

Humans and digital twins in transport decarbonisation

TransiT Innovation Report

23 June 2026



Executive summary

This report summarises insights from the TransiT workshop, *Humans and digital twins in transport decarbonisation*. The event brought together stakeholders from transport, research, policy, industry and technology to explore how human factors affect the role digital twins can play in supporting transport decarbonisation.

A clear message from the workshop was that digital twins are not purely technical tools. Their effectiveness depends on how well they represent human behaviour, support inclusive decision-making, build trust and adapt to changing circumstances. While participants recognised the significant potential of digital twins to improve understanding, test interventions and anticipate unintended consequences, they also highlighted the risks of relying on models that fail to reflect the complexity of real-world behaviour.

The discussions reinforced the need for a human-centred approach to digital twins, one that combines technical capability with accessibility, organisational readiness, transparency, stakeholder engagement and ongoing learning.

This report translates the event's presentations, discussion and workshop activity into a clear narrative for external academic, industry and policy audiences, focusing on:

What we heard

Why it matters

What it signals next

Key messages from the workshop

Human behaviour is central to transport decarbonisation, and digital twins should represent the lived experience of travel to better predict behaviour and support lower-carbon choices.

Human-centred digital twins can help decision-makers understand trade-offs: who benefits, who is disadvantaged and how different groups may respond to interventions, including potential unintended consequences.

Human factors extend beyond travellers and drivers to everyone interacting with the system, including operators, planners, policy makers and teams and organisations using the model. Each have their own requirements to be considered in digital twin design.

Accessibility must be designed in from the outset to support a just transition, representing the full range of accessibility needs. This is essential both for equitable transport systems and because accessible public transport supports greater uptake of lower-carbon modes.

Successful deployment relies on organisational readiness, including leadership, skills, shared understanding, stakeholder engagement and a clear value proposition for adoption.

Trust underpins the effectiveness of digital twins in practice. Transparency and validation are essential for users to have confidence in digital twins and the decisions they inform.

Digital twins are evolving rather than fixed models, and developers must continue to listen to voices of stakeholders as they evolve.



About TransiT

TransiT is a UKRI-funded research programme and national research hub focused on accelerating transport decarbonisation through advances in digital twinning. It brings together academic research, industry stakeholders and policy actors across transport modes to improve alignment, adoption and impact, with strong emphasis on making research outputs accessible, relevant and usable by those planning, operating and governing transport systems.

TransiT's vision is to harness the transformative power of digital twinning, and associated digital technologies, to decarbonise transport.

Event overview

The workshop was hosted by [Connected Places Catapult](#) and opened with remarks from Ali Nicholl, Director of Data and Digital Strategic Engagement. Discussions focused on three themes, each introduced by a TransiT researcher:

- How human factors can help digital twins decarbonise transport
Guy Walker
- Building human capital readiness for transport digital twinning
Shujaat Mubarik
- Disability inclusion in decarbonised transport: Social model of disability
Kate Sang

The workshop brought together participants from transport, research, policy and technology backgrounds. Through presentations, facilitated discussion and interactive workshop activities, attendees explored the relationship between human behaviour, organisational capability, accessibility and digital twin adoption. The event was designed to identify both opportunities and challenges associated with applying human-centred approaches to digital twins in support of transport decarbonisation.

What we heard – Key insights

Human behaviour is central to transport decarbonisation

A consistent theme throughout the workshop was that transport systems and the digital twins used to model them often rely on simplified assumptions about human behaviour. Participants emphasised that travel decisions are shaped by a much broader range of factors than time, cost or carbon emissions. Convenience, health, reliability, comfort and personal circumstances were all identified as significant influences on decision-making.



People do not change behaviour primarily in response to carbon. Factors such as cost, convenience and health are more influential in shaping decisions.

Car use was described as deeply embedded within people's lives and often linked to identity, independence and a sense of control. Modal shift away from private vehicles was therefore viewed not simply as a transport challenge, but as a behavioural and cultural one. The workshop reinforced that people do not always behave in the rational or optimal ways assumed within transport models, and that behavioural change can be difficult even when lower-carbon alternatives are available.

Participants also noted that travel choices are strongly influenced by perceived control. People who own cars may choose to drive even when disruption is expected because they feel they retain greater control over their journey, whereas people without access to a car may place greater value on reliability and certainty.

The lived experience of travel emerged as an important consideration, particularly the emotional and practical burden of complex journeys. Existing models may account for travel time and interchange time, but they do not always capture how people feel about a journey with three or four changes, the risk of missing a connection, the inability to rest or work properly while changing modes or the stress of navigating unfamiliar environments.

Participants argued that digital twins should move beyond modelling journey duration and cost alone, to capture the quality of journeys and the factors that shape real-world behaviour. Doing so could improve the ability of digital twins to predict responses to interventions and identify opportunities to encourage lower-carbon travel choices.

The workshop also raised questions about how travel behaviour varies by life stage, experience and culture. Participants discussed generational differences between people who have grown up in an analogue world and those for whom digital interaction has been part of everyday life from early childhood. This was not presented as a simple age divide, but as a reminder that digital confidence, expectations and readiness vary widely across the population.

Human factors extend beyond travellers to everyone using and influencing the system

The workshop highlighted that human factors should be considered far more broadly than passenger or driver behaviour alone. Participants distinguished between the people represented within a digital twin and the people using it to make decisions. Both perspectives were viewed as critical to effective design and implementation.

Discussions highlighted the diverse range of people who interact with transport systems and digital twins, including operators, planners, employers, policy makers, regulators and organisational decision-makers. Participants argued that each group brings different objectives, responsibilities, constraints and information needs that should be reflected within digital twin design.

The language used to describe digital twins was also seen as influencing adoption and engagement. Some organisations were reported to be comfortable discussing digital transformation or a digital twin journey, while being less familiar with concepts such as human factors. This suggests that effective communication and stakeholder engagement are important aspects of human-centred design.

Participants concluded that digital twins should be designed to support collaboration between stakeholders and provide outputs that are meaningful and useful to different groups involved in planning, operating and governing transport systems.

Accessibility must be designed in from the outset

Accessibility emerged as one of the strongest themes throughout the workshop. Participants consistently stressed that accessibility should be embedded within digital twins from the outset rather than treated as an additional consideration or addressed solely through consultation activities.

There was concern that digital twins built around averages or standardised assumptions could fail to represent the experiences of many users, including disabled people, neurodivergent individuals, those with temporary mobility limitations and people facing digital exclusion. Participants argued that accessibility needs should be explicitly incorporated within models through appropriate personas, variables and behavioural representations.

The workshop explored a range of practical accessibility challenges, including last-minute service changes, unavailable assistance, inaccessible information systems and disruptions that disproportionately affect some users. Participants suggested that digital twins could be used to test how operational decisions affect different groups and identify barriers before they occur in real-world settings.

The group also discussed how information reaches users, both of transport and of digital twins. Apps can be useful, but not everyone wants or can use multiple apps, mobile coverage is uneven, and some interfaces are not fully accessible.

Participants raised the need for universal or interoperable information systems, assistive technology and alternatives for people who do not or cannot rely on smartphones.

Accessibility was also linked directly to transport decarbonisation goals.

Participants noted that if shared and public transport systems are not accessible, some users may have little choice but to rely on private cars or taxis. Improving accessibility was therefore viewed as both an equity issue and an important enabler of greater uptake of lower-carbon transport modes.



Accessibility must be explicitly modelled within digital twins; without this, there is a risk that inclusion is not sustained over time.

They considered people whose ability to use public transport affected their access to employment and noted that employers have an important role in supporting accessible travel, acting as facilitators alongside transport operators and other stakeholders.

Economic impacts were also highlighted, particularly in relation to access to employment, education and services. Digital twins may reinforce existing blind spots if these impacts are not represented.



The economic cost of exclusion – including people being unable to access employment due to transport barriers – needs to be recognised and addressed.

Human-centred digital twins can reveal trade-offs and unintended consequences

Participants recognised significant potential for digital twins to support more informed and evidence-based decision making. In particular, they highlighted the ability of digital twins to explore the impacts of transport interventions across different users, communities and stakeholder groups.

Workshop discussions emphasised that transport decisions frequently involve trade-offs. Improvements for one group may create disadvantages for another, particularly where infrastructure capacity or public space is limited. Examples discussed included road space reallocation, accessibility improvements, rail service changes, and competing demands between transport modes. Participants argued that human-centred digital twins can help visualise these trade-offs, making the distribution of benefits and impacts more transparent. Participants noted that while digital twins may help expose these trade-offs more clearly, they will not remove the need for human judgement, communication and governance.



Transport interventions can be perceived as a zero-sum game, where gains for one group are seen as losses for another.

The discussions also highlighted the value of digital twins in identifying unintended consequences before interventions are implemented. Examples included autonomous vehicles, where improvements in vehicle efficiency could be offset by increases in overall travel demand, and mixed-mode journey planning, where a more realistic understanding of traveller behaviour could reveal opportunities to encourage lower-carbon journeys that conventional models might overlook.

A key message was that digital twins should help decision-makers understand not only whether an intervention works, but who it works for, who might be disadvantaged and how behaviours may change under different scenarios.

Organisational readiness is essential for successful adoption



A lack of clear, shared definitions of digital twins remains a barrier to adoption across different sectors and organisations.

Participants agreed that technical capability alone is unlikely to determine the success of digital twins. Organisational readiness was identified as a critical factor influencing adoption, implementation and long-term value.

A recurring theme was the lack of shared understanding around what digital twins are, how they should be used and what benefits they can deliver.

Participants highlighted skills gaps in areas such as data literacy, systems thinking and the interpretation of uncertainty, alongside the need for leadership that can champion adoption and support cross-functional collaboration.

The workshop also emphasised the importance of cognitive flexibility, with organisations needing the ability to work across disciplines, challenge established assumptions and engage with increasingly complex data-driven decision making. Participants suggested that digital twin adoption may require a role similar to a data champion: someone within an organisation who understands the technology, the data, the policies, the operational needs and the business case, and who can help translate between specialist teams and decision-makers.

Another important point was the risk of over-simplified outputs. Participants warned that decision-makers may ask for a single number, such as a benefit-cost ratio, when the value of a digital twin is often its ability to show a range of possibilities, trade-offs and uncertainties. Building capability therefore includes helping decision-makers understand distributions, assumptions and uncertainty, not only dashboards and headline figures.

Organisational readiness was seen as varying significantly by scale and sector. A large logistics provider with vehicle sensors and mature operational data may be well placed to develop or use digital twins, while a smaller business may need a lightweight version, a service provider model or external support. In some sectors, such as maritime, participants observed that parts of the industry still rely heavily on paper-based processes, meaning the transition to digital twins may require more basic digitalisation first.

Participants emphasised that adoption depends on perceived value. Organisations may ask: what is in it for me, and why should I invest? This is especially important where digital twins are perceived as expensive, high-level or requiring extensive transformation. Showing tangible benefits through case studies, demonstrations and role models was seen as more persuasive than a technology push.

Workforce concerns also formed part of the discussion. Some participants noted that digital twins may be perceived as another form of automation that could remove jobs. This makes communication, change management and leadership central to readiness, not secondary considerations.



Even well-designed systems will not deliver impact without organisational adoption and alignment across stakeholders.

Trust is critical to the effective use of digital twins

Trust was identified as a fundamental requirement for the successful use of digital twins. Participants consistently highlighted transparency, accountability and validation as essential conditions for building confidence among users and stakeholders.

Discussions emphasised the need for digital twins to be open about assumptions, uncertainties and limitations. Participants argued that users should be able to challenge outputs, understand how conclusions have been reached and have confidence that models have been appropriately tested and validated.

Trust was also linked to data governance and data sharing. Participants highlighted concerns around commercial sensitivity, confidentiality and regulatory requirements, suggesting that trusted architectures, standards and federated approaches may be needed to enable collaboration while protecting sensitive information.

The workshop concluded that trust cannot be assumed simply because a model is technically sophisticated. Instead, trust must be earned through transparency, evidence, engagement and ongoing validation.



Building trust in digital twins requires transparency – including testing, challenge and validation by users.

Digital twins must evolve alongside the people and systems they represent

Participants consistently described digital twins as evolving processes rather than static technical products. Their value was seen as increasing over time through continuous learning, use and refinement. Speakers also highlighted the importance of engagement, with digital twins seen as a way to involve stakeholders in understanding and shaping decisions.

The workshop highlighted the importance of ongoing stakeholder engagement throughout the lifecycle of a digital twin. Participants stressed that user needs, behaviours, and policy priorities will change so digital twins will need to adapt accordingly. This was considered particularly important where digital twins are intended to support long-term transport decarbonisation objectives.

Several discussions also highlighted the growing role of intelligent systems, digital agents and autonomous technologies. Participants suggested that digital twins could provide safe environments for experimentation, testing and learning before new systems interact with live operations, infrastructure or users.

A key conclusion was that engagement should not be viewed as a one-off activity undertaken during development. Instead, developers should continue to listen to and learn from stakeholders throughout the evolution of a digital twin, ensuring that models remain relevant, trustworthy and reflective of the people and systems they represent.



Digital twins should be understood not as static tools, but as evolving processes that become more valuable through interaction and use.

Why it matters – Research and policy implications

The workshop demonstrates that the impact of digital twins in transport depends on how effectively they integrate human factors into their design, development and use.

The opening presentations and workshop discussions together highlight that barriers to adoption are not purely technical. They include behavioural complexity, low trust, uneven organisational readiness and insufficient attention to accessibility.

At the same time, participants identified clear enabling conditions. These include:

- improved representation of behaviour in models
- stronger engagement and transparency
- clearer governance and shared understanding
- investment in skills, capability and training

The workshop also points to the importance of grounding digital twins in real-world contexts, ensuring that models and decisions reflect lived experience rather than theoretical assumptions.

Discussions suggested that research and policy should pay closer attention to the layers of human involvement in digital twins. The human in the model, the human using the model, the human designing the model, and the human affected by the model may each require different forms of representation, training, accountability and engagement.

A further implication is that the digital twin field needs clearer routes from evidence to adoption. Participants repeatedly returned to the importance of definitions, demonstrations, case studies, champions, standards and governance. Unless organisations can see practical value and understand how digital twins fit with existing systems, budgets and responsibilities, adoption is likely to remain uneven.

The discussion also suggests that digital twins should be used to interrogate assumptions, not simply confirm decisions. Their value lies partly in showing uncertainty, trade-offs and alternative futures. This requires decision-makers to be comfortable with complexity and to avoid reducing outputs to a single apparently objective number.

Finally, and crucially, if accessibility and lived experience are not designed into digital twins, there is a risk that models reproduce the needs of the most visible or easiest-to-measure users. Conversely, if accessibility variables, personas, social value and lived experience are embedded directly in the model, digital twins could help make inaccessibility visible earlier and test more solutions before decisions become locked in.

What it signals next – Recommendations and next steps

Signals for policy and industry

The workshop signals that advancing digital twins in transport will require sustained attention to human factors alongside technical development.

Areas for policy makers and industry to focus on include:

- embedding behavioural insight into modelling
- improving transparency and trust in systems
- addressing organisational capability and readiness
- ensuring accessibility is designed in from the outset.

A key signal from both speakers and participants is that digital twins should be developed not only as analytical tools, but as platforms for engagement, testing and learning.

Further recommendations for industry:

- Create clearer shared definitions of digital twins, including what human factors means in different contexts
- Develop organisational roles, such as digital twin champions, that can bridge technical, operational, legal, commercial and human-centred concerns
- Place data readiness on the same level as technology readiness, including data quality, data continuity, protocols, interoperability, confidentiality and governance
- Use digital twins to test short, medium and long-term interventions for accessibility, decarbonisation and resilience, rather than treating them only as strategic planning tools
- Build decision-maker capability so that digital twin outputs are interpreted as ranges, scenarios and trade-offs, not simple answers
- Embed accessibility and social value into models so that exclusion, employment access, wellbeing and participation are visible in business cases and operational decisions.

A key recommendation for policy makers is to support lightweight and scalable digital twin approaches for smaller organisations and sectors at earlier stages of digital maturity. This will ensure the UK transport industry can benefit from the latest tools and in turn benefit UK transport decarbonisation.

Next steps for TransiT

A range of practical research questions arose from the workshop, which the TransiT team will take forward:

- How can digital twins represent perceived control, reliability, comfort, uncertainty, anxiety and attractiveness in transport choices?
- How should digital twins account for people who do not own cars, do not hold driving licences or have limited access to digital tools?
- What is the minimum viable level of data, skills and governance needed for a lightweight digital twin to be useful to smaller organisations?
- How can digital twins model the impact of accessibility failures, such as last-minute platform changes, missing ramps, inaccessible information or poor mobile connectivity?
- How can confidential commercial transport data be used in federated or trusted ways without undermining competitive interests?
- How can decision-makers be trained to interpret uncertainty and avoid over-reliance on single-number outputs?
- How can digital twins evolve over time as climate, travel behaviour, technology and social expectations change?

TransiT partners

TransiT is a collaboration of [eight universities](#) and almost [70 industry partners](#), jointly led by [Heriot-Watt University](#) in Edinburgh and the [University of Glasgow](#). It is supported by the UKRI [Engineering and Physical Sciences Research Council](#) (EPSRC), the main funding body for engineering and physical sciences research in the UK, and by the UK government's [Department for Transport](#).

TransiT's other university partners are [University of Leeds](#), [University of Birmingham](#), [Cranfield University](#), [University College London](#), [University of Cambridge](#) and [Durham University](#).

Visit <https://transit.ac.uk/>

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