FUSION – Next Generation Adaptive Traffic Control

Anything is possible.

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TEES VALLEY

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Foreword

The transport network that underpins Tees Valley is becoming increasingly complex, shaped by rising demand, constrained infrastructure, and the need to respond to economic, environmental, and societal challenges. Within this context, Tees Valley has set out an ambitious vision to deliver a world-class transport system, supporting a more connected, productive, and sustainable region in which transport plays a central enabling role.

A key part of this ambition is the commitment to becoming a truly Smart Region, harnessing digital innovation, data, and advanced technologies to transform how the network is managed, operated, and experienced by users.

The FUSION project forms a core component of this wider transformation. As a regional intelligent traffic signal optimisation solution, FUSION represents a significant shift in how we manage and respond to real-time conditions across strategically selected locations on the Tees Valley road traffic network. Its deployment across our network of signalised junctions marks not only a technical achievement, but a clear shift in operational approach, from reactive management at a junction level to proactive, data-led optimisation at a network level, enabling more effective control of the network as a whole.

This paper sets out the approach taken to deliver FUSION, alongside a structured assessment of its performance through Monitoring and Evaluation. The findings demonstrate measurable improvements in journey time reliability, network efficiency, and overall operational performance. Beyond these outcomes, FUSION establishes a critical foundation for future digital transport capabilities, including further development of the region's traffic Digital Twin and enhanced data-driven decision-making.

Importantly, this work aligns directly with the Tees Valley's strategic objectives. By improving network performance and supporting more reliable journey times for all modes, FUSION contributes to wider goals around economic growth, improved accessibility, and the delivery of a more sustainable transport system.

As Tees Valley Combined Authority Intelligent Transport Systems lead, I have led the development and implementation of this solution from concept through to delivery and evaluation. This report reflects both the outcomes achieved and the broader strategic role that intelligent transport systems must play in shaping the future of our transport networks.

The lessons captured here demonstrate not only the impact of FUSION within the Tees Valley, but also the role that data-driven, network-level optimisation will play in delivering the next generation of transport systems.

— Sean Fryer, Digital Transport Delivery Manager & Intelligent Transport Systems Programme Lead, Tees Valley Combined Authority

1. Executive Summary

1.1 Challenges facing the Network

Transport networks across the Tees Valley are operating under increasing pressure, driven by rising demand, constrained infrastructure, and the need to support wider economic, environmental, and societal objectives. Improving how the network is managed in real time is therefore critical to delivering a more reliable, efficient, and sustainable transport system.

1.2 The FUSION Solution

The FUSION project has been delivered as part of the Tees Valley's wider Digital Transport Programme to address these challenges. Yunex Traffic's FUSION solution is an intelligent traffic signal optimisation solution that enhances the performance of existing signal infrastructure through the use of existing detection infrastructure, including above-ground and in-ground detection, combined with real-time, data-led optimisation. Unlike traditional approaches that operate at an individual junction level, FUSION enables network-level coordination, allowing traffic flows to be managed more effectively across key corridors and urban areas.

1.3 Deployment at Scale

FUSION has been deployed across 196 signalised junctions within 57 coordinated site regions, representing a network-wide implementation across the Tees Valley's Urban Traffic Management & Control (UTMC) estate. At the time of publication, this represents the largest commercial deployment of this solution outside of London. This scale of deployment marks a significant advancement in how the network is operated, moving from reactive traffic management to a more proactive and adaptive approach.

1.4 Performance & Outcomes

A structured Monitoring and Evaluation programme has been undertaken to assess the impact of FUSION using independent, real-world journey data. The results demonstrate measurable improvements in network performance, including reductions in delay of over 50% at individual sites and significant annualised journey time savings across key corridors. These benefits are most pronounced during peak periods and across coordinated regions, where network-level optimisation delivers the greatest impact.

1.5 Strategic Impact

Beyond immediate performance improvements, FUSION plays a key role in supporting the Tees Valley's wider strategic objectives. By improving network efficiency and reliability, the system contributes to economic productivity, supports more reliable public transport services, and helps create the conditions necessary to encourage modal shift towards more sustainable forms of travel.

1.6 Future Role

FUSION also establishes a critical foundation for future digital transport capabilities. The data, coordination, and operational insights generated through the solution will support further development of the Tees Valley's transport Digital Twin, enabling more advanced predictive modelling, scenario testing, and data-driven decision-making.

In this context, FUSION is not only an operational improvement, but a critical enabling technology in the transition towards a fully integrated, data-driven transport system for the Tees Valley. It functions as both an operational tool and a strategic enabler within the region's evolving digital transport ecosystem.

2. Introduction & Strategic Context

2.1 Tees Valley

Tees Valley, in North East England, comprises five local authorities: Darlington, Hartlepool, Middlesbrough, Redcar & Cleveland, and Stockton-on-Tees, with a population of around 700,000 and a road network of approximately 1,700 miles (Figure 1). The area benefits from major transport assets, including Teesport, Teesside International Airport, and strong national rail and road connections, supporting the movement of people and freight across the region and beyond.

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, where data and technology are used to deliver sustainable growth and improved connectivity.

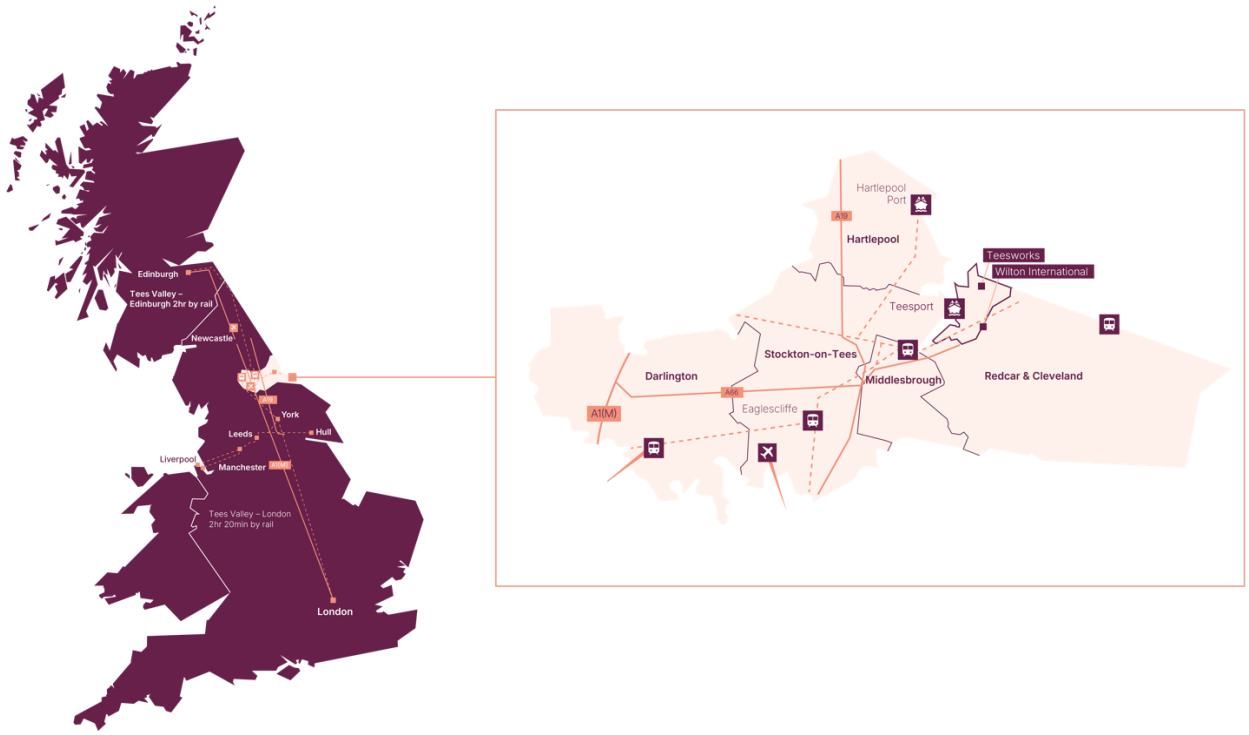


Figure 1 - Tees Valley Combined Authority

2.2 Tees Valley Combined Authority (TVCA)

Formed in 2016 through a devolution agreement between the UK Government and the five Tees Valley local authorities, TVCA is led by the Tees Valley Mayor and is responsible for strategic decision-making across transport, the economy, skills, and infrastructure.
TVCA plays a central role in planning and delivering regional transport investment, with a clear focus on improving connectivity, supporting economic growth, and enhancing quality of life. Through devolved powers, the authority is able to take a coordinated, region-wide approach to transport planning and network management, enabling the development of an integrated transport system that supports people, freight, and business across all modes.

2.3 Tees Valley Strategic Transport Plan (2020 -2030)

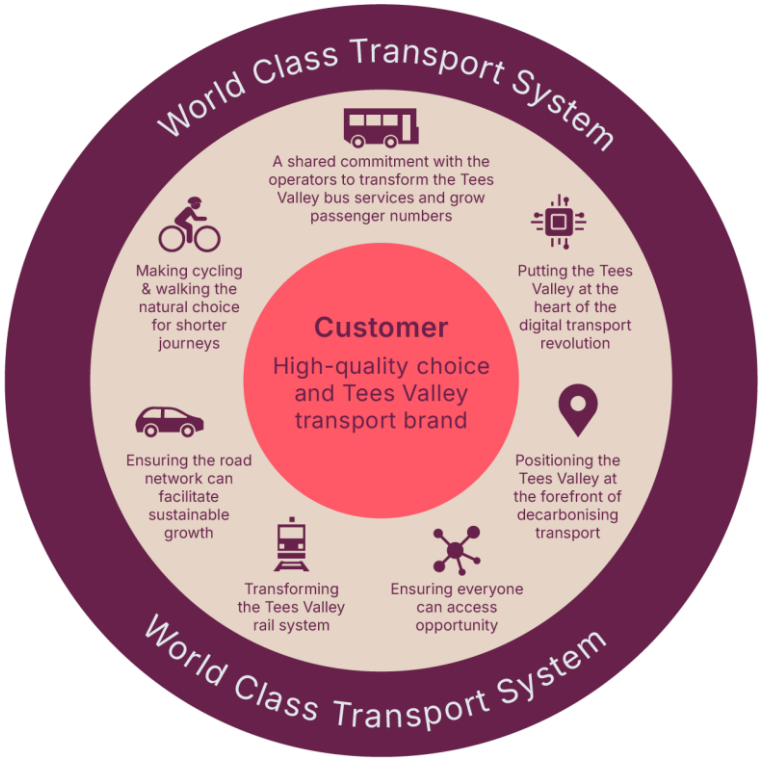


Figure 2 - Tees Valley Strategic Transport Plan

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 residents, businesses, and visitors.

The plan is centred around the customer, ensuring that the transport network delivers reliable, accessible, and integrated journeys across all modes, while reinforcing a strong Tees Valley transport identity.

The STP identifies a series of priority areas to support this ambition, including the transformation of the bus network, the decarbonisation of transport, improved connectivity to key destinations, and the development of a more efficient and resilient road network. A core component of the strategy is the role of digital technology, with a clear focus on expanding the use of real-time data, predictive tools, and intelligent systems to improve how the network is managed and operated.

In this context, the STP establishes the need for a more proactive, data-led approach to network management, moving beyond traditional, reactive traffic control to a coordinated, region-wide model. This provides the strategic foundation for the deployment of intelligent transport systems such as FUSION.

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

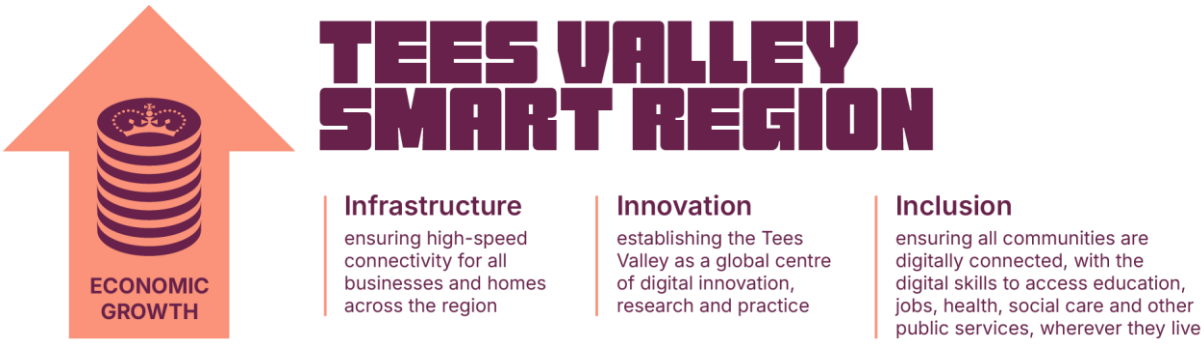


Figure 3 - Tees Valley Digital Strategy

The Tees Valley Digital Strategy sets out the region's ambition to become a truly Smart Region, using digital infrastructure, data, and innovation to create opportunities for residents and businesses, and to support a cleaner, more connected, and more efficient transport system.

The strategy identifies transport as a key area for digital transformation, with a focus on developing an integrated, data-driven network that supports all modes and users. Central to this ambition is the use of real-time data, open information sharing, and connected infrastructure to improve journey planning, enhance the user experience, and enable more effective network management.

A core component of this approach is the development of a smart infrastructure backbone, including sensors, IoT, and connected systems, enabling a shift towards predictive and responsive transport operations. This supports more proactive, data-led decision-making, using analytics, modelling, and automation to optimise network performance and improve reliability.

In this context, the Digital Strategy establishes the need for intelligent transport systems that can operate at a network level, making use of real-time data to dynamically manage traffic conditions. This provides a clear strategic foundation for solutions such as FUSION, which enable coordinated, data-driven optimisation of the road network in line with the region's wider Smart Region ambitions.

2.5 Introduction

Transport networks across the Tees Valley are facing increasing pressure from rising demand, changing travel patterns, and the need to support economic growth while reducing environmental impact. As the region continues to develop, the ability to manage the network efficiently and reliably in real time has become increasingly important.

Historically, traffic signal control across the network has operated at an individual node or junction level, with optimisation typically based on fixed plans or limited local responsiveness. While these approaches have historically delivered effective performance over time, they are inherently constrained in their ability to respond to dynamic conditions across a wider network, particularly during periods of peak demand or disruption.

At the same time, the increasing availability of real-time data, advances in sensing technology, and the development of connected systems present an opportunity to take a more coordinated and proactive

approach to traffic management. Moving towards a network-level model enables traffic flows to be managed more effectively across corridors and regions, rather than being optimised in isolation.

Within this context, the FUSION project has been developed to enable a significant shift in how the Tees Valley road network is managed and operated. By applying real-time, data-led optimisation across multiple junctions simultaneously, FUSION supports a more responsive, adaptive, and efficient network, aligned with the region's wider strategic ambitions for a smarter, more integrated transport system.

This paper sets out the approach taken to deliver FUSION, alongside the outcomes achieved and the lessons learned through its implementation. It demonstrates how intelligent transport systems can be deployed at scale to deliver measurable improvements in network performance, while supporting longer-term strategic objectives.

3. Project Overview

3.1 Introduction

Building on the strategic context, the FUSION project has been developed and delivered to enhance the operation of the Tees Valley road network through the application of intelligent, data-led traffic signal optimisation.

This section provides an overview of the project, including the evolution of traffic signal control approaches, the role and functionality of FUSION, and how the solution has been applied across the network. It sets out how existing traffic signal infrastructure has been enhanced to enable a more coordinated, adaptive, and efficient approach to network management.

3.2 Evolution of Traffic Signal Control

Traffic signal control systems have evolved over time, with a number of established approaches used across UK urban networks to manage traffic flow at different levels of scale and complexity.

Vehicle Actuated control represents a foundational form of responsive signal operation, using local detection to adjust signal timings based on immediate demand at an individual junction. While effective in responding to real-time conditions locally, VA operates in isolation and does not account for conditions elsewhere on the network.

MOVA™, developed in the late 20th century, builds on this approach by optimising signal timings at individual junctions using detected traffic demand to minimise delay and improve efficiency. MOVA is widely used across the UK and can deliver significant performance improvements at isolated sites or within corridors but remains primarily focused on junction-level optimisation rather than wider network coordination.

SCOOT™, originally developed in the 1970s and continuously enhanced since, introduced a more advanced form of adaptive traffic control, enabling the coordination of multiple junctions within defined areas. SCOOT continuously adjusts signal timings in response to real-time traffic conditions, improving progression along corridors and overall network performance within those areas. However, optimisation is typically focused within configured regions, with coordination and optimisation strategies generally applied at a corridor or area level rather than across the wider network as a whole.

FUSION builds on these established approaches by enabling more adaptive and coordinated optimisation of traffic signals across configured junction groups and corridors. By integrating real-time data from multiple sources and applying optimisation across multiple junctions simultaneously using advanced optimisation algorithms, FUSION enables traffic flows to be managed more efficiently and responsively across wider areas of the network.

This progression from local, junction-based control towards coordinated, network-level optimisation supports a more proactive and adaptive approach to traffic management. It enables the network to respond more effectively to changing conditions, including peak demand, incidents, and variability in travel patterns, improving journey time reliability and overall network efficiency.

Table 1 Tees Valley Method of Control Comparison

MOC	Level	Limitation
VA	Local	Reactive
MOVA	Junction	Isolated optimisation
SCOOT	Corridor/area	Coordinated adaptive optimisation
FUSION	Network/Regional	Advanced coordinated optimisation

3.3 FUSION - Next Generation Adaptive Traffic Control

Building on the evolution of traffic signal control systems, FUSION has been deployed as a regional intelligent traffic signal optimisation solution to enhance the operation of the Tees Valley road network.

FUSION operates as an advanced adaptive method of control within the existing traffic signal environment, enabling coordinated optimisation across multiple junctions and corridors. The solution integrates with the existing signal estate and UTMC environment, supporting a scalable and cost-effective approach to enhancing network performance without the need for wholesale infrastructure replacement.

At its core, FUSION uses real-time traffic data to assess current network conditions and dynamically adjust signal strategies in response. This includes data derived from existing traffic detection infrastructure and other available data sources, enabling a more comprehensive understanding of traffic flow and network conditions.

By analysing traffic conditions across multiple junctions simultaneously, FUSION is able to identify emerging congestion, manage competing demands across corridors, and implement coordinated responses that improve overall network performance. This supports a more adaptive and responsive approach to traffic management across wider areas of the network.

Integration with the existing UTMC environment ensures that FUSION aligns with established operational processes, while enhancing the capability of traffic signal control across the region.

Through this approach, FUSION provides a more coordinated, data-driven method of managing the road network, supporting improved journey time reliability, reduced congestion, and more efficient use of existing infrastructure.

In this context, FUSION acts as the operational layer within the wider digital transport ecosystem, delivering real-time optimisation that directly complements the predictive and analytical capabilities of the Tees Valley Traffic Digital Twin.

3.4 Deployment and Delivery of FUSION

The deployment of FUSION across the Tees Valley has been undertaken as a coordinated, region-wide programme, designed to enhance the performance of the existing traffic signal network at scale.

The solution has been implemented across 196 signalised junctions within 57 coordinated site regions, representing a comprehensive deployment across the Tees Valley's UTMC managed estate. This scale of implementation required a structured and phased approach to ensure effective integration with existing systems while maintaining operational stability across the network.

Delivery of the project has involved close collaboration between TVCA, UTMC teams, and local authority partners. This collaborative approach ensured that the solution was aligned with both regional strategic objectives and local operational requirements. This approach has been critical in enabling a consistent and coordinated deployment across multiple authorities and network areas.

The implementation has been undertaken in phases, allowing the solution to be introduced progressively across the network. This approach enabled performance to be monitored and validated as deployment progressed, while also providing opportunities to refine configuration and optimisation strategies based on real-world conditions.

A key aspect of the deployment has been the integration of FUSION within the existing UTMC environment. By operating alongside established systems such as UTC-UX and Stratos, the solution has been embedded within existing operational processes by our UTMC team, minimising disruption while enhancing overall network management capability.

The complexity of deploying a network-level optimisation system across a live urban traffic environment has required careful management of data inputs, system configuration, and operational interfaces. Ensuring the quality and reliability of data sources, alongside effective coordination across junction groups, has been critical to achieving the intended performance outcomes.

Through this structured and collaborative delivery approach, FUSION has been successfully implemented as a scalable, region-wide solution, enhancing the capability of the existing traffic signal network and enabling a more coordinated and data-driven approach to traffic management.

4. Monitoring & Evaluation

A structured Monitoring and Evaluation programme has been undertaken to assess the impact of FUSION on network performance across the Tees Valley. The approach has been designed to provide an objective and robust assessment of outcomes using independently sourced, real-world journey data.

4.1 Evaluation Methodology

The evaluation methodology focuses on comparing network performance before and after the implementation of FUSION, using journey time data derived from Floating Vehicle Data to assess

changes in traffic delay and overall network performance. Analysis has been undertaken primarily under weekday peak conditions, where demand on the network is highest and the benefits of adaptive optimisation are most pronounced.

4.2 Monitored Site Regions and Sample Coverage

Detailed analysis has been undertaken across a representative sample of monitored sites. These locations were intentionally selected to reflect a range of operational conditions, including high-demand corridors, coordinated junction groups, and varying existing methods of control. This targeted approach provides a robust and challenging test of system performance, with findings that are indicative of wider network behaviour.

Table 2: Monitored Site Regions and Sample Coverage

Site Region	Authority	Nodes	Existing MOC	Period Vehicle Demand Level Up To	Journey Time Avg Saving per vehicle Up To
RHL	Hartlepool Borough Council	5	Local	252	14%
RAA	Middlesbrough Council	1	Local	465	6%
RTH	Stockton-on-Tees Borough Council	2	MOVA	1524	18%
RYK	Hartlepool Borough Council	6	Local	459	6%
RNO	Stockton-on-Tees Borough Council	2	MOVA	1,453	9%
RSS	Stockton-on-Tees Borough Council	2	SCOOT	46,121	54%

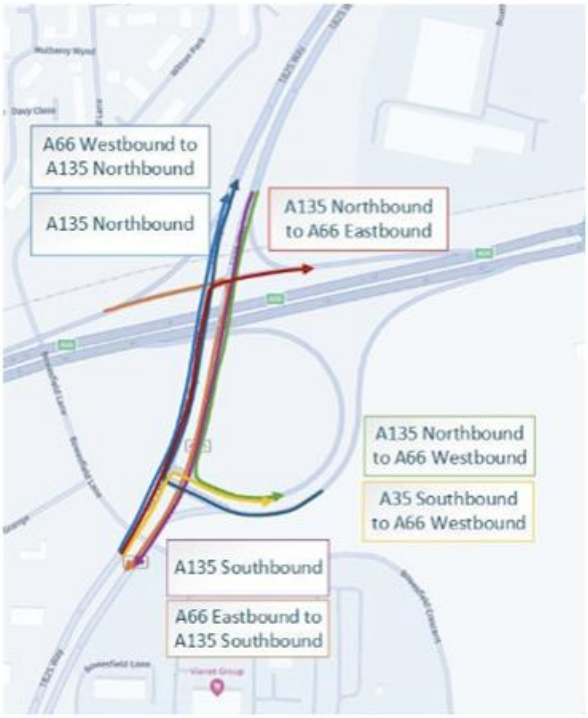
The monitored sample sites and regions selected for detailed evaluation are shown below, representing a range of authorities, traffic conditions, and operational environments across the Tees Valley.

The results demonstrate clear and measurable improvements in traffic performance across the sites assessed. Reductions in delay are observed across the majority of locations, with the most significant benefits realised during peak periods. At individual sites, peak delay reductions of over 50% have been recorded, particularly on complex, high-demand corridors such as the South Stockton Bypass.

4.3 Detailed Performance Case Studies

RSS – South Stockton Bypass

Figure 4: Stockton South Bypass Intersection



Period	SCOOT vs Free Flow Delay (seconds)	FUSION vs Free Flow Delay (seconds)	FUSION improvement (seconds)	FUSION Improvement (%)
AM	6.5	5.9	-0.6	-9%
IP	7.3	4.9	-2.3	-32%
PM	6.1	2.8	-3.3	-54%
All Day	6.8	4.6	-2.2	-32%

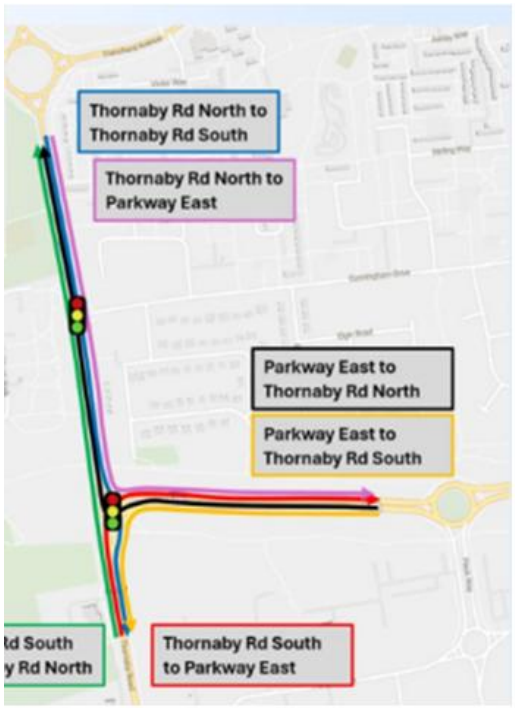
Table 3: South Stockton Bypass SCOOT vs FUSION

Observations:

- MOC: FUSION vs SCOOT - Significant improvements in performance observed
- Average delay reductions achieved, with peak reductions exceeding 50%
- Example of coordinated corridor-level optimisation across multiple junctions

RTH – Thornaby Road / Parkway (A174)

Figure 5: Stockton, Thornaby Road



Demand weighted average over all links Period	Local AVG per vehicle delay (seconds)	FUSION AVG per vehicle delay (seconds)	FUSION delay difference vs Former MOC per vehicle (seconds)	FUSION delay difference vs Former MOC per vehicle (%)
AM	29.96	26.03	-0.93	-3%
IP	25.67	25.06	-0.61	-2%
PM	40.07	32.93	-7.13	-18%

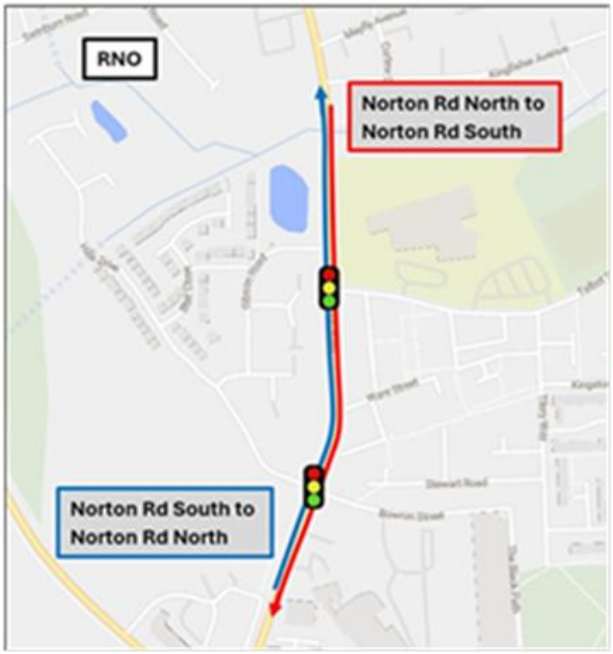
Table 4: Thornaby Road / Parkway MOVA vs FUSION

Observations:

- MOC FUSION vs MOVA - Clear improvements observed in all day and specifically during PM peak
- FUSION effectively responding to changing demand conditions
- Positive impact on overall junction performance

RNO – Norton Road

Figure 6: Stockton, Norton Road



Demand weighted average over all links Period	Local AVG per vehicle delay (seconds)	FUSION AVG per vehicle delay (seconds)	FUSION delay difference vs Former MOC per vehicle (seconds)	FUSION delay difference vs Former MOC per vehicle (%)
AM	29.1	26.8	-2.31	-8%
PM	22.3	20.2	-2.07	-9%

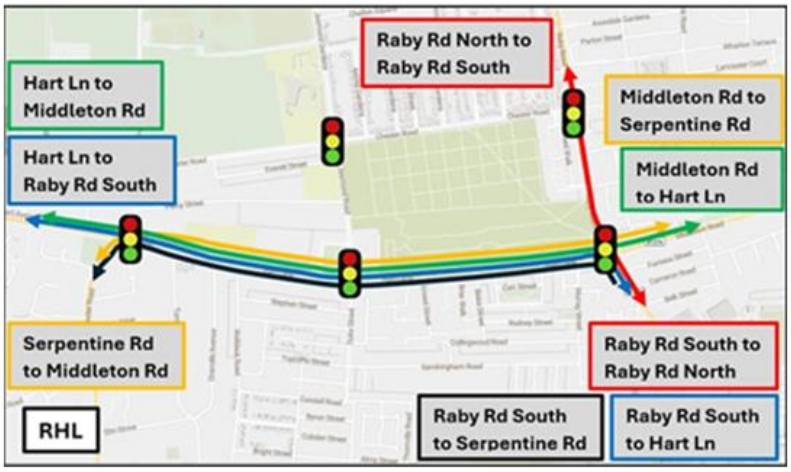
Table 5: Norton Road MOVA vs FUSION

Observations:

- MOC FUSION vs MOVA - Strong performance improvements observed, particularly during PM peak periods
- Previously congested movements (notably North–South) better managed under FUSION
- Demonstrates effectiveness on high-demand, strategic corridors

RHL – Hart Lane

Figure 7: Hartlepool, Hart Lane



Demand weighted average over all links Period	Local AVG per vehicle delay (seconds)	FUSION AVG per vehicle delay (seconds)	FUSION delay difference vs Former MOC per vehicle (seconds)	FUSION delay difference vs Former MOC per vehicle (%)
AM	51.38	44.41	-6.97	-14%
PM	61.80	58.98	-2.81	-5%

Table 6: Hart Lane Local vs FUSION

Observations:

- MOC FUSION vs Local Control - Positive performance observed under FUSION
- Benefits aligned with dominant directional flows (East–West)
- Improvements most evident during operational peak periods

RYK – York Road

Figure 8: Stockton, York Road



Demand weighted average over all links Period	Local AVG per vehicle delay (seconds)	FUSION AVG per vehicle delay (seconds)	FUSION delay difference vs Former MOC per vehicle (seconds)	FUSION delay difference vs Former MOC per vehicle (%)
AM	33.30	32.26	-1.04	-3%
IP	70.00	71.35	1.36	2%
PM	67.22	63.09	-4.13	-6%

Table 7: York Road Mova vs FUSION

Observations:

- MOC FUSION vs Local Control- Consistent improvements observed across both AM and PM peaks
- Stable performance throughout the day, indicating effective optimisation
- Demonstrates FUSION's ability to maintain performance across varying demand conditions

RAA – Acklam Road / Ayresome Street

Figure 9: Middlesbrough, Acklam Road



Demand weighted average over all links Period	Local AVG per vehicle delay (seconds)	Fusion AVG per vehicle delay (seconds)	Fusion delay difference vs Former MOC per vehicle (seconds)	Fusion delay difference vs Former MOC per vehicle (%)
AM	22.55	21.12	-1.43	-6%
IP	24.49	24.29	-0.21	-1%
PM	26.18	26.51	0.33	1%

Table 8: Acklam Road / Ayresome Street Local vs FUSION

Observations:

- MOC FUSION vs Local Control - Neutral to modest improvement observed
- Site characteristics limit overall optimisation potential:
  - Single junction layout
  - Existing control already operating efficiently
- FUSION maintains performance while providing a platform for future network integration

Monitoring Observations

The evaluation shows that FUSION delivers the greatest benefits where network-level optimisation can be applied across multiple junctions, improving coordination, reducing queue propagation, and enhancing progression along key routes. These improvements are driven by more effective allocation of green time, improved management of competing traffic movements, and the ability to respond dynamically to changing demand conditions.

Performance varies depending on site characteristics. Strong improvements are observed on strategic corridors and within coordinated urban networks, where network-level optimisation delivers the greatest benefit. At more isolated junctions, or locations with highly variable or lower traffic demand, more neutral outcomes are observed, particularly where existing control strategies are already operating efficiently.

In these cases, sites remain FUSION-enabled and are able to operate under FUSION when conditions require, or where deemed appropriate by the UTMC team, such as during periods of increased demand or network disruption. However, traditional control strategies such as MOVA or VA control may continue to provide the most appropriate method of control under typical operating conditions or between peak periods, reflecting the need for a targeted and flexible approach to traffic signal management across the network.

At a network level, these reductions in delay translate into meaningful real-world benefits, with aggregated journey time analysis indicating significant annualised travel time savings across monitored regions.

4.4 Aggregated Journey Time Analysis

Table 9: Aggregated Journey Time Analysis

Site Region	Number of Traffic Nodes	Location	Approx Travel Time Saved (Hours/Year)
RHL	5	Hart Lane - Hartlepool	575
RAA	1	Acklam Road, Ayresome Street - Middlesbrough	255
RTH	2	Thornaby Road / Parkway A174 - Stockton	2780
RYK	6	York Road - Hartlepool	365
RNO	2	Norton Road - Stockton	715
RSS	2	South Stockton Bypass - Stockton	300

4.5 Stakeholder Feedback

The quantitative findings are also supported by operational feedback from stakeholders involved in day-to-day network management, as summarised below.

Table 10: Stakeholder Feedback Summary

Stakeholder	Feedback Summary
Stockton-on-Tees Borough Council	*Monitoring and Evaluation has produced encouraging results and identified clear benefits, particularly along some of the borough's busier corridors.*
Middlesbrough Council UTMC	*Findings demonstrate the value of FUSION as part of the regional traffic management toolkit, particularly where coordinated, network-level optimisation supports busier corridors and changing traffic conditions.*
Hartlepool Borough Council	*It is pleasing to see consistent improvement along two corridors which have in recent years experienced increasing delays. Fusion has provided demonstrable benefits, and I look forward to future phases being rolled out across Hartlepool.*

4.6 Overall Findings

In addition to performance improvements, the evaluation demonstrates increased network resilience. FUSION enables the system to respond more effectively to fluctuations in demand, reducing the impact of congestion and improving the consistency and reliability of journeys for network users.

Overall, the Monitoring and Evaluation programme provides strong evidence that FUSION is delivering measurable improvements in network performance. It demonstrates the value of applying data-driven, network-level optimisation to manage traffic more effectively, particularly in complex and high-demand environments. The consistency of these findings across multiple site types and authorities provides a strong level of confidence in the scalability and transferability of FUSION as a regional traffic management solution.

5. Issues, Risks and Considerations

The Monitoring and Evaluation findings have identified clear and measurable benefits from the region's FUSION rollout. However, as with any live operational traffic management system, long-term success depends on the effective management of key operational considerations and risks.

The following considerations reflect operational experience from deployment and Monitoring and Evaluation findings, highlighting key factors that influence performance and long-term success.

5.1 Site Suitability and Network Characteristics

Performance outcomes vary according to local layout, traffic demand, junction interaction, communications infrastructure, and surrounding network constraints. While strong benefits have been demonstrated on coordinated corridors and higher-demand routes, some locations may continue to be better served by alternative methods of control during certain operating periods, with FUSION remaining enabled and ready for when traffic volumes increase or where a more dynamic control strategy is required.

5.2 Ongoing Review and Optimisation

Traffic patterns change over time as a result of development, travel behaviour, roadworks, and wider economic activity. As with any MOC, periodic review, configuration updates, validation, and optimisation are therefore important to ensure system settings remain aligned to prevailing network conditions.

5.3 External Network Disruption

Incidents, temporary traffic management, severe weather, and abnormal demand can influence performance across the network. These factors may affect any signal control strategy and should be considered when assessing operational outcomes.

5.4 Data and Communications Dependencies

FUSION relies on accurate data inputs and resilient communications links to support real-time optimisation. Maintaining reliable connectivity, good-quality detector data, and robust supporting infrastructure remains a vital operational requirement.

5.5 Supplier and Technology Assurance

As with all specialist intelligent transport systems, ongoing supplier support is required for maintenance, software updates, cybersecurity, and future enhancements. Appropriate governance, contract management, and assurance arrangements are therefore essential.

5.6 Flexible Control Strategy Approach

A key lesson from deployment is that no single method of control is optimal in every location. FUSION should therefore be considered as part of a wider traffic management toolkit alongside

MOVA, and Vehicle Actuated control, enabling the most appropriate strategy to be applied according to site conditions and operational needs.

Overall, these considerations do not diminish the benefits demonstrated through the programme. Rather, they highlight the importance of active stewardship, targeted deployment, and continuous improvement in maximising long-term value.

6. Lessons Learned

6.1 **Lessons Learned at a Glance**

The following summary highlights the key lessons identified through deployment and Monitoring and Evaluation, alongside their practical implications for future delivery.

- Target deployment where it matters most. FUSION delivers the greatest benefit on coordinated corridors and higher-demand routes where network-level optimisation can be applied.
- Use the right control strategy for the right location. No single method of control is optimal everywhere; FUSION should be deployed alongside MOVA, and Vehicle Actuated control as part of a flexible toolkit.
- Data quality underpins performance. Reliable detection, communications, and data inputs are essential to enable effective real-time optimisation.
- Evidence builds confidence. Robust Monitoring and Evaluation is critical to demonstrating value, supporting decision-making, and enabling future investment.
- Flexibility improves resilience. The ability to adapt control strategies in response to demand, incidents, and network conditions strengthens overall network performance.
- Collaboration drives successful delivery. Strong partnership working between TVCA, local authorities, UTMC operators, and suppliers has been key to effective implementation.
- Optimise at a network level. The most significant benefits are realised where optimisation is applied across multiple junctions rather than at isolated sites.

Figure 10: Lessons Learned at a Glance

Overall, these lessons demonstrate that successful intelligent transport deployment is not solely about technology or any one organisation's ambition, but about combining evidence-led decision-making, operational buy-in, and effective partnership working to deliver sustained, network-level outcomes.

7. Future Steps

Building on the lessons identified through deployment and Monitoring and Evaluation, the successful deployment of FUSION provides a strong foundation for the next phase of Tees Valley's digital transport programme.

Future activity should focus on maximising value from the existing deployment while identifying further opportunities to enhance network performance and support wider strategic objectives.

Continued Optimisation of Existing Sites

Ongoing review of operational performance, signal strategies, and site suitability will help ensure that existing FUSION-enabled locations continue to deliver optimum benefits as traffic patterns evolve over time.

Expanded Monitoring and Evaluation

Continued performance monitoring undertaken by the region's UTMC team across additional sites, seasons, and demand conditions will strengthen the evidence base, support continuous improvement, and help inform future operational and investment decisions.

Targeted Future Deployment

Opportunities for further rollout should be considered where evidence indicates the strongest potential benefits, particularly on coordinated corridors, higher-demand routes, and locations where network-level optimisation can address existing congestion or reliability challenges.

Digital Twin Integration and Operational Alignment

FUSION and the Tees Valley Traffic Digital Twin are independent systems that can operate separately, each delivering distinct operational and analytical value within the region's wider digital transport environment. However, when integrated, the two systems can operate as complementary components within a more advanced data-driven transport management approach, enabling enhanced operational insight, predictive capability, and more informed network management decision-making.

FUSION functions as the operational layer, using real-time traffic data to dynamically optimise signal performance across the network. It enables immediate, responsive management of traffic conditions, improving flow, reducing delay, and enhancing journey reliability.

The Tees Valley Traffic Digital Twin provides the analytical and predictive layer, using both real-time and historic data to model, simulate, and forecast network behaviour. It enables scenario testing, performance forecasting, and the assessment of potential interventions in a controlled, risk-free environment.

Together, these systems form a continuous feedback loop. Data generated through FUSION, including traffic conditions, signal performance, and network response, is used to inform and refine the Digital Twin, improving model accuracy and analytical capability. In turn, insights generated through the Digital Twin, such as optimised strategies, predicted congestion patterns, or tested interventions, can be used to inform how FUSION is configured and deployed across the live network.

This integrated approach supports a shift from reactive traffic management towards a more proactive and predictive model. While FUSION optimises the network in real time, the Digital Twin enables

forward-looking decision-making, allowing the region to anticipate and respond to future conditions more effectively.

In combination, FUSION and the Digital Twin represent a fully integrated approach to transport management, where real-time control and predictive modelling operate as a continuous, data-driven feedback loop. This enables both immediate optimisation of current conditions and more informed, forward-looking decision-making, improving network performance, resilience, and long-term efficiency.

Supporting Wider Transport Objectives

Future development should also consider how adaptive traffic management can further support bus reliability, active travel, decarbonisation, freight efficiency, and improved accessibility across the region.

Building Long-Term Capability

Continued investment in skills, governance, data management, and operational capability will be important to ensure the Tees Valley remains at the forefront of intelligent and data-driven transport management.

Overall, FUSION is not the end point of the region's digital transport journey, but an important platform from which the next generation of smart transport capabilities can be delivered.

8. Acknowledgments

The successful delivery of the FUSION programme has been made possible through the collaboration and commitment of a wide range of partners and stakeholders across the Tees Valley.

Tees Valley Combined Authority would like to recognise the continued support of the five constituent local authorities of Darlington, Hartlepool, Middlesbrough, Redcar & Cleveland, and Stockton-on-Tees, whose ongoing partnership and local operational knowledge have been central to the successful deployment of the programme.

Recognition is also given to the Urban Traffic Management and Control teams and operational officers across the region for their day-to-day expertise, flexibility, and commitment in supporting implementation, monitoring, and continuous improvement.

Thanks are also extended to Yunex Traffic as delivery partner for the provision, configuration, and technical support of the FUSION solution.

The progress achieved through FUSION reflects the value of partnership working in delivering innovative, region-wide transport improvements.

FUSION Delivery Team:

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Table 12: FUSION Project Delivery Team

9. Conclusion

The deployment of FUSION across the Tees Valley represents a significant advancement in how the regional road network is managed and operated. Through the application of real-time, data-driven optimisation, the system has demonstrated measurable improvements in network performance, reducing delay and improving journey time reliability, particularly across complex and high-demand corridors.

The findings from the Monitoring and Evaluation programme confirm that the greatest benefits are realised where coordinated, network-level optimisation can be applied. At the same time, the results reinforce the importance of adopting a targeted and flexible approach to traffic signal control, with FUSION operating as part of a wider toolkit alongside established methods such as MOVA, and Vehicle Actuated control.

Beyond its immediate operational benefits, FUSION plays a key enabling role within the Tees Valley's wider digital transport ecosystem. Its integration with the Tees Valley Traffic Digital Twin establishes a continuous, data-driven feedback loop between real-time network operation and predictive modelling. This enables both immediate optimisation of live conditions and more informed, forward-looking decision-making, supporting a transition towards a more proactive and intelligence-led transport system.

Looking ahead, continued Monitoring and Evaluation, targeted optimisation, and further integration with digital systems will be critical to maximising long-term value. There is a clear opportunity to expand network-level optimisation, enhance data coverage, and further strengthen the region's capability in data-driven transport management.

FUSION is not only delivering measurable improvements in current network performance, but also acting as a critical foundation for the continued development of a fully integrated, data-driven transport system, supporting the Tees Valley's ambition to become a leading Smart Region through data-driven, network-level transport management.

TEES VALLEY

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