn connected devices, roughly 3 for every person on the planet, with some forecasts suggesting this will increase to 36Bn by 2025 and 50Bn by 2030 – a doubling over the next 10 years.

These connected devices have spurred a wave of location-based services from basic asset tracking and general activity monitoring, journey planning and navigation software, telematics, to more recent advances in connected vehicle data. As penetration rates of location-based services continue to increase, this ability to understand the movement and behaviour of people, platforms and goods will provide us with the ability to reduce our dependence on dedicated sensor networks (e.g. road-side detectors), expand our intelligence of the operation of transport networks where dedicated sensor networks do not exist, all of which has the potential to improve safety, reduce costs, improve the flow of transport networks and the experience of users, and improve environmental outcomes through optimised journeys. More fundamentally, it provides us with a detailed and objective understanding of the actual journeys we make allowing us to think different about how to optimise the transport network of the future.

TRL has extensive experience with the application of geo-analytics to process and analyse new data sources to derive information and intelligence to support the operation of our transport networks.

## 4. The Internet of Mobile Things and Infrastructure IoT

Every moving device can also be a mobile sensor, providing real-time information about itself, and its environment. For example, a modern mobile phone contains more than 10 sensors such as a camera, cellular, Wi-Fi, and Bluetooth transmitters, a magnetometer, gyroscope, accelerometer, and barometer. A modern vehicle might have some 100 sensors, with this number increasing with each release. What we are now seeing is the practical application of this mobile sensor data to solve transport challenges. For example, automotive companies are now using vehicle sensor data, often referred to as connected vehicle data, to not only provide diagnostic information and personal mobile control interfaces with the vehicle, but to share data across the vehicle fleet. Recent reports have referred to this as swarm data and intelligence. We see increasing applications of this data for wider transport applications such as asset management, where for example skid resistance of the road surface can be transferred in near real-time or video data can be used to monitor safety infrastructure.

The deployment of low-power connected sensors to our transport infrastructure, when fused with other data sources and calibrated with data models for assets, and incorporated into asset management practices, can help fundamentally shift us from scheduled manual surveys to pervasive intelligence-led predictive maintenance, enabling interventions that are triggered by events, condition and risk. This helps remove boots from the ground and makes transport infrastructure more available, reducing impact on users, and resulting in a more cost-efficient maintenance regime. Future concepts such as embedded sensors within infrastructure that trigger the call-up of data from the last mobile survey, satellite pass or the deployment of drones are also emerging.

TRL has decades of practical experience with the development, application and evaluation of new sensor technologies, with a successful track record of incorporating such technologies into the management and operation of transport infrastructure.

## 5. Ubiquitous mobile connectivity

Real-time data exchange and connected services need reliable communications. The real-time tracking, use of IoT and Internet of Mobile Things (IoMT), and use of connected services are all fundamentally dependent on machine to machine (M2M) data communication.

Whilst many communication technologies currently exist within the transport and smart city environments, such as WiFi p / ITS G5, mesh networks, LoRA, and satellite links, the ubiquitous deployment of real-time services across transport requires good quality contiguous cellular communications. Research that TRL has undertaken for the UK Department for Transport has shown that many connected service use cases can be supported by current technology.

By combining our Cooperative ITS and Connected Vehicle domain experience with new techniques for analysing cellular performance, together with test facilities and partnerships with Telefonica at the Smart Mobility Living Lab, TRL has the ability to support the cost-effective wide-scale roll-out of connected services.

### 6. Open or accessible data

We envisage a future where data will be made open or accessible for societal good, with data registers and catalogues, access points, and data exchanges spurring innovative new applications that move us towards smarter, safer, cleaner and more efficient transport systems. Whilst there is much discussion about open data, and examples of good practice, particularly by Transport for London, this holy grail is still far from existence. Opening-up data can come with a cost and providing access to data can require legal frameworks to encourage sharing.

Through our strategic research capabilities, TRL can advise on how data can be made more accessible, as our work with the European Commission on access to in-vehicle data demonstrates.

### 7. Big world simulation

In the future, we expect the use and scale of modelling and simulation to continue to increase, ushering in possibilities for 'Big World' experimentation and visualisation to stress-test new transport policies and solutions at the scale of towns, cities, regions, and nations. Such simulation capabilities are now emerging and provide the ability to support all stages of the transport system lifecycle inclduing:

· Experimentation and accelerated testing of new transport concepts and technologies

· Strategic transport planning

· The use of synthetic environments to support procurement of the right transport solutions

· Immersive virtual environments to support stakeholder management and user centred design

· Digital rehearsals of construction activities

· What if analysis and optimisation of existing transport networks

TRL can develop and is actively working with partners to apply large scale simulation technologies to solve transport challenges, improving safety, delivering cost efficiencies, and ensuring transport solutions are right first time.

## 8. Digital twins

We see significant investment in digital twins in the design and build of infrastructure, evolving from Building Information Modelling (BIM). This should expand to focus on transport outcomes such as safer, cleaner and zero carbon transport, with more focus on users, and the efficient operation, maintenance, and evolution of our transport system.

The use of digital twins within the transport sector continues to gain prominence. Building on IoT and IoMT deployments, modelling and simulation, and advances in data science, cyber twins of real–world physical environments continue to emerge. For many years we have had SCADA systems for our tunnels, bridges and critical transport infrastructure, pulling in data from sensors embedded in key aspects of the infrastructure, enabling real–time monitoring of the assets and providing intelligence on which to optimise the performance of the asset and predict when interventions might be needed. Given the growth in deployment of sensors technologies and availability of new data sources, the logical evolution of this concept is its expansion to the whole transport system (people, modes, transport infrastructure and wider supporting systems) at the scale of major infrastructure projects, towns, cities, transport networks and an ambition for a National Digital Twin. A key challenge to this is interoperability of digital twins and standardisation.

TRL has built an enviable reputation in this space with deployments of twinned digital environments with our Smart Mobility Living Lab, where for example we can now test Automated Vehicles (AVs) in a cyber replica of 24kms of road, and interoperability between digital test environments in the UK.

We are also leading the CEDR CODEC project to understand from a road infrastructure perspective how a digital twin can be standardised, what data is required, and how new dynamic sources of data can be incorporated[22].
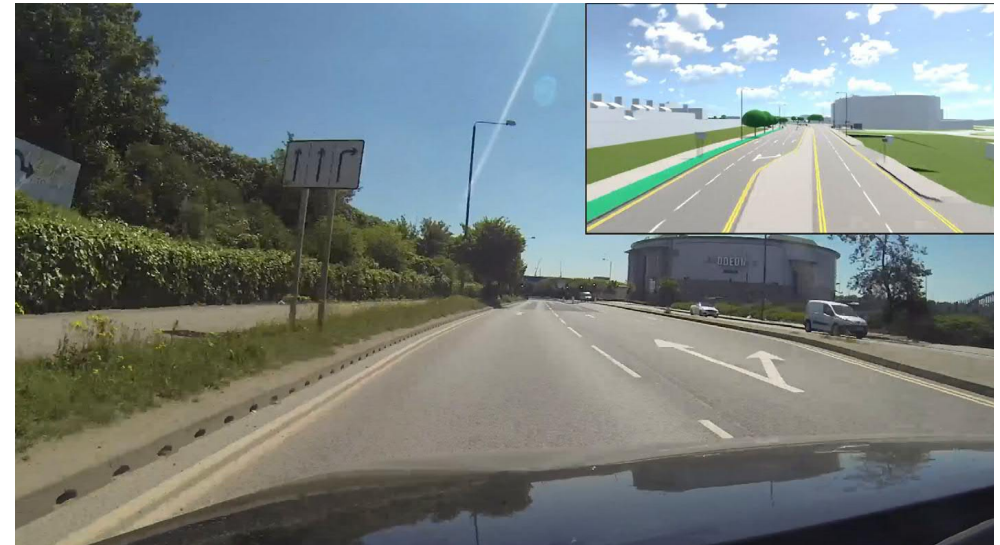
# FIT FOR DIGITAL

*Making the transport sector fit for the digital age*

9.   Investment in new skills

10. New partnerships

### 9.  Investment in new skills

The successful delivery of transport-related digital projects requires our sector to learn a new language, new ways of working, and new skills. In particular, investments in agile working practices and alignment with Government Digital Service standards are needed, together with skills development in systems thinking and engineering, geo-analytics, data science such as big data analysis, machine learning and IoT, sensor deployment, communications and modelling and simulation. In addition, knowledge of wider digital trends such as 'Cloud-First' is becoming a necessity.

TRL is undertaking an evaluation of the future skills needed to support the sector, and investing in new digital skills required to support this transformation.

## 10. New partnerships

We are seeing a wave of innovation within the transport environment, from start-ups, scale-ups, and large technology organisation, bringing new technologies, new approaches and new business models. Delivering digital transformation and shaping the right outcomes for the transport sector requires the combination of transport domain-specific expertise with the injection of digital skills and technology that these new entrants and other sectors bring.

TRL is a natural partner in this space with extensive experience of collaborations to deliver change. By working in partnership, we help to deliver outcomes faster, and enable the transport sector to build on and adapt advances in technology to customer needs.

# TRL's Strategic Themes

TRL is strategically investing, producing disruptive research and delivering innovation linked to these strategic themes:

### Environment & Decarbonisation

Transport solutions that protect the natural environment. The primary challenge is the decarbonisation of transport.

### Transport Safety

Safe systems incorporating safe roads, safe speeds, safe vehicles, safe road users.

### Transport for Sustainable Development

The role of transport in driving sustainable development, with a focus on low to middle income economies.

### Automation in Transport

What automation will enable, and how it will be applied to transform the transport domain.

### Digitisation of Transport

Data and connectivity enabling new journey capabilities; this also includes digital roads and developing efficiencies for lifecycle asset management, including road design, construction, condition monitoring and maintenance.

### New Mobility

New ways of moving people & goods, including active travel, and new business models and on–demand services to promote inclusivity and ease of use.

For more information on these themes, visit: www.trl.co.uk/strategy

# About TRL

## Our mission: Creating clean, efficient transport that is safe reliable, and accessible for everyone

TRL is a team of expert scientists, engineers and specialists working together with our clients and partners to create the future of transport.

We publish software that helps the world's largest cities, and many smaller towns too, reduce pollution, carbon footprint and congestion with advanced traffic management, better road design and good asset management.

We conduct leading edge research into infrastructure, vehicles and human behaviours which enables safer, cleaner, more efficient transport.

We deliver detailed incident investigation, structural survey and other high value field services to help clients to improve the service they give their customers.

We work with universities and other partners to invest in basic and applied research that will underpin future needs.

We have built, with partners from government and industry, the Smart Mobility Living Lab: the world's first physical and virtual testbed in a global megacity (London) that lets companies test new mobility products and services safely on live public roads.

Established in 1933 as the UK government's Road Research Laboratory, the renamed TRL was privatised in 1996 and today has more than 1000 clients in many countries. Our headquarters are in Crowthorne House, near Bracknell, and we have offices in Birmingham, Edinburgh, London, Germany and India.

## Transport Research Foundation (TRF)

The TRL group of companies is owned by the Transport Research Foundation: a non-profit distributing company that enables our experts to give independent advice without influence from shareholders or finance companies.

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# TRL
## THE FUTURE OF TRANSPORT

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