Delivered for

Department for Transport

Integrated Network Management Digital Twin

Economic Benefits Analysis Project

Executive Brief

September 2024

Executive Summary

Integrated Network Management Digital Twin – Economic Benefits Analysis Project

Project Objective

This project has the central objective of quantifying the potential economic benefits of an ecosystem of federated digital twins dedicated to integrated transport network management. This ecosystem of connected integrated transport network management digital twins (IN-DT) could enable data sharing across organisational and sectoral boundaries, facilitating whole-system decision making to achieve better mobility outcomes for transport system users and operators.

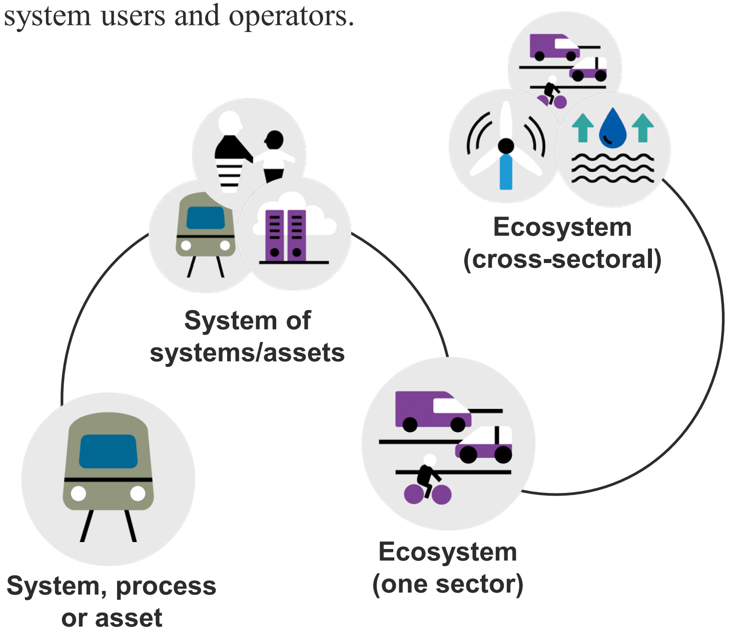

Figure 1: The journey of digital twin interconnectedness

Economic benefit analysis

Over the course of this study thorough stakeholder engagement, literary analysis, and use case identification was completed to inform an Economic Benefits Analysis (EBA) consistent with Transport Analysis Guidance (TAG) from a range of units, including Unit A1-3 "User and Provider Impacts" dated May 2022.

From the body of evidence investigated, a long list of potential IN-DT use cases were identified. A filtering activity was completed to select **five priority use cases** for quantitative analysis. The combined economic value from these five use cases amounts to approximately **£856m as a present value** across a 10-year appraisal period. Quantified benefits for each use case are provided below under core assumptions and as a range from sensitivity analysis.

The key sources of quantified benefits for each use case are as follows:

- *Network capacity management*: reduced congestion under business-as-usual conditions
- *Multimodal journey optimisation*: journey time savings from reducing interchange time between transport modes
- *Integrated incident and emergency management*: reduced congestion through better responding to incidents that occur on the transport network
- *Planned works and maintenance management*: saving journey time through improving the efficiency of temporary traffic control during roadworks
- *Freight management at ports*: reduced emissions by decreasing turnaround times for cargo ships

Network capacity management	£110.8m	(£60m-£230m)
Multimodal journey optimisation	£110.9m	(£55m-£160m)
Freight management at ports	£16.9m	(£10m-£35m)
Integrated incident and emergency management	£88.7m	(£40m-£190m)
Planned works and maintenance management	£528.3m	(£180m-£880m)

Figure 2: Monetised benefits of the five digital twin use cases analysed (in present value terms, 2010 prices)

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Glossary

BAU	Business as Usual
BCR	Benefit to Cost Ratio
CDBB	Centre for Digital Built Britain
DfT	Department for Transport
TRIB	Transport Research & Innovation Board
DSS	Decision Support System
DT	Digital Twin
EBA	Economic Benefits Analysis
EBR	Evidence Base Report
ICM	Integrated Corridor Management
IMS	Incident Management System
IN-DT	Integrated Transport Network Management Digital Twin
NDTP	National Digital Twin Programme
NUAR	National Underground Asset Register
RCM	Remote Condition Monitoring
RTCC	Regional Transport Coordination Centre
SITS	Surface Intelligent Transport System
SME	Subject Matter Expert
VMS	Variable Message Sign

Introduction – Context and approach to the study

Better integrated transport network management

In 2023, the Department for Transport's (DfT) Transport Research Innovation Board (TRIB) created a clear vision and roadmap to facilitate the development of a national ecosystem of federated digital twins focused on improving the performance of integrated UK transport by 2035.

Responding to this vision, the TRIB Digital Twin Community of Practice (CoP) identified *network and operations management and crisis response* as the top priority use case for a digital twin of integrated transport. DfT commissioned this study to quantify the potential economic benefits of a transport digital twin dedicated to integrated network management. This has been delivered by a consortium led by Arup, including Connected Places Catapult and Digital Twin Hub, with specialist advice provided by the Chief Transport Analyst at TfL.

To quantify potential economic benefit, this study has adopted a process and deliverables set out in Figure 3. To achieve better integrated transport network management, any digital twin will be completing several nested functionalities (use cases) that coexist to achieve superior integrated transport network management. Hence this study has adopted a *use case approach* to bolster understanding of the potential functionalities of IN-DT, and work towards comprehending a possible future IN-DT architecture.

Evidence base, use cases and economic benefits

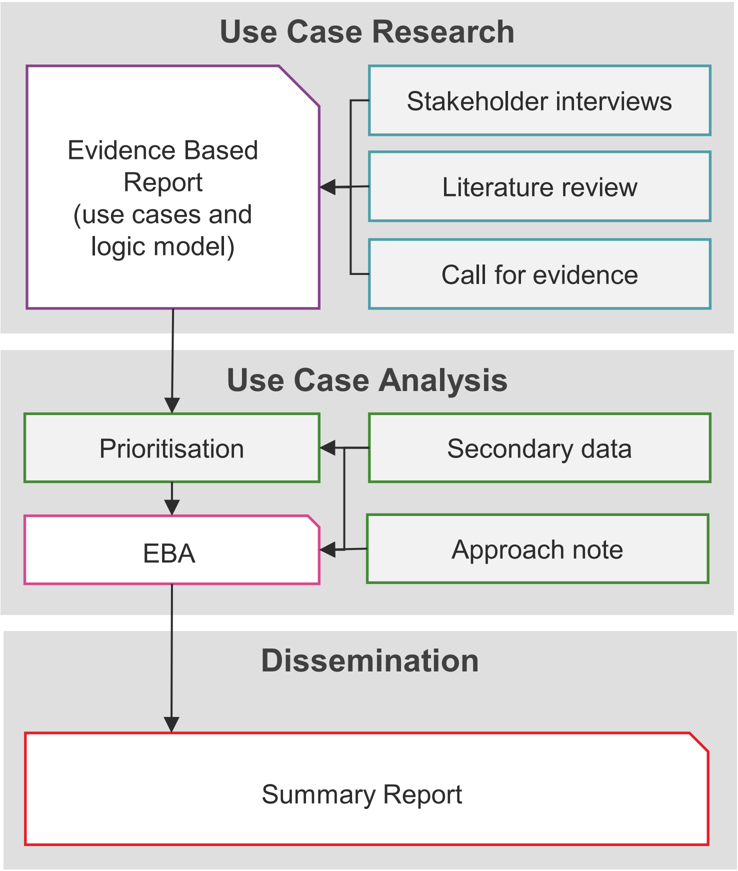
The identification and understanding of potential use cases during this study was completed via an Evidence Base Report (EBR) development process involving a thorough literature review, stakeholder engagement, and logic model conceptualisation procedure. The EBR was then used as a foundational document from which to explore each use case in more detail.

Within the constraints of this study, it was only possible to quantitatively analyse the economic benefits associated with five of 22 use cases. Through a scoring process outlined later in this document, the most applicable use cases were selected for inclusion in the Transport Analysis Guidance (TAG) consistent Economic Benefit analysis (EBA).

The EBA clearly sets out the approach and assumptions that have been used to estimate benefits, underpinned by a core set of assumptions, and sensitivity analysis. The quantified benefits are consistent with the TAG framework, with key benefits including journey time savings, journey quality and reliability.

This report is organised over three sections covering the evidence review, use case analysis, and economic benefits analysis.

Figure 3: Process and deliverables



Evidence Review – Stakeholder engagement

Purpose

Following the initial scoping review of the literature, over 20 organisations were engaged through formal interviews and a wider call for evidence process. The call for evidence was enabled by the Digital Twin Hub at the Connected Places Catapult and ITS UK.

The purpose of engaging stakeholders was to:

- Understand what individual stakeholders perceive transport network management to be in relation to digital twins.
- Confirm or refute use cases found within the literature review and, add new use cases which can be evidenced from stakeholder input/future ad-hoc searches.
- Aid the process of understanding what is of most importance to this study e.g., which thematic use case groupings matter most and what are the problems that stakeholders are trying to overcome in the context of integrated transport network management.
- Consider any barriers they may be facing in achieving their own digital twin initiatives.

Use cases

The case studies identified through the evidence review process are all examples of where digital twins are being used in slightly different ways, by different people, to solve different problems that they face in dynamically managing a transport network.

We use the term “use case” to encapsulate these kinds of dynamic. The important thing being that each use case ultimately generates real value to the transport users.

Figure 4: Stakeholder organisations engaged

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Evidence Review – Case studies

The case studies were identified through desk-based research, interviews with digital twin experts, and through the delivery team's collective digital twin experience.

In addition to those highlighted here, examples from National Underground Asset Register (NUAR), the Climate and Resilience Demonstrator (CReDo), and the National Digital Twin Programme (NDTP) were reviewed in detail.

Regional control centre incident management

Transport for West Midlands (TfWM) has a multimodal dashboard within its Regional Transport Coordination Centre (RTCC) that works with an Incident Management System (IMS) to improve coordination between network managers, local authorities, transport operators, emergency services, and communication with transport users.

The systems are updated with real time events, and data insights have led to a full signal upgrade on the M5 Junction 1 which led to improvements to public transport journey times. National Express have reported a 10% improvement in route punctuality.

Integrated corridor management

Integrated corridor management (ICM) strategies have been developed for popular freight, tourist and commuter corridors in San Diego, Dallas and Minneapolis. ICM strategies aim to proactively coordinate these traffic corridors across modes to increase their performance.

Overall ICM was shown to increase reliability, reduce travel times, delays, fuel consumption and emissions. BCR's for ICM range between 10:1 and over 20:1. ICM is particularly useful under traffic incident scenarios where the corridor is unexpectedly constrained.

Surface intelligent transport system

Transport for London's (TfL's) Surface Intelligent Transport System (SITS) contains a digital twin interacting with an upgraded Real Time Optimiser traffic signal system, control room Decision Support System (DSS), the Transport for London (TfL) integration service, and a predictive capability in the future.

It is leading to improvements in situational awareness, incident management, congestion relief, air quality, road safety, and supporting the prioritisation of bus services and active travel across London.

SITS has an approximate lifetime cost of £118m (£75m capital expenditure, £43m operational expenditure) and an original estimated Benefit Cost Ratio (BCR) of 7.3:1. A more recent analysis has suggested benefits of circa £1bn per annum from 2028

Transport for West Midlands

VDOT

RM3P
Travel Decisions Powered by Data

Transport for London

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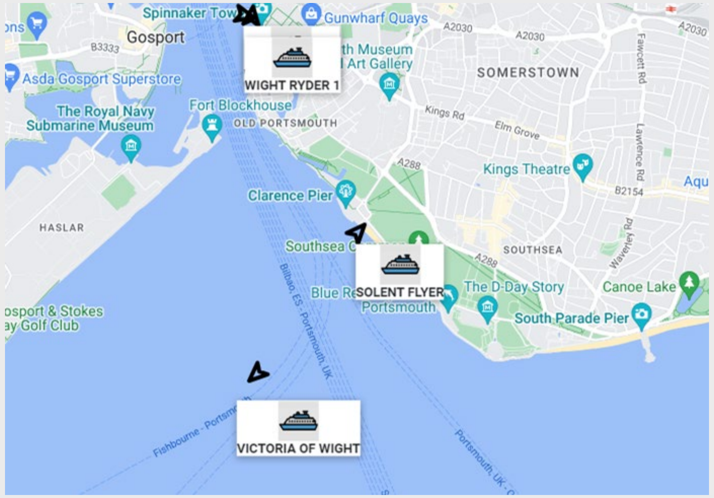
Evidence Review – Case studies

Portsmouth maritime – road integration

The Portsmouth City Council (PCC) network management team utilise ferry tracking against timetable and anomaly detection to assess potential impact on approach roads, vehicle stacking, emergency services, and to inform customers on travel arrangements. The solution has improved situational awareness and helped overcome communication challenges between ferry operators and PCC.



Monitoring of Ferry locations versus timetable, anomaly detection. Image courtesy of PCC.

Network Rail ENRICH

Enhanced Network Rail Information interCHange (ENRICH) seeks to overcome data sharing barriers across the rail industry, mainly for Remote Condition Monitoring of vehicles or infrastructure assets e.g. wheels or overhead lines.

Whilst Network Rail has exchanged data sets with the industry for many years, interfaces have often been developed without an overarching data interchange framework, which creates inconsistencies and limits the ability to link data across the industry to innovate.

ENRICH has leveraged the Rail Delivery Group's (RDG's) Rail Data Marketplace (RDM) to agree suitable technical and commercial approaches for sharing of data.

NATS project Bluebird

The National Air Traffic Service's project Bluebird is a government-funded research project to deliver the world's first AI system, using digital twinning approaches, capable of controlling a section of airspace in live trials.

The digital twin has access to over 25 million flight data records and has three principal objectives:

1. To perform probabilistic modelling and risk-based analysis
2. To build and train 'agents' that can perform the role of air traffic controller to a suitable degree of competency
3. To harness the potential of Artificial Intelligence, whilst ensuring trustworthiness and traceability – of key importance to this operational setting.

Portsmouth CITY COUNCIL NetworkRail NATS

Evidence Review – Identified use case themes

Use cases identified

Use cases have been identified through the evidence review that could be supported by an IN-DT. It should be noted that the use cases provided are not exhaustive and they reflect solely the evidenced examples captured by literature review and stakeholder engagement.

These applications could yield positive economic outcomes under both business as usual (BAU) and atypical transport network conditions. Due to the number of, and inherent connections between use cases, they have been grouped into four themes as shown.

Theme 1

Better business-as-usual operations across modes enabled from sharing operational information/data between transport system actors (e.g., multi-modal schedules) at local and/or national scales to enable more comprehensive network performance monitoring, design of timetables, and network capacity management for network management organisations.

Theme 2

Increased transport network resilience from network monitoring, coordination and dynamic response at a "whole system" level. This more holistic operational decision coordination between authorities, agencies, and modal operators could lead to faster and more efficient detection and response to planned and unplanned events across transport networks. It includes an understanding of implications to wider transport network elements and transport network users to minimise disruption.

Theme 3

Improved collaboration with other stakeholders, through the creation of a single way of interacting digitally. This includes cross-sectoral private sector organisations (e.g., road, rail, energy, weather, manufacturing, utilities etc.) leading to more effective network operations, more reliable journeys, improved processes, especially at hubs e.g., stations, depots, ports etc. Whilst not the focus for this analysis, this could include benefits to other sectors, such as those given as examples above.

Theme 4 – *emerging concept theme*

Enabling future transport solutions such as self-driving vehicles or drones through digital twin technologies. An Integrated Transport Network Digital Twin (IN-DT) could potentially support and de-risk deployment and enable a level of collaboration beyond what is currently possible.

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Evidence Review – Identified use cases

Theme 1: Better business-as-usual operations across modes between network management operators

- Network capacity management
- Multimodal journey planning
- Network capacity management around hubs
- Multimodal journey optimisation
- Network management at authority interface points
- Demand responsive transport

Theme 2: Increased transport network resilience

- Integrated incident and emergency management
- Crisis/disaster response planning and management
- Planned works and maintenance management
- Events planning and management
- Scenario analysis and forecasts
- Network management performance enquiries
- Intersection safety
- Freight abnormal loads

Theme 3: Improved collaboration with other stakeholders

- Strategic transport hub planning
- Public services planning
- Freight management at ports
- Operational resource planning
- Parking planning and management
- Energy-transport operational management

Theme 4: Enabling future transport solutions (emerging concept)

- Next generation transport enablement
- Operator training (Human and Artificial Intelligence)

Use Case Prioritisation

Prioritisation process

This study quantitatively analysed the economic benefits associated with high-priority use cases across the themes (see right). The selection of these use cases was completed through a scoring exercise depicted in Figure 5 below.

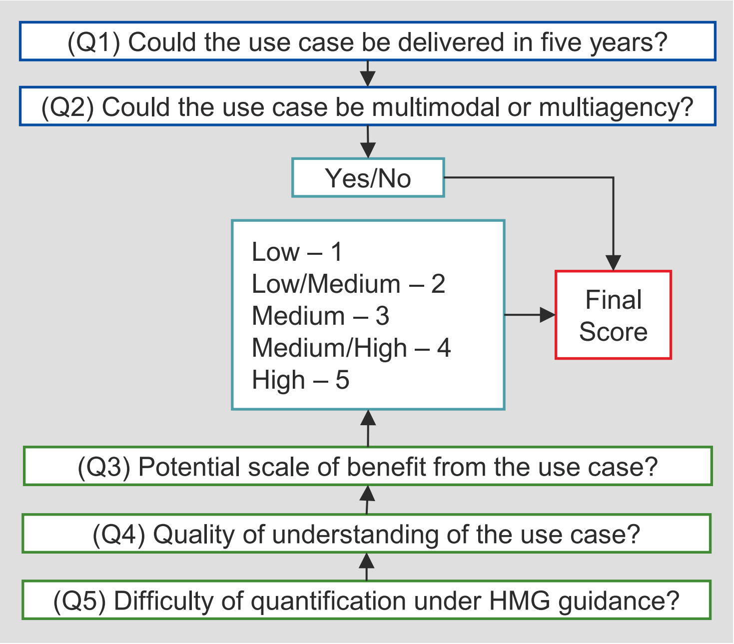
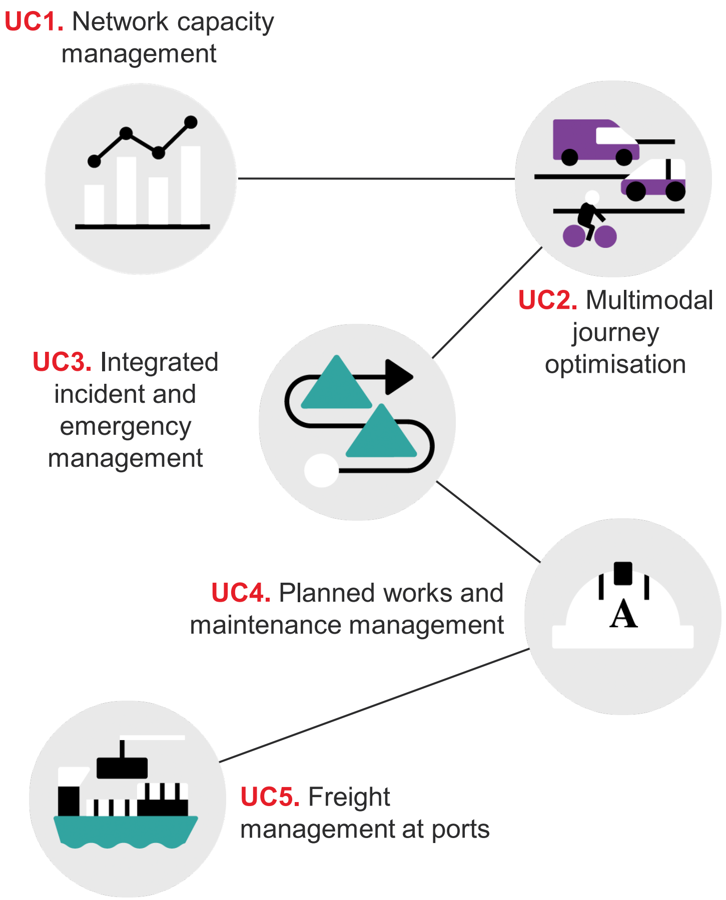


Figure 5: Use case scoring methodology

Figure 6: Five priority use cases for quantitative analysis



Assessment process

The five selected priority use cases had evidence to support their potential impact (Q3. scale of benefit). Arup has a good understanding of each use case's outcome (i.e. what success and improvement means for the use case) and the underlying functionality needed to achieve this (Q4). Quantification for each use case can be completed consistent with HMG guidance (TAG) (Q5) and it is likely that a digital twin providing such a use case is deliverable within the next five years (Q1).

Moreover, each of the priority use cases complete a multimodal or multiagency function (Q2). All five use cases involve road, rail, maritime and active travel modes; public and private sector collaboration; freight and passenger transport; and different transport system network management facets e.g., business as usual management, incident management, maintenance management, planning etc.

The following section describes each priority use case in detail to provide an understanding of the problem they are solving, supporting case studies, the digital twin functionality required to enable them including required data and stakeholders that need to be involved.

UC1. Network capacity management

Problem Definition

Growth in network demand can make managing network capacity difficult. Capacity constraints can arise quickly, impact wider network components and be difficult to alleviate. A federated ecosystem of digital twins could enable various capacity management initiatives with an aim to improve the matching of network capacity with demand across the network.

This could include changing traffic signalling to prioritise buses or emergency vehicles, load balancing across the network, or mitigating disturbances at hubs that could impact capacity on nearby transport networks. For example, if inclement weather creates delays at an airport or port, incoming traffic may become congested as outflows are reduced. These impacts could ripple outwards from the hub onto the wider transport network.

The network capacity management use case proposes information is provided to inbound transport users to mitigate impacts on the neighbouring transport network. This use case is currently being considered by Portsmouth City Council, and explored by Virginia's Department of Transport (US) within its Integrated Corridor Management programme, RM3P.

Related Case Studies

Integrated corridor management (ICM) pilots that increase communication and improve collaboration for network operators to actively manage corridor capacity during or following incidents have demonstrated strong Benefit Cost Ratios between 10:1 and 20:1.

Portsmouth City Council use ferry tracking and timetabling data to detect anomalies, assessing impact on incoming traffic to the port. Information can be provided to port customers via Variable Message Signs (VMS) and wider network impacts can be mitigated.

Functionality Required and Enablement

Network capacity management is dependent on the availability of broad information related to network condition(s) and incidents across the network. This information can be made available from journey planning apps, sensor networks or vehicle status information. Development could be expedited through parallel coordination of initiatives e.g., connected traffic signal upgrades, in vehicle information schemes (Green Light Optimal Speed Advisory, next generation e-call initiatives etc.).

Potential Beneficial Outcomes

TAG Consistent – Reduction in network capacity constraints could reduce journey times, increase journey time reliability which also has second order effects including fuel savings, emission savings and localised air quality improvements.

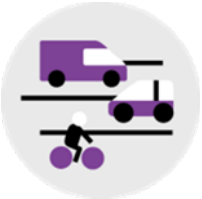
Qualitative – Improved administrative efficiency, capacity constraint recovery/relief speed, infrastructure utilisation, explicit mode performance (e.g., ambulance vehicle response time), reduced rat running.

Stakeholders Involved

- Relevant transport authorities and operators across different modes (highway, rail, maritime, freight and passenger etc.)
- local, regional and national government
- emergency services
- map and journey planner app developers

Example Data Acquisitions / Flows

Traffic and incident information e.g., journey time (e.g. INRIX, National Highways NTIS), Google Maps congestion API, Waze. Live weather and forecast data, emergency services location and utilisation data.



UC2. Multimodal journey optimisation

Problem Definition

The efficiency of multimodal journeys is heavily reliant on independencies including interchange timings, customer facility provision, well designed wayfinding, weather conditions, and mitigating disruptive events such as vehicle breakdowns, delays, infrastructure failures (power, telecoms etc.).

Improving the timeliness, accuracy, and richness of data associated with transport networks could enable improved planning and operational resilience of multimodal interchanges. This could directly reduce interchange times, increase user satisfaction and the ease of travel.

Additionally, journeys could be planned more effectively in a dynamic, data driven fashion against certain objective functions e.g., speed, resilience, comfort, work, emissions (i.e., eco-routing) etc.

Furthermore, end-to-end integrated journey planning, timetabling/integration could be completed at a more granular place-based level i.e., based on right-time transport network performance, especially during periods of delay/change to positively impact journey time reliability and/or customer situational awareness.

Related Case Studies

VDoT Regional Multi-Modal Mobility Programme (RM3P) is a multi-agency, multi-mode programme leveraging the collaborative use of real-time data (e.g. transport demand, parking availability) by Virginia's public and private sectors to improve travel safety, reliability, and mobility.

Functionality Required and Enablement

Multimodal journey optimisation would benefit from operator decision making/journey planners, aided by an (potentially AI-based) decision support system. Tie in with other use cases such as incident/capacity management to ensure journey time reliability and/or alternative routings. Mechanisms to encourage certain modal patterns could include dynamic incentivisation. Interoperability and indications of data ownership/control restrictions to protect commercial sensitivities are key.

Example Data Acquisitions

Weather/climate, incident/capacity management data, parking data, multimodal movement data.

Potential Beneficial Outcomes

TAG Consistent – Increases in journey time reliability and safety. Reductions in transit times at interchanges. Reductions in emissions from eco-routing. Reduction in fuel use/wasted milage (i.e., costs) for freight consignments.

Qualitative – Journey quality/seamlessness. Increased efficacy of multimodal provision helps to meet the demands of diverse communities/populations.

Stakeholders Involved

- Relevant transport operators across freight and passenger transport (highway, rail, aviation, maritime etc.)
- local, regional and national authorities/operators
- journey planners/maps (Waze/Google/other DaaS)
- tolling stakeholders
- weather data providers
- OEM vehicle data brokers, for-hire vehicle data

UC3. Integrated incident and emergency management

Problem Definition

Unplanned incidents and emergencies occur regularly within transport networks and often impact multiple modes concurrently. These events can be unintentional (e.g., traffic crashes, poor weather related) and exacerbated by low network resilience (e.g., power faults, congestion, IT failures) however, they could be identified, analysed and responded to in a more effective way.

Improving the timeliness, accuracy, and richness of incident and emergency detection across transport modes could be facilitated directly by digitalisation and the use of digital twin technology. Centralised information provision via singular dashboards for transport network operators already influences the quality of their incident response e.g., coordinating with the most appropriate system actors.

Over time the analysis of archived incident and emergency reports (e.g. incident characterisation, contextualisation, and frequency) could also assist with the development of more effective response plans, especially mitigation through the utilisation of alternative modes, accurate information provision to operators/customers.

Related Case Studies

Transport for West Midlands (TfWM) have developed within their Regional Transport Coordination Centre (RTCC) a consolidated network dashboard that is fed right-time incident data federated across multiple sources. This data is used to improve workflows with an integrated Incident Management System (IMS).

Transport for London's (TfL's) Surface Intelligent Transport System (SITS) also provides a single view of the transport network with consolidated incident data and action plans through use of a digital twin.

Functionality Required and Enablement

Integrated incident and emergency management requires integration of incident data sources across relevant modes into shared view dashboards of the transport network. Predictive/automated response plan capability can be enabled by a digital twin using information from these sources. The twin can then augment administrative tasks including incident reporting, communication (e.g., to emergency services), ongoing monitoring, post incident evaluation/archiving, future analysis/factoring into future incident planning/suggested mitigation strategies.

Potential Beneficial Outcomes

TAG Consistent – Reduction impacts to transport network through reduction in incidents and incident severity. This improves journey time and journey time reliability which could yield subsequent economic and wider benefit.

Qualitative – Management/administrative efficiency gains lead to a decrease in calls, emails, wasted mileage, improved incident recovery plans (resilience), future mitigation strategies (resilience investment)

Stakeholders Involved

Relevant modal authorities (highway, rail, maritime etc.), local, regional and national authorities and resilience forums, emergency services and healthcare providers, journey planners (Waze/Google), works contractors, breakdown agencies, alternative transport service providers (e.g., rail replacement buses).

Example Data Acquisitions / Flows

Incident metrics, weather, journey planner data (e.g., Waze for Cities Data Prog.), hub statuses, emergency service info, CCTV etc.

UC4. Planned works and maintenance management

Problem Definition

Across transport networks, the upkeep of infrastructure and assets is imperative to ensure reliable and efficient operation. The planning of maintenance works can occur across a multitude of actors including vehicle asset owners, highway/railway authorities, utility providers i.e., water, gas, electric etc.

Maintenance works typically result in disruptive transport conditions from temporary roadworks, partial station closures or capacity degradations etc. Furthermore, it is possible for some work to be duplicated (e.g., multiple excavations in the same location by separate utilities) or for works to not consider alternative transport modes (e.g., closing a highway when rail lines are also closed – leaving travellers with few/no alternative methods of travel).

Digital twins federating data, such as that provided by remote condition monitoring (RCM) and maintenance plans, could enable a deeper understanding, scheduling and control of maintenance works impacting transport. Functions could include combining maintenance tasks/improving scheduling to reduce maintenance work and minimise disruption or through improving the performance of roadworks.

Related Case Studies

Enhanced Network Rail Information interCHange (ENRICH) seeks to overcome data sharing barriers across the rail industry, mainly for RCM e.g., for wheels or overhead lines.

The National Underground Asset Register (NUAR) could deliver benefits of £490m/year from productivity gains, reduced asset strikes, public/business impacts.

SITS' single view of the transport network could help to mitigate roadwork congestion. GLA roadworks utility co-ordination platform could help reduce works.

Functionality Required and Enablement

Planned works and maintenance management will require incorporation of datasets e.g., NUAR, temporary traffic assets to understand works locations across sectors and avoid conflicts, whilst identifying coordination opportunities. Maintenance plans will be integrated to give right-time insight and alerts, and the digital twin will update plans to optimise accordingly. Temporary traffic signals could be remotely managed to network needs. Digital diversion routes, digitised temporary traffic regulation orders (TTROs) could be embedded to improve efficiency.

Potential Beneficial Outcomes

TAG Consistent – Reduced quantity of maintenance works from improved collaboration (could reduce overall congestion, emissions, or disruption).

Qualitative – Predictive maintenance/forecasting could help coordination, connected temporary traffic signals could reduce delays (UTC to SCOOT), workflow automation e.g., TTRO applications, could improve short term planning/response times when works are needed for acute incidents.

Stakeholders Involved

Relevant modal authorities (highway, rail, maritime etc.), local, regional and national authorities, industry stakeholders (contractors, planners, designers, engineers etc.), asset/infrastructure owners, financers, emergency services, journey planners/maps (Waze/Google), local transport system users/impacted businesses.

Example Data Acquisitions / Flows

RCM, TRO, diversion route, traffic flow, congestion, temporary traffic signals/infrastructure data, communication to users e.g. VMS, in-cabin display.

UC5. Freight management at ports

Problem Definition

Ports constitute a complex environment of actors providing varied services including but not limited to; cargo handling; container operations; vessel loading and unloading; storage and repair functions; outbound traffic loading/unloading; and the planning/timing of these activities so that they act symbiotically e.g., matching infrastructure (e.g., cranes, berths) with inbound vessels for processing, and/or HGV/rail arrivals with parking spaces, train sidings and a supply of outbound freight.

Holistic information provision via a digital twin could enable a more collaborative, integrated operational environment. Often, from the literature reviewed by this project, port digitalisation can be termed as the use of a port decision support system (DSS) or port management system. Such a system could be beneficial during normal operations or during periods of incident that require recovery e.g., advising a vessel of a new routing or arrival time (requiring a reduction in speed etc.).

Port operations have significant interdependencies with internal/inter-port stakeholders: border control/customs, maritime operations, global logistics firms, neighbouring communities/transport networks (coastal), supporting land transport operations (road/rail).

Related Case Studies

Port of Antwerp-Bruges (PoAB) has developed the APICA digital twin which aims to provide situational awareness and decision support through information provision related to traffic situations, bridge and lock statuses, infrastructure, and environmental sensor data.

Port of Rotterdam's use of a port management system and community system has resulted in 30 min vessel turnaround time saving (approx. €160m saving/year), 5-10% saving in dredging costs, €245m saving from reduced phone calls, email traffic, freight mileage.

Functionality Required and Enablement

Freight management use cases require federation of multimodal/agency data within a digital twin using existing/future resources (e.g., AIS, sensor networks, drones, GIS) to build a reliable, neutral source of port information that could augment functions such as administrative/financial processing, departure/arrival control, berth/cargo planning/handling, incident response etc. Any digital twins must be easy to integrate with and indicate data ownership/control restrictions to protect commercial sensitivities.

Potential Beneficial Outcomes

TAG Consistent – Reduction in dwell times for inbound/outbound traffic leading to fuel savings and time savings which could contribute to emissions savings and localised air quality improvements.

Qualitative – Management/administrative efficiency gains lead to a decrease in calls, emails, wasted mileage, improved incident recovery (resilience), infrastructure utilisation, journey reliability, and customs checks could be more effective.

Stakeholders Involved

Port owners (e.g., Associated British Ports), lessees (e.g., terminals, logistics facilities, industrial sites, real estate), carriers (e.g., road/rail/maritime operators), freight agencies, service providers (e.g., towing, bunkering, maintenance), NGOs (e.g., IMO), authorities (e.g., local, regional, national), other ports.

Example Data Acquisitions / Flows

Fleet information (timing, vehicle, consignment etc.), border updates, infrastructure utilisation, air quality, incidents/events e.g., nearby roads/rail corridor status.

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Commonalities across prioritised use cases

Functionality

Data Sharing Architecture and Interoperability enabling various data sources such as sensor networks, vehicle or asset status information, incident data, response plans, and datasets like NUAR to exchange information. This integration is essential for providing comprehensive and accurate information for decision-making.

In addition to sharing, interoperability of this data (enabled by agreements on standards, data models, taxonomies etc. and in coordination with NDTP) between public and private entities are key requirements across multiple use cases. For example, future works and events plans being shared between contractors, local authorities, and transport network managers and operators.

Dashboards and Decision Support Systems (DSS) that make use of federated data sources allow stakeholders to access relevant data and information easily, can model alternative scenarios and their impacts facilitating incident management, maintenance planning, and coordination of works. Such systems can then output to communications systems to inform relevant stakeholders (e.g. transport users, or emergency services agencies).

Right-time Monitoring and Control for example, remotely managing road closures, monitoring port operations, and responding to incidents promptly.

Actors

Relevant Modal Authorities/Operators: Mentioned in all use cases, as different modes of transportation are involved in each scenario.

Local, Regional, and National Government: Also mentioned in all use cases, indicating their significant role in transportation management and governance.

Emergency Services: Common across all use cases, as they play a crucial role in incident management and response.

Journey Planners/Maps (Waze/Google): Found in multiple use cases, highlighting their importance in providing navigation and route planning services.

Maintenance Staff/Contractors: Mentioned in both UC3 and UC4, indicating their involvement in incident management, maintenance, and infrastructure development.

Data flows

Incident and emergency data: All use cases involve incident-related metrics, such as journey time, reliability, congestion data.

Environmental conditions data: Weather and climate data is important for understanding environmental conditions that may impact transportation operations, incidents and safety.

Journey Planner data: Data from journey planning applications provides real-time information about traffic conditions and alternative routes, which is valuable for journey optimization and incident management.

Traffic flow data: including congestion data, is essential for understanding traffic patterns. From sources like Google Maps API, road sensors, telematics and Waze inputs.

Utilisation data e.g., occupancy, freight loads.

Scheduling and demand information including timing, vehicle, and consignment details etc.

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Economic Benefits Analysis – introduction

Background

The evidence review, set out in the previous section, sought to find evidence of quantifiable benefits of integrated network management and related digital twins which could be used to inform the EBA. Alongside this, use cases for digital twins in this area were identified and developed from the evidence gathered. A prioritisation process led to five use cases being shortlisted, as set out in the previous section.

The intention of the EBA is to be consistent, where possible, with TAG (DfT Transport Analysis Guidance). This sets out a framework for assessing the economic benefits of a transport project. Schemes are assessed against four overarching impact categories in TAG, with additional sub-categories within each of these.

A logic model was developed, linking the inputs and activities that would be required to deliver an IN-DT with the outputs that would be produced, the outcomes that would follow from this, and the ultimate impacts that would be delivered. The impacts were designed to align with benefits that are assessed in TAG.

TAG Impact Categories

Economy – Benefits to businesses, business users, and private sector providers - in terms of generalised travel time or cost savings, improved reliability or wider economic impacts.

Environment – Impacts that transport may have on noise, local air quality and greenhouse gas emissions.

Social – Benefits to commuters and other transport users and non-users, including generalised time or cost savings, or improvements in safety, journey quality, physical activity or reliability.

Public Accounts – Impacts on public sector transport budgets or taxation.

Content

This section takes the use cases that have been identified in the earlier stages of the study forward to EBA and develops the correspondence between these use cases and quantified benefits.

The approach, underpinning assumptions and key data sources that have been used to estimate benefits.

The results (benefits that have been quantified) under a set of core assumptions; and sensitivity tests.

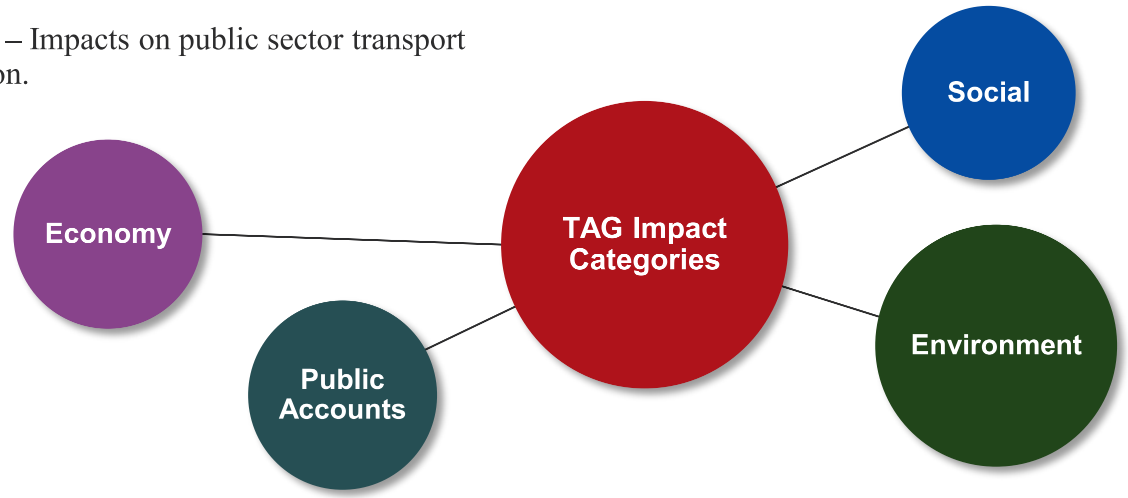

Figure 7: Transport Analysis Guidance (TAG) impact categories

Economic Benefits Analysis – use cases

Benefits of the use cases

The next step was to understand which impacts would be likely to correspond with which use cases and would also be quantified in the EBA. This was based on an assessment of what the most significant quantified benefits were likely to be,

Table 1: Correspondence between use cases and quantified benefits

	Use Case				
Benefit	UC1 Network capacity management	UC2 Multimodal journey optimisation	UC3 Integrated incident and emergency management	UC4 Planned works & maintenance management	UC5 Freight management at ports
Journey time savings	✓	✓	✓	✓	
Reliability	✓		✓		
Journey quality		✓			
Vehicle operating costs	✓		✓	✓	
Mode shift benefits excluding environmental		✓			
Environmental benefits		✓			✓
Output change in imperfectly competitive markets	✓	✓	✓		

Economic Benefits Analysis – conclusions

Conclusions

This chapter sets out the results of an economic benefits analysis for a set of use cases for an Integrated Transport Network Management Digital Twin. The use cases were developed as part of an evidence review at the outset of this study; a prioritisation process was undertaken in order to reduce an initial longlist down to five that were taken forward for EBA. These were selected on the basis of the whether there was sufficient evidence to undertake a quantification, and whether the benefits were likely to be at sufficient scale to justify doing so.

The analysis is based on underpinning evidence wherever possible. Where evidence for an assumption was more limited, a value was selected, and sensitivity tests undertaken to examine the impact of altering that assumption.

The quantified benefits are consistent with the TAG framework, with key benefits including journey time savings, journey quality and reliability. The results of the analysis suggest that quantified benefits for each use case could be in a range (see summary report Table 6 for details). In total, the benefits across the five use cases using the core set of assumptions are approximately £1,850m in undiscounted terms, or c.£850m as a present value.

It is not always possible to capture all impacts of an investment in quantitative terms. Non-monetised benefits should also be considered in determining the value of a project and prioritising investments. For the use cases examined here, non-monetised impacts are likely to include:

- Cost savings to businesses
- Cost savings to the public sector
- Additional environmental benefits
- Health benefits due to increase levels of physical activity
- Improved access to services.

In summary, the results of the EBA suggest that there is value in further developing the case for investment in an IN-DT.

EBA results

£1.85bn

Undiscounted value, 2010 prices, 10-year appraisal period

£856m

TAG-consistent present value, 2010 prices, 10-year appraisal period

ARUP