TEES VALLEY

# The UK's First, Region-Wide, Automated Traffic Digital Twin

**Anything is possible.**

**Author:** Sean Fryer
**Title:** Digital Transport Delivery Manager, Tees Valley Combined Authority

TEES VALLEY

**Contents** 2

**Foreword** 4

**1. Executive Summary** 5

*Foundations* 5

*Digital Twin, Phase One Deliverables* 5

*Delivery and Performance* 6

*Strategic Contribution* 6

*Social and Local Value* 6

*Conclusion and Next Steps* 6

**2. Tees Valley and the Tees Valley Combined Authority** 8

*Tees Valley* 8

Figure 1 - Tees Valley Combined Authority 8

*Tees Valley Combined Authority (TVCA)* 8

*Tees Valley Strategic Transport Plan (2020 -2030)* 9

Figure 2 - Tees Valley Strategic Transport Plan 9

*Tees Valley Digital Strategy (April 2022 – March 2032)* 10

**3. Introduction and Context** 11

*UK Digital Twins* 12

Table 1 UK Digital Twin Case Studies 12

**4. Project Overview** 13

*Introduction* 13

*Partnership and Governance* 13

*Solution Design and Requirements* 13

*Phase One Delivery* 13

*Incident Detection Module* 14

Figure 3 Illustration of Aimsun's Incident Detection Module (IDM) traffic flow monitoring 14

*Bus Reliability Module* 15

Figure 4 Example of Aimsun's Bus Reliability Module (BRM) evaluation for detected bus delay 15

*Delivery Timeframes and Future Phases* 15

**5. Technical Architecture and System Integration** 16

*System Structure* 16

*Core Platform* 16

*System Connectivity* 16

*Data Standards, Hosting & Performance* 16
*Scalability and Future Development* 16

**6. Delivery Process and Work Packages** **17**

**7. Outcomes and Benefits Realisation** **17**
*Quantitative Outcomes* 17
*Qualitative Benefits* 17
*Strategic Alignment and Long-Term Benefits* 18

**Table 2 Expected Wider Benefits for Tees Valley** **18**
*Ongoing Monitoring and Evaluation* 19

**8. Stakeholder Feedback** **19**
Table 3 Key Themes from Stakeholder Feedback 20

**9. Issues and Risks** **21**
*Risk Management Approach* 21
*Key Issues and Mitigations* 21
*Residual Risks and Future Considerations* 22
Table 4 Summary of Key Risks and Mitigations 22

**10. Lessons Learned** **23**
Figure 5 Lessons at a Glance - Phase One Insights 23
*Key Lessons* 24

**11. Future Vision and Next Steps** **25**

**12. Conclusion** **26**

**13. Acknowledgements** **27**
*Project Delivery Team* 27
*Local Authority Partners:* 28
*Technical and Delivery Contributors:* 28
*Strategic Partners and Support:* 28

# Foreword

Developed under the wider Tees Valley Digital Transport Programme, the Tees Valley Traffic Digital Twin demonstrates how innovation, data, and collaboration can transform transport management across the region. Phase One represents a foundational step in delivering a smarter, more reliable, and future-ready transport system for the Tees Valley.

“Delivering the Digital Twin has been a genuine team effort. It’s shown how combining technology with local expertise can make a real difference on our roads today. Phase Two will take that progress further, extending automation, broadening coverage, and strengthening the Tees Valley’s position not only as a leader in digital transport innovation, but also in fulfilling TVCA’s ambition to genuinely improve the lives of people across the region.”
— Sean Fryer, Digital Transport Delivery Manager, Project Lead & Author, Tees Valley Combined Authority

“This marks a major step in our wider Digital Transport Programme and demonstrates how innovation and data can drive lasting change. By combining local expertise with world-class technology, we are building the foundations of a truly Smart Region, one where digital capability supports cleaner growth and better connectivity.”
— Andrea Reacroft, Digital Transport Programme Delivery Manager, Tees Valley Combined Authority

# 1. Executive Summary

The Tees Valley Traffic Digital Twin Project marks a major milestone in the region's ambition to deliver a world-class transport network and become the UK's first truly Smart Region. Being delivered as a pilot as part of Tees Valley's City Region Sustainable Transport Settlement (CRSTS) programme, the project brings together innovation, data, and collaboration to transform how the Tees Valley manages its network, supporting cleaner growth, improved connectivity, and a better experience for all users.
At its core, the project establishes the nation's first region-wide, automated, real-time, Artificial Intelligence (AI) - driven Digital Twin for traffic management. Built on the Aimsun Live platform and integrated with Yunex Stratos and UTC-UX, the system continuously monitors live data from roadside sensors, inductive loops (sensors embedded in the road surface), and GPS tracked buses to simulate and predict traffic conditions across the entire region.

In 2025, the Department for Transport recognised the Tees Valley Traffic Digital Twin as a national example of how artificial intelligence can improve bus services and traffic management. The DfT's Transport AI Action Plan highlights Tees Valley's predictive corridor-management approach as a model for how AI and simulation can enhance public transport reliability across the UK.

## Foundations

This project builds upon more than £3.5 million of earlier investment in the region's Urban Traffic Management and Control (UTMC) capability through the Transforming Cities Fund (TCF) investment programme, which significantly enhanced Tees Valley's roadside infrastructure. This included new Automatic Traffic Counters (ATCs), Variable Message Signs (VMS), enhanced CCTV coverage, and improved communications networks. The programme also strengthened partnerships with key stakeholders, including Cleveland Police, Durham Constabulary and National Highways, through data sharing and Collaborative Traffic Management (CTM).

These assets and partnerships have substantially enhanced the region's UTMC capability, improving both digital resilience and data quality. This investment provided the high-quality, real-time information that underpins the region's Traffic Digital Twin, enabling a continuous and reliable flow of live network data.

Through these combined investments in physical and digital infrastructure, the Tees Valley has positioned itself at the forefront of data-driven transport innovation, equipped with the tools to manage its network more intelligently, sustainably, and inclusively.

## Digital Twin, Phase One Deliverables

Phase One of delivery focused on pilot projects to demonstrate what could be achieved in relation to bus reliability and network optimisation. It successfully deployed:

- A live, region-wide Aimsun simulation model connected to real-world data feeds.
- An Incident Detection Module (IDM) using machine learning to identify and forecast congestion up to one hour ahead.

- A Bus Reliability Tool that flags late-running services and automatically tests and implements targeted signal strategies.
- Seamless integration with existing UTC and Stratos systems, enabling automated alerts and enhanced situational awareness.

## Delivery and Performance

The project was delivered on budget, with only minor schedule adjustments to accommodate integration with new data sources. Initial monitoring and evaluation evidence measurable performance gains:

- 13.7% reduction in average delay for general traffic where strategies were deployed.
- +11.6 mph average speed recovery for buses within 15 minutes of intervention.

## Strategic Contribution

Beyond its operational achievements, the project lays the groundwork for realising the wider ambitions for the CRSTS programme, acting as a catalyst for:

- Driving growth and productivity through infrastructure investment.
- Levelling up public transport services across all boroughs.
- Decarbonising transport, encouraging modal shift to buses, walking, and cycling.
- Supporting other investment packages within the CRSTS programme, including the bus theme which seeks to work with operators to transform the Tees Valley bus services and grow passenger numbers.
- In Tees Valley, CRSTS funding is also being used to prepare for future mobility, including connected and autonomous vehicles (CAVs), through digital readiness and policy work.

It also advances the Tees Valley's strategic aims of creating a digitally enabled, integrated, and inclusive transport network that uses open data, smart infrastructure, and analytics to optimise performance and support sustainability.

## Social and Local Value

Delivery partners have further contributed substantial social and local value, including a regional supply-chain spend exceeding £2.5 million, virtual work-experience placements for 30 students, participation in local Science, Technology, Engineering and Mathematics (STEM) outreach, and an estimated 9.6 tonnes of $CO_2$ saved through digital-first collaboration.

## Conclusion and Next Steps

The success of this first phase provides a strong foundation for Phase Two, which will extend automation, integrate new corridors and data sources, and introduce controlled evaluation trials to quantify the impact of interventions more precisely.

The Tees Valley Traffic Digital Twin demonstrates how regional innovation, and partnership can translate national investment into measurable local outcomes, delivering a transport system that is cleaner, smarter, more reliable, and ready for the future.

# 2. Tees Valley and the Tees Valley Combined Authority

## Tees Valley

Tees Valley, in North East England, comprises five local authorities: Darlington, Hartlepool, Middlesbrough, Redcar & Cleveland, and Stockton-on-Tees, with around 700,000 residents, ( Figure 1). The area benefits from major transport assets including Teesport, Teesside International Airport, and strong national rail and road connections. The Tees Valley economy is driven by advanced manufacturing, clean energy, digital innovation, and logistics, supported by strategic initiatives such as Teesworks, the Teesside Freeport, and the Hydrogen Transport Hub. These sectors underpin the region's ambition to become a leading Smart Region, using data and technology to deliver sustainable growth.

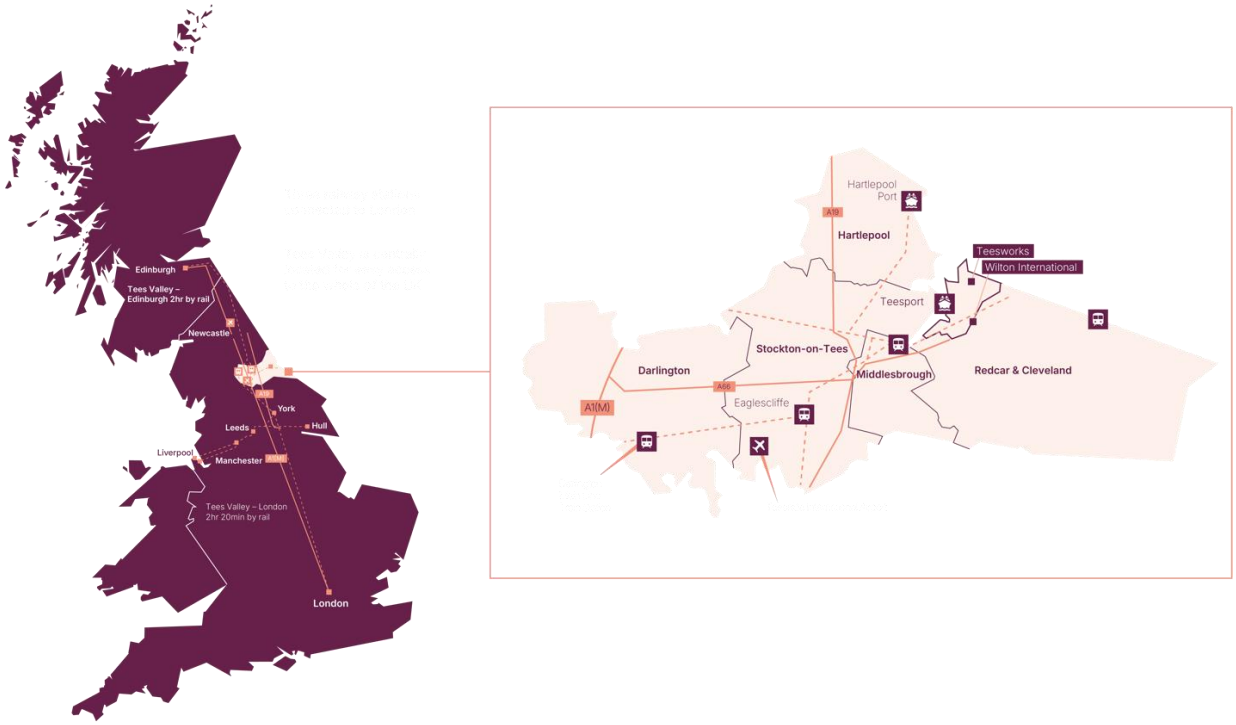


*Figure 1 - Tees Valley Combined Authority*

## Tees Valley Combined Authority (TVCA)

Formed in 2016 through the devolution agreement between UK Government and the five Tees Valley councils, TVCA is led by the Tees Valley Mayor and coordinates regional decision-making on the economy, transport, skills, and infrastructure. Its role is to drive economic growth, improve connectivity, and enhance quality of life across Tees Valley by investing in major infrastructure,

supporting innovation, and ensuring that residents and businesses benefit from sustainable, inclusive development.
Through devolution, TVCA has greater control over regional transport planning and investment, enabling the creation of an integrated transport network that supports people, freight, and business across all modes.

## Tees Valley Strategic Transport Plan (2020 -2030)

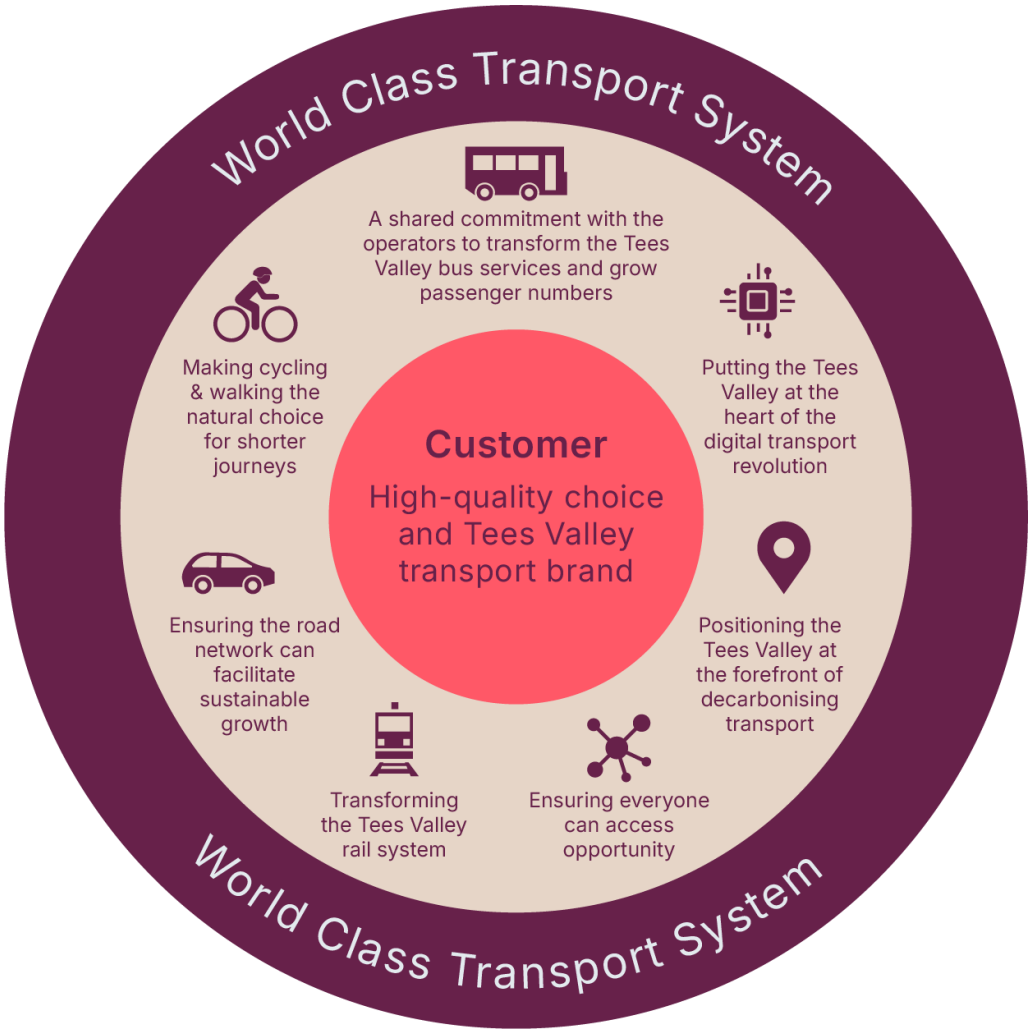


*Figure 2 - Tees Valley Strategic Transport Plan*

The Tees Valley Strategic Transport Plan (STP) sets out the region's long-term ambition to deliver a World-Class Transport System that enables sustainable economic growth, improves quality of life, and provides high-quality travel choices for all residents, businesses, and visitors.

The plan is centred around the customer, ensuring the transport network delivers high-quality choice and reinforces a strong Tees Valley transport brand.

It identifies the key interventions needed to support growth, accessibility, decarbonisation, and the transformation of bus, rail, road, cycling, and walking networks across the region.

Core priorities within the STP include:

- Transforming the Tees Valley bus network, a shared commitment with operators to improve service quality, reliability, and passenger growth through better infrastructure, integrated ticketing, and enhanced information.
- Putting the Tees Valley at the heart of the digital transport revolution, expanding the use of real-time data, predictive technologies, and smart systems to improve efficiency and support a modern, digitally enabled transport network.
- Positioning the Tees Valley at the forefront of decarbonising transport, reducing emissions across all modes by supporting modal shift to sustainable travel and ensuring the network supports the region's Net Zero ambitions.
- Ensuring everyone can access opportunity, improving connectivity to jobs, education, health, and services across all communities, reducing barriers to travel and supporting inclusive growth.
- Transforming the Tees Valley rail system, enhancing capacity, service quality, accessibility, and integration with other modes, ensuring rail plays a key role in supporting regional and national mobility.
- Ensuring the road network supports sustainable growth, delivering a reliable, well-managed road system that reduces congestion bottlenecks, improves safety, and supports economic activity across key corridors.
- Making cycling and walking the natural choice for shorter journeys, improving active travel infrastructure, safety, and connectivity to encourage healthy, low-carbon travel choices.

## Tees Valley Digital Strategy (April 2022 – March 2032)

The Tees Valley Digital Strategy outlines the regions ambitions to become the UK's first truly Smart Region, using world-leading digital infrastructure and innovation to create opportunities for all residents and businesses; where technology, data, and innovation underpin a cleaner, fairer, and more connected transport future. The strategy covers smart: buildings, education, government, health services, homes, manufacturing and construction, retail, and transportation.

A key enabler for smart transportation in the region is the installation of a Traffic Digital Twin to enable more people to move around more quickly, supporting the strategic aims set out in the Tees Valley Digital Strategy, Digital Transport Delivery Plan and Strategic Transport Plan (2020 – 2030):

- Establishing a digitally enabled, integrated transport network that supports all modes and users.
- Promoting open data and real-time information sharing to improve journey planning, network management, and user experience.
- Developing a smart infrastructure backbone through sensors, Internet of Things (IoT), and connected systems to enable predictive and responsive transport management.
- Supporting decarbonisation and sustainability, encouraging modal shift from private cars to public transport, walking, and cycling.

- Enhancing accessibility and inclusivity by designing digital tools that serve all users, including those with limited digital access or mobility.
- Enabling proactive, data-driven decision-making through analytics, simulation, and automation to optimise network performance.

## 3. Introduction and Context

TVCA has set out a clear vision to deliver a world-class transport network and to establish the region as the UK's first truly Smart Region by creating a digitally enabled, integrated transport system that supports sustainable growth, inclusion, and delivers cleaner, smarter, and more reliable journeys across the Tees Valley. Achieving this vision requires a shift from traditional, reactive traffic management towards data-driven, proactive, predictive systems that can anticipate issues and optimise performance across all modes of transport.

The transport challenges facing the region mirror those experienced across the UK, increasing congestion, limited real-time visibility of network conditions, pressure to decarbonise, and growing expectations from passengers for reliable, joined-up journeys. With five local authorities operating interconnected networks, managing transport at a regional scale demands stronger coordination, higher-quality data, and more intelligent tools.

CRSTS provides the strategic and financial framework to address these challenges. Its objectives, to drive productivity, level up local services, decarbonise transport, and prepare for future mobility, align directly with the Tees Valley's ambitions for a Smart Transport Region. Within this context, the Digital Twin Project emerged as a key innovation, designed to demonstrate how AI, real-time simulation, and open data can transform network management and service delivery.

Before embarking on the Digital Twin, the region invested in modernising and expanding its roadside infrastructure. This programme enhanced the capability of the region's ATCs, VMS, and CCTV coverage, dramatically improving the quality and reach of transport data across the Tees Valley. These assets created the digital foundation upon which the Traffic Digital Twin has been built and continues to evolve.

Equally important was the establishment of new partnerships and governance models to enable effective regional collaboration. As the lead authority for UTMC, Middlesbrough Council plays a central role in coordinating network operations across the Tees Valley. The project built upon the existing relationships between TVCA, Middlesbrough Council's UTMC team, and the five local authorities, while also fostering new partnerships with Cleveland Police, Durham Constabulary, and National Highways under a shared data and operations framework. Through this collaboration, the region has been able to test and implement the principles of CTM, ensuring that decisions made in one part of the network deliver benefits across the whole region.

The Tees Valley Traffic Digital Twin represents a major step forward in this transformation journey. It moves the region from managing congestion as it happens towards predicting and mitigating it before it occurs, providing the intelligence, integration, and foresight needed to support sustainable mobility and future innovations such as CAVs. It also lays the groundwork for scaling data-led transport management through future CRSTS phases, alternative funding streams, and the wider Tees Valley Smart Region ambition.

## UK Digital Twins

To understand the significance of the Tees Valley Traffic Digital Twin, it is useful to consider its position within the wider UK digital transport landscape, (Table 1). Across the country, a number of cities and research programmes are developing digital twins for transport and infrastructure management. However, most remain focused on individual cities, single modes, or pilot-stage deployments.

The Tees Valley model distinguishes itself as the first fully operational, region-wide, automated traffic digital twin in the UK, integrating live data, predictive simulation, and control across multiple local authorities and modes.

*Table 1 UK Digital Twin Case Studies ((All information based on publicly available sources as of 2025.)*

| Location | Scope / Focus | Operational Status | Key Difference from Tees Valley |
|---|---|---|---|
| Manchester | Corridor-based pilot digital twins (bus reliability and traffic flow) within the M60 area, according to publicly available project announcements. | Pilot / research deployment. | Focused on two specific corridors for evaluation; not integrated with UTC systems and does not deliver automated real-time traffic or bus management. |
| West Midlands (Birmingham & Wolverhampton – DIATOMIC) | AI-enabled traffic and air-quality digital twin as part of the DIATOMIC programme, supporting analysis and scenario modelling (per Digital Twin Hub documentation). | Operational pilot (2024). | Public sources indicate a city-scale research platform focused on analytics; no publicly documented region-wide automation or real-time bus/traffic management. |
| Liverpool City Region (KUDATA Project) | Regional research initiative developing data-driven and AI-supported multimodal planning tools, according to publicly accessible project summaries. | Pilot / research stage (2024–2025). | Available information indicates a planning-orientated programme rather than an operational real-time management system. |
| Glasgow | City-level digital twin and smart city initiatives (e.g., environmental and street infrastructure) as reported in smart city publications. | Operational components; not a unified transport digital twin. | Public documentation shows domain-specific city projects without multi-authority transport integration, predictive simulation, or automated control. |
| London | Multiple asset-specific digital twins (e.g., Elizabeth Line, Thameslink, utilities), documented through industry and transport authority publications. | Operational at asset level. | Public sources do not indicate a unified, cross-authority transport management twin; systems are asset-specific rather than network-wide. |
| Tees Valley | Region-wide, multi-authority traffic and bus digital twin integrating Aimsun Live, Yunex Stratos and UTC-UX with real-time multimodal data, as stated in official TVCA and supplier announcements. | Fully operational (2025), with deployment supported by ongoing optimisation and phased expansion across the network. | First of its kind, a region-wide predictive and automated traffic and bus management system, connected to and informed by on-street roadside infrastructure. It currently covers 11 priority corridor hotspots, with capacity for further expansion, and provides automated region-wide incident detection within a unified operational environment. |

This comparison shows that meaningful innovation isn't limited to the UK's largest metropolitan areas. The Tees Valley has established itself as the UK's first region-wide, fully operational traffic digital twin,

actively managing live transport operations and bus reliability through predictive automation. It demonstrates how collaboration, modular design, and intelligent data use can drive progress beyond city-level pilots, setting a new benchmark for innovative digital transport delivery.

# 4. Project Overview

## Introduction

The Tees Valley Traffic Digital Twin Project was established to support the region's ambition to deliver a smarter, more resilient, and data-driven transport network. Its core objective was to deploy a live, operational digital twin capable of modelling and managing traffic conditions across the entire Tees Valley in real time, enabling improved network performance and enhanced bus reliability.

## Partnership and Governance

The project was led by the TVCA in collaboration with Middlesbrough Council's UTMC team, the five Tees Valley local authorities, and delivery partners Aimsun Ltd and Yunex Traffic. This partnership combined local operational knowledge with international expertise in traffic simulation, AI, and intelligent transport systems, resulting in the delivery of the UK's first region-wide automated traffic digital twin.

## Solution Design and Requirements

A structured design process ensured the solution aligned with regional priorities. Project partners defined clear objectives and functional requirements. Once requirements were established, Aimsun and Yunex assessed the region's data environment to determine readiness. This assessment reviewed data availability and quality, identifying where machine learning could enhance existing data and where additional on-street infrastructure or alternative data sources (e.g., floating car data) would be required. Findings informed refinement of the functional requirements and the decision to adopt a phased deployment approach, comprising three phases. This paper focusses on the Phase One.

## Phase One Delivery

Phase one focussed on deploying Aimsun Live, the digital foundation of the traffic digital twin on which module systems could be deployed. The Aimsun Live comprises three core components:

- Machine learning traffic data models
- Real-time data integration
- Development of a high-fidelity traffic simulation model

The Aimsun Live system provides historical, live, and one-hour predictive network visibility within a web interface, utilising data from urban traffic control (UTC) systems, VivaCity sensors, Street Works, and the National technical information service (NTIS). The system is fully integrated with Yunex Stratos and UTC-UX, enabling two-way data sharing, automated notifications, and direct actuation of signal strategies on-street.

Once the Aimsun Live was implemented, Aimsun's incident detection module (IDM) and Bus Reliability Module (BRM) were installed.

## Incident Detection Module

IDM is an AI-driven system which identifies traffic incidents across the network, automatically alerting operators to on-street disruptions. It uses live traffic feeds to identify when traffic flow deviates significantly from the expected trend and / or drops to zero between two detection points, ( Figure ). When this happens, it produces an automatic alert to operators so that they might direct their attention to areas of the network requiring active support and management. This system is designed to improve situational awareness whilst reducing cognitive burden on operators, thereby building capacity.

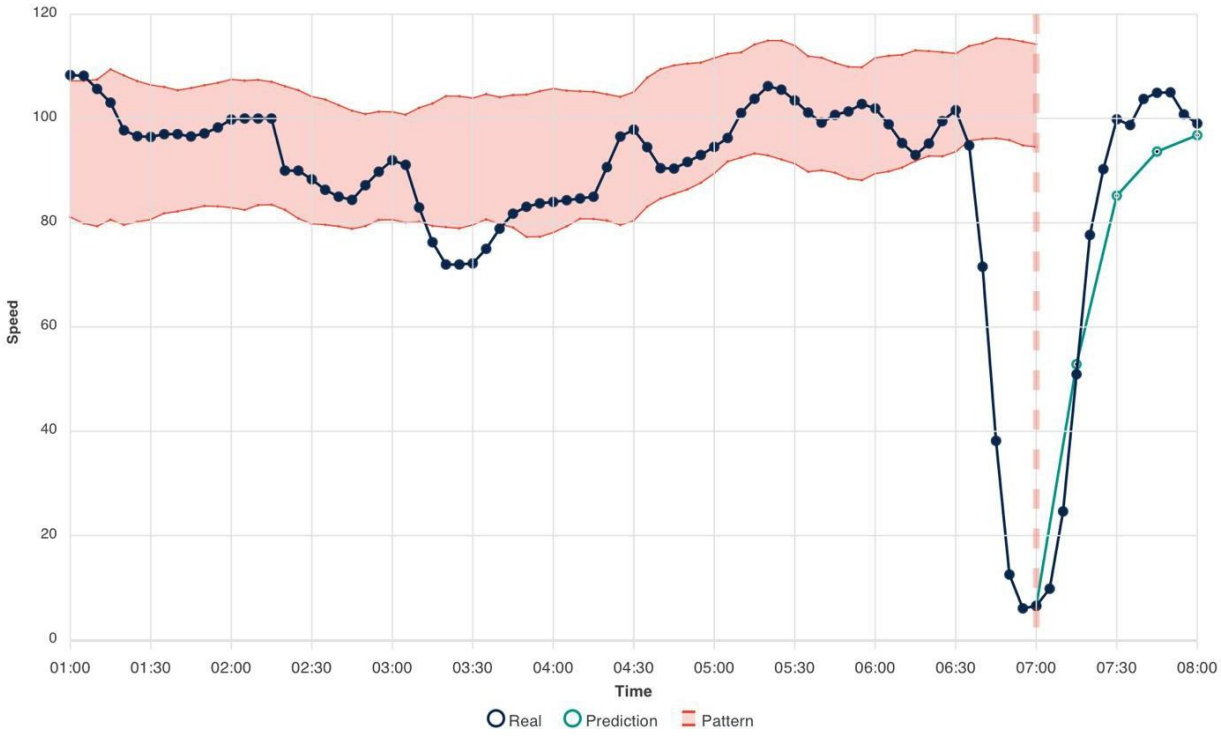


*Figure 3 Illustration of Aimsun's Incident Detection Module (IDM) traffic flow monitoring*

## Bus Reliability Module

BRM provides real-time monitoring of bus performance using the Bus Open Data Service (BODS) and SIRI-VM to continuously assess bus journey times and identify when they are deviating from schedule. When bus delay is identified, the system tests up to 3 pre-established signal strategies, alongside a do-nothing option, to identify the most appropriate solution to improve bus schedule adherence whilst minimising adverse impacts on general traffic and intersecting bus routes, (
Figure ). The system is deployed across 11 pre-selected priority corridors within Tees Valley.

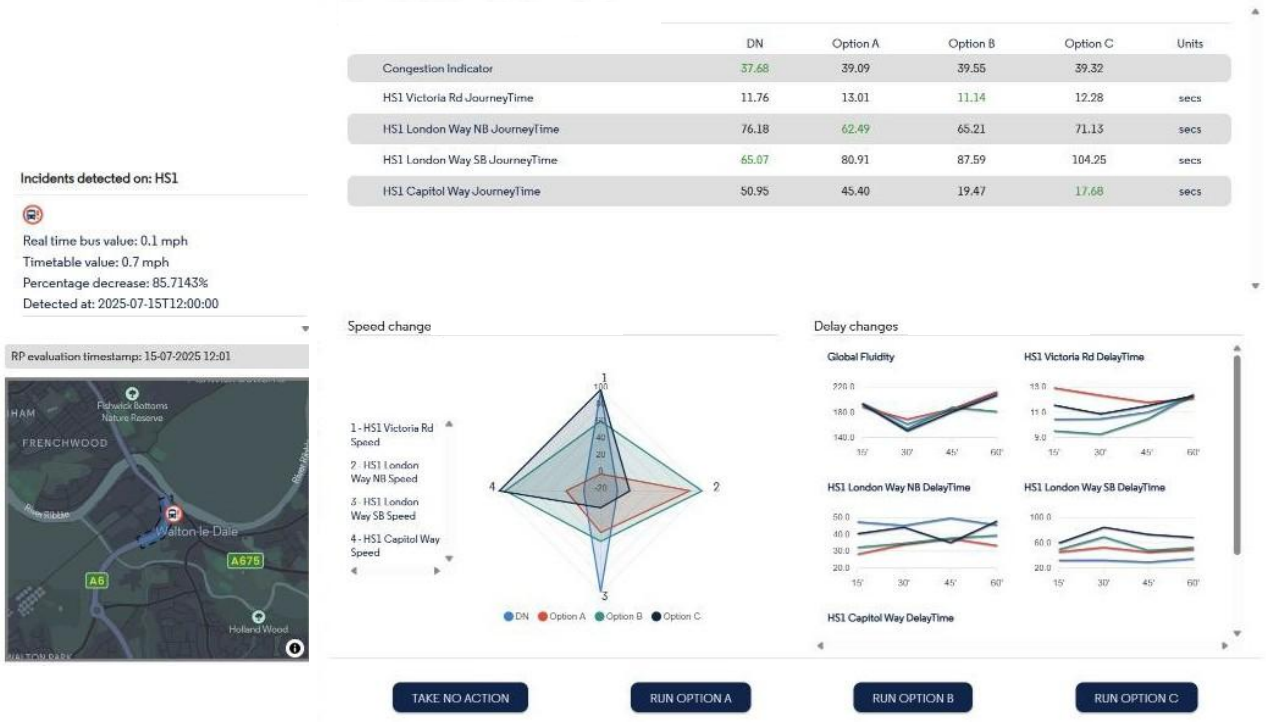


*Figure 4 Example of Aimsun's Bus Reliability Module (BRM) evaluation for detected bus delay*

## Delivery Timeframes and Future Phases

Delivery commenced in January 2024 and completed in May 2025, with operational handover in June 2025. Successful delivery of Phase One establishes a scalable digital foundation capable of absorbing new data sources, increased automation, and wider geographic coverage. This framework positions Tees Valley to expand its digital transport capability through future CRSTS phases and other innovation funding streams.

# 5. Technical Architecture and System Integration

## System Structure

The Tees Valley Traffic Digital Twin integrates live data, simulation, and automated decision-support tools within a unified operational ecosystem. The design links existing transport infrastructure with new predictive and analytical components to enable proactive network management.

## Core Platform

Aimsun Live operates as the real-time simulation and decision engine, continuously ingesting data from:

- Automatic traffic counters and loop detectors
- CCTV analytics
- BODS and SIRI-VM bus feeds
- Urban traffic control systems

This data provides real-time situational awareness, congestion forecasting, and the ability to test interventions before implementation.

## System Connectivity

The digital twin is fully integrated with Yunex Stratos and UTC-UX, allowing seamless data and command exchange. Key automation functions include:

- IDM alerts via Microsoft Teams and operator-triggered response selection
- BRM applying automated predictive signal optimisation along defined corridors.

This integration enables automated or operator-approved traffic control responses through Yunex Stratos Strategy Manager, delivering a digital twin which can actuate change on-street.

## Data Standards, Hosting & Performance

Industry-standard protocols such as DATEX II ensure interoperability across suppliers and datasets. The system is hosted in a secure cloud environment, providing high availability (≥95%), resilience, and automated software and algorithm updates. Continuous feedback loops allow the digital twin to learn from historical trends and real-time performance, improving accuracy over time.

## Scalability and Future Development

The modular architecture supports integration of new data sources and technologies, including floating car data and connected-vehicle information. This future-proof design ensures the digital twin remains a strategic asset aligned with wider transport innovation programmes and funding opportunities within Tees Valley.

# 6. Delivery Process and Work Packages

The Tees Valley Traffic Digital Twin Project followed a structured, collaborative delivery process designed to ensure technical integrity, transparency, and value for money. The approach was phased, with clear work packages that aligned supplier responsibilities, governance oversight, and regional stakeholder engagement. This method enabled the project to progress efficiently while managing dependencies across multiple systems and organisations.

Project delivery was overseen by the TVCA Digital Transport Delivery Manager as project lead, and Programme Delivery Manager as SRO supported by Middlesbrough Council's UTMC team, acting as the operational lead. Delivery partners Aimsun Ltd and Yunex Traffic were responsible for technical design, system integration, and software deployment. Regular governance meetings ensured close alignment with TVCA & CRSTS objectives, allowing issues to be identified early and resolved collaboratively.

# 7. Outcomes and Benefits Realisation

Phase One of the Tees Valley Traffic Digital Twin Project has delivered a fully operational platform that is already demonstrating measurable benefits for network management, bus reliability, and data-led decision-making. While the system will continue to evolve as it embeds into business-as-usual operations, early results from the first phase show clear evidence of improved performance and capability across the region.

## Quantitative Outcomes

Preliminary results from monitoring and evaluation, for the period July to September 2025, found:

- For simulation-based results: A 13.7% reduction in average travel time for general traffic where strategies were deployed, demonstrating more efficient network management.
- For on-street data validation results: A mean improvement of 11.6 mph in bus segment speeds within 15 minutes of strategy activation, showing the effectiveness of automated signal interventions in restoring punctuality.

These results confirm that the Digital Twin's predictive capabilities are delivering real operational improvements and forming a solid foundation for future expansion and automation. Further monitoring and evaluation will be conducted over a 12-month period.

## Qualitative Benefits

Beyond measurable performance gains, the project has strengthened the Tees Valley region's ability to manage its transport network proactively.

Key qualitative benefits include:

- Enhanced network visibility: Operators now have a real-time view of traffic conditions across the entire Tees Valley, supported by predictive forecasting and automated alerts.
- Faster incident detection and response: The IDM enables quicker identification of issues and provides context-aware decision support for operators.

- Improved public transport reliability: The BRM delivers tangible support to operators, automatically implementing pre-tested signal strategies to reduce delays and improve timetable adherence.
- Data-driven decision-making: The Digital Twin brings together live and historical data, allowing decisions to be based on evidence rather than assumptions.
- Reduced operator cognitive burden: Automation of routine monitoring and control tasks allows UTMC staff to focus on higher-value network management and planning activities.

## Strategic Alignment and Long-Term Benefits

The benefits of the Digital Twin extend beyond operational improvements, (Table 2). The system directly supports the wider goals of CRSTS, the Tees Valley's strategic aims, and Smart Region ambitions, through:

- Driving regional productivity through better use of data and digital infrastructure.
- Levelling up transport services by improving journey reliability across the region.
- Supporting decarbonisation by encouraging public transport use through more reliable, efficient services.
- Supporting other investment packages within the CRSTS programme, including the bus theme which seeks to work with operators to transform the Tees Valley bus services and grow passenger numbers.
- Enhancing resilience by providing a scalable data fuelled platform capable of integrating with future technologies.

*Table 2 Expected Wider Benefits for Tees Valley*

| For the Public | For Operators and Local Authorities | For the Region |
|---|---|---|
| Faster, more reliable bus journeys | Real-time visibility of network conditions | Better air quality and reduced congestion |
| Shorter travel times and fewer delays | Faster incident detection and response | Improved access to jobs and services |
| More consistent and predictable journeys | Evidence-based decision-making | Supports Net Zero and sustainability targets |
| Clearer, data-driven information for travellers | Streamlined collaboration across five authorities | Strengthens Tees Valley's position as one of the UK's leading Smart Regions |

These benefits position the Tees Valley as a national leader in applying AI, machine learning, simulation & automated technologies to real-world transport management. The project demonstrates how regional collaboration, and digital investment can translate directly into improved service quality, reduced congestion, and better passenger experience.

The Digital Transport Programme also supports the region's long-term ambitions for skills and employment. Far from replacing people, the introduction of AI and digital systems creates new opportunities for skilled jobs in areas such as network operations, data science, and intelligent transport systems. The continued development of the UTMC control room will require new digital capabilities, providing high-value employment and training pathways within the Tees Valley.

Looking ahead, these digital foundations align closely with the forthcoming Tees Valley Local Growth Plan, which will further set out how investment in innovation, connectivity, and skills can deliver sustainable economic growth across the region.

### Ongoing Monitoring and Evaluation

As the Digital Twin continues to transition into full business-as-usual operation, its performance and benefits will continue to be monitored. A structured framework is in place to track:

- Key performance indicators (KPIs) including journey time reliability, incident detection rates, and bus service punctuality.
- System availability and data quality metrics to ensure ongoing reliability.
- Feedback from network operators and stakeholders to identify opportunities for refinement.
- Comparative analysis between simulated and observed outcomes to measure ongoing accuracy and predictive improvement.

Continuous monitoring will inform both future CRSTS phases and alternative funding opportunities to support the case for expanding digital traffic management capabilities.

## 8. Stakeholder Feedback

Stakeholder engagement played a central role in shaping and validating the Tees Valley Traffic Digital Twin Project. Feedback was collected through workshops, technical reviews with operational teams, local authorities, and delivery partners.

The following themes, (Table 3), reflect the collective perspective of those directly involved in the project's development and implementation, highlighting how collaboration, innovation, and regional commitment have contributed to its success.

*Table 3 Key Themes from Stakeholder Feedback*

| Stakeholder Group | Feedback Summary |
|---|---|
| Operations Team, *UTMC Manager - Middlesbrough Council, Mark Walker* | "As the end user of this tool, it's encouraging to see how the Digital Twin Bus Reliability Project has laid a strong foundation for smarter traffic management in the Tees Valley. The integration of predictive modelling and strategic control shows real promise for improving bus flow and reducing congestion, and particularly in how it contributes to more reliable journeys across our region." |
| Bus Operator *Business Director, Go North East, Ben Maxfield* | "Although only impacting a small portion of Go North East's network, the initial findings as set out in the Monitoring and Evaluation of the Digital Twin Bus Reliability Tool are promising and we are optimistic for how the tool can be used further to improve journey times and overall bus punctuality." |
| Bus Operator *Head of Commercial, Arriva - North East & Yorkshire, Richard McGowan* | "The bus reliability tool is already evidencing reduced average delays across key locations. Improved journey times directly enhance the customer experience, and Arriva remain committed to working with the Combined Authority to deliver faster, more reliable bus services." |
| Delivery Partners *Aimsun Ltd, Dr Gavin Bailey, Regional Head of Business Development for the UK and Nordics* | "Tees Valley's commitment to deploying the TVCA Traffic Digital Twin places them at the forefront of operational digital twin technologies in the UK. Specifically, at the time of deployment it was the first traffic digital twin in the UK to connect to on-street infrastructure enabling actuation of strategies identified by the data-led and simulation supported insights from the system. It is great to see that the breadth of benefits the system is delivering so early on. The collaborative approach to deployment of the system, fostered by TVCA has been key to the successful delivery and operation of the traffic digital twin system. Their ambition continues to support us to push the art of the possible and integrate increasingly innovative solutions within their digital transport system." |
| Tees Valley Combined Authority *Chief Executive, Tom Bryant* | "The collaborative work by our Digital Transport team and local authorities to bring this project forward, and to fruition, has been very heartening and it's really encouraging to see the early indicative data from the pilot. One of our key overarching goals is to achieve economic growth for the Tees Valley and making a world-class transport system in a key long term aim to enable this. The modernisation and development of the UTMC is vital part of this and it's good to see the Digital Twin in action and having a material impact on our network in its early stages." |
| TVCA Cabinet Member for Transport and Infrastructure, Councillor, *Steve Harker* | "We're making our transport network smarter, faster, and more reliable. The Digital Twin shows what our region can do when use the best of technology to improve our network and make a material difference to everyone on our roads.<br>I'm interested to see how the expansion of the project will cut more delays for bus users across the Tees Valley to make it a more reliable choice for thousands of local people." |
| Tees Valley, *Mayor, Ben Houchen* | "Delivering the UK's first region-wide, fully automated, AI-managed Traffic Digital Twin is a huge milestone for our region and is already making a real difference to everyday journeys on our road network.<br>"By using real-time data and modelling to spot and fix problems before they escalate, we're reducing delays, easing congestion and helping road users get back on time more quickly. It means smoother journeys for motorists, hauliers and public transport users right across Teesside, Darlington and Hartlepool.<br>"This system is live, operational, and already delivering results. It shows exactly how serious we are about backing drivers, improving bus reliability, and building a modern, efficient transport network that keeps our region moving." |

Stakeholder feedback highlights the shared enthusiasm for the regions Digital Transport ambition, supported by the Digital Twin which is already transforming operations and collaboration across the Tees Valley. The feedback demonstrates a strong collaborative approach, confidence in system growing capability, and a collective commitment to advancing the next phase of digital transport innovation.

# 9. Issues and Risks

As with any complex, multi-agency innovation project, the delivery of the Tees Valley Traffic Digital Twin involved a number of risks and issues that required active management. Many of these were inherent to developing and integrating new digital technologies across multiple systems and partners. Effective governance, clear communication, and collaborative problem-solving ensured that all identified risks were managed and resolved without impact to the overall project outcomes.

## Risk Management Approach

A risk register was established at project inception and maintained throughout all delivery phases. Risks were reviewed during technical meetings and formally at monthly governance boards with the project lead and the Urban Traffic Control (UTC) manager present. Each risk was assigned an owner, likelihood, and impact rating, with mitigation strategies tracked through to closure. This approach ensured early visibility of potential challenges and enabled proactive resolution.

## Key Issues and Mitigations

Data integration and external dependencies: Integration with third-party systems, data suppliers and bus data feeds, occasionally led to configuration delays and data quality inconsistencies. These were managed through direct engagement with suppliers, additional testing cycles, and refinement of interface protocols. The modular design of the system also allowed other work packages to progress in parallel, minimising schedule impact.

Data quality and consistency: Variability in the accuracy and availability of data posed challenges for model calibration and prediction accuracy. This was addressed through enhanced validation routines, regular data cleansing, and the implementation of monitoring scripts to flag anomalies automatically.

Technology integration and system testing: Developing a fully integrated environment across Aimsun Live, Yunex Stratos, and UTC-UX introduced compatibility and interface challenges. Early joint testing sessions and shared configuration reviews between Aimsun and Yunex teams resolved these efficiently. Lessons learned from these exercises have informed a more streamlined integration process for future phases.

Programme dependencies and scheduling: Delivery schedules were affected by dependencies between work packages and external systems. The project team adopted an agile approach, allowing concurrent delivery of independent components and flexible reallocation of resources. This adaptability-maintained progress and ensured timely completion despite shifting priorities.

Operational readiness and training: As the system moved from development to live operation, additional time was required to train UTMC and operations staff. Aimsun delivered tailored training sessions and provided ongoing support during handover, ensuring operators were confident using the new tools and processes.

## Residual Risks and Future Considerations

While all delivery risks were successfully mitigated, several residual risks remain relevant for ongoing operations and future phases, (

Table 4).

Data availability and continuity: Continued collaboration with data suppliers will be essential to maintain consistent data quality and coverage.

Cybersecurity: As the system expands and new data sources are integrated, ongoing security assessments will be required to protect sensitive operational data.

System scalability: Future expansion may introduce additional integration demands; maintaining the modular structure will be key to managing complexity.

Staff capability and knowledge retention: Continuous training will be necessary to preserve expertise and support the evolution of digital operations

*Table 4 Summary of Key Risks and Mitigations*

| Risk Area | Description | Impact | Mitigation Actions | Residual Status |
|---|---|---|---|---|
| Data Integration | Delays or inconsistencies in connecting third-party systems, bus data feeds). | Medium | Early supplier engagement, additional testing cycles, and modular design allowing parallel progress. | Resolved – ongoing supplier coordination maintained. |
| Data Quality and Availability | Variability in accuracy and completeness of real-time data affecting model calibration. | High | Enhanced validation routines, automated anomaly detection, and regular data cleansing. | Partially mitigated – continued monitoring required. |
| Technology Integration | Compatibility challenges between Aimsun Live, Stratos, and UTC-UX environments. | Medium | Joint configuration sessions between Aimsun and Yunex; early interface testing. | Resolved – improved process adopted for future phases. |
| Programme Dependencies | Schedule pressures caused by interdependent work packages and external systems. | Medium | Agile delivery approach with overlapping work packages and flexible resource allocation. | Closed – delivery completed on time. |
| Operational Readiness | Staff familiarity and capability with new tools during handover phase. | Medium | Targeted training for UTMC operations team; extended support period post-handover. | Closed – staff trained and system operational. |
| Cybersecurity and Data Protection | Potential vulnerability as data volume and integrations increase. | High | Secure cloud hosting, routine penetration testing, and adherence to ICT security policy. | Ongoing – subject to regular review. |
| System Scalability | Future expansion could introduce new integration and maintenance challenges. | Medium | Maintain modular design; document all interfaces for future development. | Ongoing – monitored in Phase Two planning. |

| | | | | |
|---|---|---|---|---|
| AI Public perception | Public concern that the use of artificial intelligence in transport management could lead to job losses or reduced human oversight. | Low | Clear communication through publications like this report, emphasising that AI tools are designed to support skilled operational teams, not replace them. Ongoing engagement with staff and stakeholders to explain how the Digital Twin creates new digital roles, enhances decision-making, and requires upskilling within the UTMC and wider transport teams. | Emerging – Upskilling of existing roles underway and assessment of future digital roles in progress. |

By addressing these risks proactively, the project has strengthened regional capacity for managing digital systems at scale. The lessons learned from Phase One provide a strong platform for expanding automation, integrating new data feeds, and enhancing resilience as part of the next phase of Tees Valley's Smart Region journey.

## 10. Lessons Learned

The phased delivery of the Tees Valley Traffic Digital Twin Project provided valuable insights into how complex, data-driven transport systems can be successfully implemented across multiple organisations. As the first region-wide automated digital twin for traffic management in the UK, the project inevitably encountered challenges associated with integrating innovative technologies, managing large datasets, and coordinating delivery between diverse partners. These experiences have generated important lessons that will guide the next phase of development and future digital transport initiatives across the Tees Valley.

- Collaboration drives success. Early, consistent communication between stakeholders kept delivery on track.
- Manage data dependencies. Integration with external systems must be planned and monitored from day one.
- Design with operators. Involve operations teams early to ensure tools fit real-world use.
- Keep it modular. A flexible, phased architecture reduces risk and enables smooth upgrades.
- Protect data quality. Continuous validation and cleaning underpin accurate modelling and AI learning.
- Invest in skills. Ongoing training builds confidence and embeds new digital capabilities.
- National frameworks are still evolving. Regions delivering digital and AI projects need clearer, more flexible national guidance and assurance pathways to scale innovation effectively.

*Figure 5 Lessons at a Glance - Phase One Insights*

Together, these outcomes show how the Digital Twin is already improving daily journeys while laying the groundwork for even smarter, cleaner transport across the Tees Valley.

## Key Lessons

Early and continuous collaboration is critical: Strong partnership working between TVCA, Middlesbrough Council's UTMC team, the five local authorities, Aimsun, and Yunex Traffic was fundamental to success. Regular communication through bi-weekly technical reviews and governance meetings helped to maintain alignment and resolve issues quickly. Establishing joint working relationships early in the process proved essential, particularly when managing dependencies between system suppliers and data providers.

Integration dependencies must be actively managed: The performance of the Digital Twin depends heavily on the quality and timeliness of live data. Integration with external systems required close coordination and occasionally introduced delays during configuration. Clear data-sharing agreements and early engagement with third-party suppliers are essential to maintaining delivery momentum and ensuring system readiness.

Operational input is vital to effective system design: Engagement with UTMC and operational teams throughout the design phase ensured the tools delivered were relevant and practical. However, earlier involvement of operational managers could have further improved functionality and user experience. Future phases should involve end-users from the outset to shape requirements, prioritise features, and ensure seamless adoption into day-to-day operations.

Modular, flexible design supports resilience: The modular design of the system enabled incremental configuration and testing, reducing risk and allowing functions to come online progressively. This approach enabled the project to maintain momentum despite integration challenges and provided the flexibility needed to incorporate new data sources and automation features in future phases.

Data quality and consistency underpin performance: Accurate and reliable data is central to predictive modelling and machine learning. Data validation and cleansing processes were crucial to achieving the required model accuracy. Future projects should continue to invest in data quality monitoring and the integration of new sources to enhance resilience and improve predictive precision.

Navigating the national innovation landscape remains challenging: National frameworks for digital and AI-enabled transport innovation are still evolving, which can create uncertainty for regions looking to deploy advanced capabilities at pace. While the Department for Transport is increasingly supportive of new approaches, existing assurance processes, regulatory structures, and funding mechanisms are primarily designed for traditional infrastructure projects. This can make it difficult to plan multi-year digital development, scale successful pilots, or align emerging technologies with established governance requirements.

Recommendations for Future Phases: Building on these lessons, the following recommendations are proposed to strengthen the delivery of future phases:

- Engage operational users from day one, in system design workshops to align features with real-world workflows.
- Continue to maintain a clear integration plan that identifies dependencies, responsibilities, and escalation routes from project inception.

- Prioritise data governance and quality assurance to ensure continuous improvement of the live model.
- Continue phased, modular delivery to enable incremental upgrades without operational disruption.
- Develop a long-term training and capability plan to embed digital skills within UTMC and local authority teams.
- Sustain strong partnership governance between TVCA, suppliers, and local authorities to preserve the collaborative culture established prior to and during Phase One.

These lessons highlight the importance of collaboration, data integrity, and operational engagement in successful digital transformation, forming a strong foundation for Phase Two to scale automation, enhance intelligence, and expand data coverage.

## 11. Future Vision and Next Steps

Strategic Outlook: The completion of Phase One positions the Tees Valley as the UK's first region-wide automated Traffic Digital Twin. This is an important milestone, but only the first step. Building on its success, future phases will scale the system's capability, extend coverage across additional modes, and embed predictive data tools into everyday transport management and planning. These developments will directly support our goal of delivering a world-class transport system and realising the ambition of becoming a truly Smart Region.

Scaling the Digital Twin Platform: The next stage of development will expand the Digital Twin from its current focus on traffic and bus reliability to a wider, multimodal model that further incorporates freight, active travel, and environmental data.

Enhancements will include:

- Integration of FCD to fill network coverage gaps and improve predictive accuracy.
- Deployment of an Enhanced Incident Detection Module (e-IDM) building upon phase Ones IDM, capable of automated detection, testing and strategy response to non-recurrent congestion events.
- Introduction of Blackspot incident Detection and Near-Miss Analytics to identify safety risks to support road safety objectives, including collision reduction and near-miss analysis, aligned with Tees Valley's emerging 'Vision Zero'-style approaches.
- Development of specialised Digital Twins for air quality, walking and cycling.

Expanding Data and Sensor Coverage: To support these capabilities, the region will continue to invest in digital infrastructure, including additional ANPR cameras, ATCs, VMS, CCTV, and AI-based sensors. New air-quality and environmental monitoring equipment will feed live data into both Aimsun Live and Stratos, enabling climate-sensitive traffic management. Drone surveillance and additional data capture will further enhance situational awareness during incidents and major events.

Supporting Automation, Sustainability, and Inclusion: Future phases will also advance the region's readiness for CAVs through the integration of low-latency communications and connected-vehicle

data. The programme will continue to promote inclusion through user-centred design while enhancing sustainability through integrated emissions modelling and adaptive signal control, directly contributing to Net Zero and air-quality targets.

Delivery Model and Governance: The expansion of the Digital Twin will continue through a phased, modular approach to ensure compatibility, manage cost, and realise benefits early. TVCA will maintain its partnership governance structure with stakeholders, supported by structured monitoring and evaluation. Revenue models, such as shared data services and licensing, will be explored to sustain the platform beyond the funding window.

Long-Term Vision: By 2032, the Tees Valley Digital Twin will have evolved into a fully connected, multi-layered ecosystem that models and manages all transport modes while integrating environmental, demographic, and economic insights. This will enable proactive, adaptive, and sustainable network management, give operators real-time intelligence and support evidence-based decisions that improve journeys and regional outcomes.

This vision positions the Tees Valley as not only a national leader in digital transport innovation but as a demonstration of how regional collaboration, intelligent data use, and forward-thinking policy can deliver a cleaner, smarter, and more connected future.

## 12. Conclusion

The completion of Phase One of the Tees Valley Traffic Digital Twin represents a significant milestone in the region's journey towards becoming the UK's first fully integrated Smart Transport Region. The project has delivered a live, operational digital twin capable of real-time simulation, prediction, and optimisation across the entire Tees Valley network, establishing the foundations for data-led decision-making and smarter, more sustainable transport management.

Through strong partnership working, technical innovation, and disciplined delivery, the project has achieved its core objectives: improving network performance, enhancing bus reliability, and building the digital infrastructure required to support future mobility. The system is now fully operational and embedded within the UTMC environment, providing operators with a powerful, evidence-based tool for proactive network management.

Phase One has not only delivered measurable outcomes but also proven the value of collaboration across local authorities, technology providers, and regional governance. It demonstrates how intelligent data use and automation can improve both operational efficiency and public experience.

Looking ahead, the focus will shift to scaling and deepening these capabilities. Future phases will expand coverage across new transport modes, integrate additional data sources, and increase automation to deliver faster, more adaptive network control. The continued evolution of the Digital Twin will strengthen resilience, support decarbonisation goals, and help ensure that every transport decision in the Tees Valley is informed by high-quality, real-time insight.

The TVCA and its partners remain committed to advancing this programme as a cornerstone of the region's Smart Region agenda. With a strong foundation now in place, the next steps will focus on scaling innovation, embedding predictive analytics into policy and operations, and ensuring that the benefits of digital transformation are realised across all modes, communities, and boroughs.

The Digital Twin is more than a technology project, it represents a new way of managing transport: proactive, collaborative, and data driven. As it continues to evolve, it will help deliver a transport system that is cleaner, smarter, and more connected, driving forward the Tees Valley's vision of a world-class transport network for all.

Developed under the wider TVCA Digital Transport Programme, this project demonstrates how innovation, data, and collaboration can transform transport management across the Tees Valley.

## 13. Acknowledgements

The TVCA would like to extend sincere appreciation to all partners, stakeholders, and individuals who contributed to the successful delivery of the Tees Valley Traffic Digital Twin Project. This achievement reflects the dedication, collaboration, and shared ambition of organisations and people across the region.

### Project Delivery Team

| Name | Title & Organisation | Project Role |
|---|---|---|
| Sean Fryer | Digital Transport Delivery Manager, Tees Valley Combined Authority | Project Lead & Author |
| Andrea Reacroft | Digital Transport Programme Delivery Manager, Tees Valley Combined Authority | Programme Advisor |
| Colin Torode | Transport Modelling & Data Officer, Tees Valley Combined Authority | Project Advisor |
| Alan Madgwick | UTC Manager, Middlesbrough Council | Operations Lead |
| Mark Walker | UTMC Manager, Middlesbrough Council | Operations Advisor |
| James Daniels | Managing Director, Aimsun Ltd | Project Director Aimsun Ltd |
| Gavin Bailey | Regional Head of Business Development UK & Nordics, Aimsun Ltd | Project Advisor |
| Carles Illera | Head of Solutions Delivery, Aimsun Ltd | Project Lead for Aimsun Ltd |
| Iain Lyall | Regional Head of Professional Services, Aimsun Ltd | Project Lead for Aimsun Ltd |
| Kerellos Mishriki | Transport Modeller, Aimsun Ltd | Project Advisor |
| Andrew Wilson | Project Manager, Yunex Traffic | Project Lead for Yunex Traffic |
| Tom Hargreaves | Head of Operational Services, Yunex Traffic | Project Advisor |

| | | |
|---|---|---|
| Dawid Szewczyk | Solutions Architect, Yunex Traffic | Project Advisor |
| Paula Berrie | Lead Project Engineer, Yunex Traffic | Project Advisor |
| Philip Pycroft | Senior Technical Support Engineer, Yunex Traffic | Project Advisor |

## Local Authority Partners:

The project was delivered in close collaboration with the five Tees Valley local authorities:

Middlesbrough Council

Darlington Borough Council

Redcar & Cleveland Borough Council

Hartlepool Borough Council

Stockton-on-Tees Borough Council

## Technical and Delivery Contributors:

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TEES VALLEY

For more information contact
info@teesinvest.com
www.teesvalley-ca.gov.uk/business/netzero

@TeesValleyCA