FINAL BOOKLET

D8.4

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Executive Summary

This deliverable represents D8.4, the Final Booklet in deliverable format for formal submission. This presents an overview of the project from the perspective of completion for the general public, with links within to deliverables which provide key aspects and more technical details for experts in their fields and other interested parties. This will be presented with finalised text within this document, with some room for minor changes or clarifications in the designed version. The designed version, which can be used to showcase the accomplishments of the project, will be provided mid-November, as the priority was to ensure the completion of most of the tasks within the project, which still runs for another month, and this overview is scheduled to be delivered somewhat in parallel. For further details on the project and specific results, kindly refer to the key deliverables referred to within this document. The final booklet will be presented here as the main chapters, which will serve as the foundation for the designed final booklet.

The following represents the structure and text for the Final Booklet.

*The photos and images used in this brochure have been created by internal partners and/or cited appropriately. Detailed references and the source material for this brochure can be found on and downloaded from the project website.

Key words

Final Booklet, Results, Traffic Management

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Acronym	Meaning
CAVs	Connected and Automated Vehicles
CCAM	Connected, Cooperative, and Automated Mobility
DRT	Demand Responsive Transport
DCP	Dynamic Congestion Pricing
FRT	Fixed-Route Transit
KRN	Key Route Network
MTM	Multimodal Traffic Management
MTMC	Multimodal Traffic Management Cluster
NTM	Network and Traffic Management
PT	Public Transport
SICI	Smart Infrastructure Classification Index
SIRI	Smart Infrastructure Readiness Index
SRICI	Smart Road Infrastructure Classification Index

SUMP	Sustainable Urban Mobility Planning
TMC	Traffic Management Centre
TfGM	Transport for Greater Manchester

1 Introduction

Network and Traffic Management (NTM) has historically been deployed in silos by different operators within a city or region, with a disproportionate focus on optimising road transport. However, a better connected and multimodal network is possible through improved cooperation between stakeholders working on the transport network, including traffic managers from multiple authorities, transport operators, infrastructure managers, municipalities and regions, and other public and private bodies. They all play a crucial role in **orchestrating and coordinating current and future transport modes.** Their actions directly impact users' mobility patterns, enhancing door-to-door travel by improving efficiency, safety, security, sustainability, and cost reduction for all.

In this context, TANGENT, an EU-funded Horizon 2020 project, enabled knowledge creation, facilitated city-led pilots, and developed **complementary tools for optimising traffic operations in a coordinated and dynamic way from a multimodal perspective**. These tools were designed through multi-actor co-creation and cooperation processes and implemented in four demonstrations, namely Lisbon, Great Manchester, Rennes, and Athens. The TANGENT project took place between September 2021 and November 2024 and was coordinated by the University of Deusto, based in Bilbao, Spain.

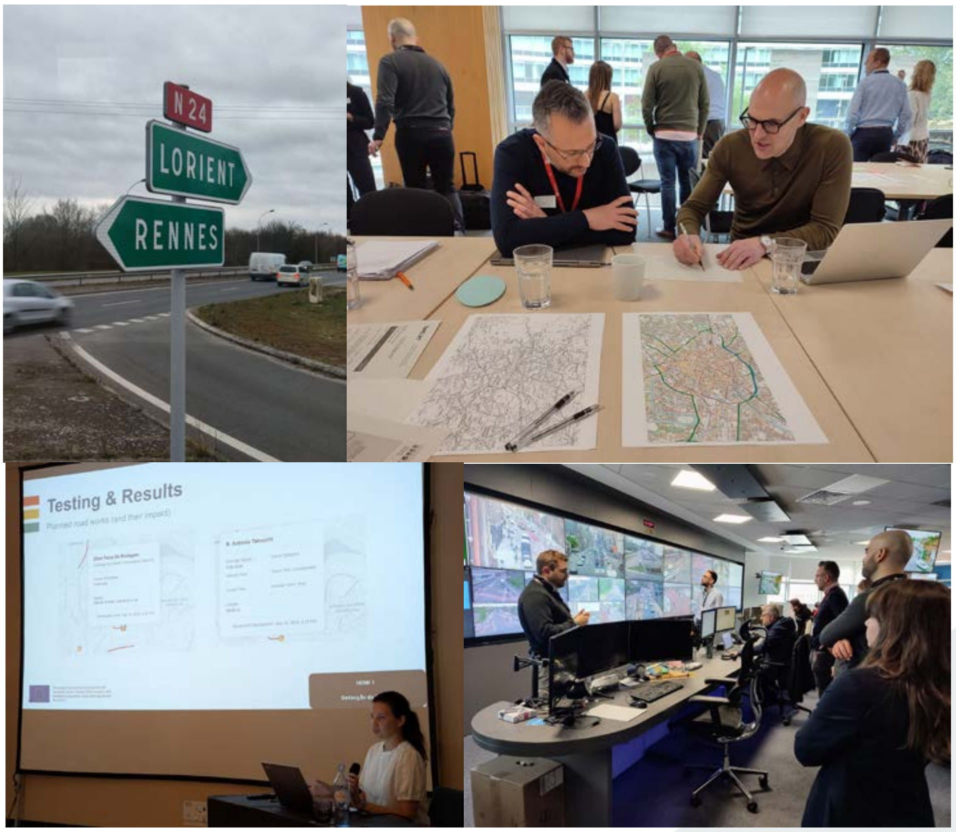


Figure 1: (from top to bottom, left to right) Route de Lorient, the Rennes Metropole case study area (Source: POLIS); A first TANGENT workshop with various operators in Greater Manchester (2022) (Source: POLIS); The last TANGENT workshop presenting the dashboard testing results in Lisbon (2024) (Source: Rupprecht Consult); Transport for Greater Manchester traffic control site visit in 2022 (Source: POLIS Network).

2 TANGENT's Traffic Management Tool and Services

The TANGENT project developed a web-based dashboard tailored for management and operational roles working in different urban traffic management environments. The dashboard's functionalities include **monitoring and visualisation** of live data in maps, indicators, and tables, **forecasting** through predictions in a time horizon, and **planning and incident management,** which involves creating, visualising, and using response plans to address incidents in real-time.

Figure 2: The four services required to develop the TANGENT tool. (Source: A-to-Be)

In a nutshell, the TANGENT tool is composed of 4 components:

1. **Service 0 - Data**
   To feed the dashboard, **large-scale historical and real-time data sets** were identified, collected, and harmonised from various sources and modes such as multimodal travel and traffic data from transport operators, travellers' data, and open data. The system also allows for new data sources to be added and customised, a key requirement to enable traffic managers to adapt to a fast-changing innovative mobility sector. In addition, data visualisation in the dashboards was adapted to each demonstration according to their needs.

2. **Service 1 - Monitoring and Forecasting**
   Through the dashboard, traffic managers can **monitor, visualise, and forecast the traffic flow and traffic conditions**. They can customise their city's dashboard to visualise live data in maps, indicators (KPIs) and tables, as well as forecast scenarios of transport demand and supply under various circumstances, including accidents and sporting events.

3. **Service 2 and 3 - Incident Management and Planning.**
   To facilitate decision-making and conflict resolution between stakeholders managing traffic (traffic managers, public transport operators, rail operators, etc.), new arbitration models were established that balance individual versus collective needs. These are based on the simulation of various scenarios, including cooperative response plans to incidents. These are integrated into the TANGENT tool in the format of a **decision-making support tool** based on **response plans for real-time incident management**. For example, a plan can offer **concrete actions** that should be activated to resolve the incident, along with a group chat involving the relevant stakeholders. Actions can include responses such as changing the timings of traffic lights and/or increasing public transport frequencies on certain lanes.

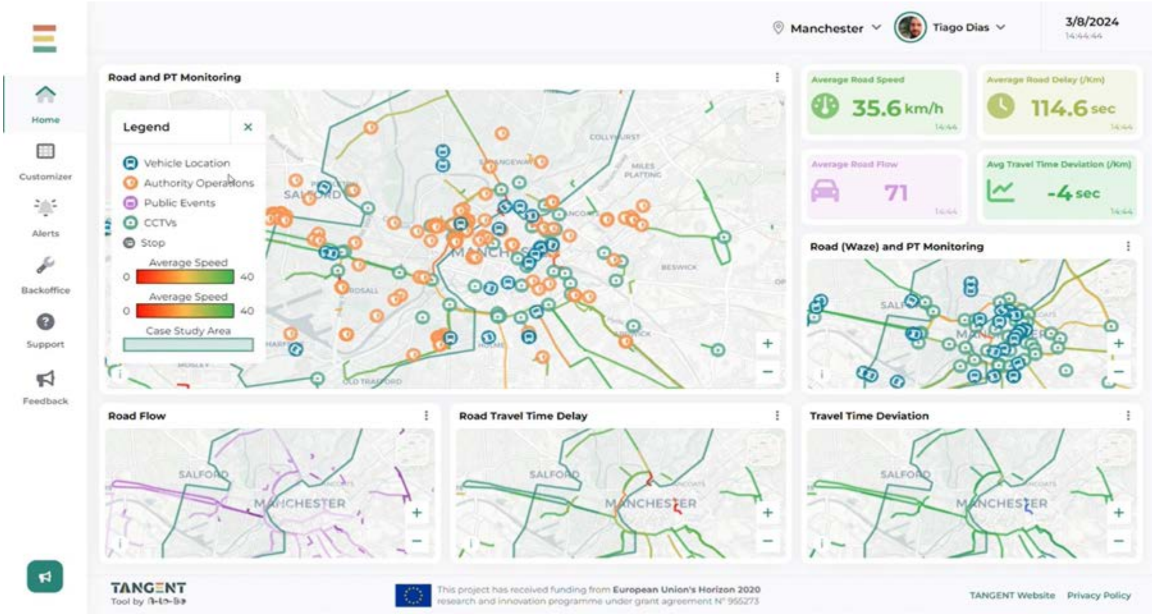


Figure 3: The TANGENT Dashboard developed for Transport for Greater Manchester (Source: A-to-Be).

The TANGENT Dashboard developed for Transport for Greater Manchester. The dashboard demonstrates some of the following available characteristics: different traffic views, colour coding providing extra information such as average speeds of lines, delays of buses, and more.

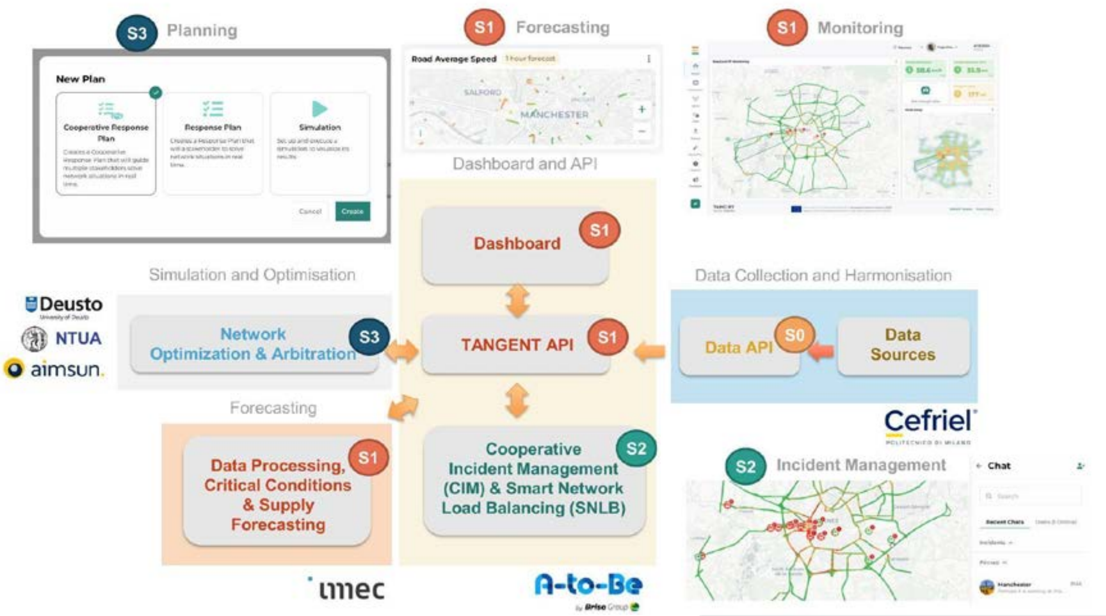


Figure 4: The TANGENT Tool Architecture (Source: A-to-Be)

The TANGENT tool was **tested and validated in four cities**, to assess, through simulation, the impact of the delivered decision-making tool and services in their multimodal network. These cities are Rennes, Lisbon, Greater Manchester, and Athens (virtual use case).

TANGENT contributed to developing **Next Generation Traffic Management Systems that do not focus on a single agency or mode**. Rather, TANGENT's dashboard focuses on intuitively bringing together traffic and transport managers across agencies, thus favouring multimodality, while integrating novel tools such as forecasting, simulation and response plans. As the dashboard is easy to customise and improve over time, traffic managers will gradually take ownership of the services offered by the project.

Figure 5: The TANGENT dashboard used in Transport for Greater Manchester's Traffic Management Control Centre. (Source: TfGM)

3 Multi-Actor Co-Creation and Cooperation

To improve traffic management in a city, and multimodality, local stakeholders need **systemic knowledge exchange and information flows**, notably to understand and consider each other's needs, priorities, capacities, and working methods.

Within each demonstration, TANGENT implemented structured **multi-actor, co-creation, and cooperation processes** to grasp the local context of conditions and system requirements in the design of the TANGENT tools. In addition, these activities enabled the definition of cooperative planning approaches and structures for multimodal traffic management solutions (MTM) by defining common targets and indicators, cooperation structures and agreements (including data governance requirements), key recommendations, and factors for the upscaling of MTM and TANGENT solutions.

This staged approach followed the SUMP planning principles and concept: each stage addressed key aspects of TANGENT's multi-actor cooperation towards optimal NTM, which included on-site workshops, interviews, and surveys during four stages of the project.

Stage 0 **Preparation and planning**	This stage included the presentation of the co-creation methodology to all involved parties, with task and activity planning per case study.
Stage 1 **Assessing needs and systems requirements**	The first official stage involved in-person workshops to gather a **comprehensive overview of each use case**: local context, key priorities, roles and needs of different stakeholders, characterisation of the transport network, stakeholder mapping, traffic management strategies, transport modelling, impact overview, scope and scenario definitions, and data visualisation and interaction. These workshops concluded with an in-depth description of the functionalities to be tested in TANGENT, including the needs and requirements to test them.
Stage 2 **Setting up multi-actor cooperation**	The second stage focused on establishing the conditions and structures for effective multi-actor cooperation. They cooperatively analysed the organisational, governance, and operational structures- identifying and validating roles and tasks for each actor, as well as the preferred cooperation formats, and assessing requirements for data governance models.
Stage 3 **Case Study validation and lessons learned**	The final stage of the co-creation process involved the analysis of the case study implementation and its policy implications. The multi-actor cooperation and multimodal traffic management tools' challenges and benefits were evaluated, and key lessons learned and recommendations were identified.

Table 1: The Stages of the multi-actor co-creation and cooperation methodology

Key recommendations from these processes include:

- **Enhanced Data Collection and Sharing**: develop clear protocols and requirements for data sharing among transport operators, city authorities, and other stakeholders. Exploit the benefits of the common dashboard to encourage further data collection and integration. Further investment in digital infrastructure to enable MTM solutions and data collection is needed.

- **Governance and Policy Frameworks**: establish clearer governance frameworks that define roles and responsibilities among stakeholders, particularly during incidents, based on the roles and tasks considered for TANGENT's case studies. This could involve developing policies that ensure all operators respond consistently and effectively to disruptions.

- **MTM solutions as a mobility planning tool**: regularity of data collection and monitoring to steer collaborative mobility planning between public and private stakeholders, establishing cooperation structures that enable strategic alignment and preparation of MTM response plans and operational coordination.

- **Training and Capacity Building**: provide training for transport operators and city authorities on the use of new tools and data systems to ensure smooth adoption and maximise the benefits of traffic management innovations. Such efforts should understand the challenges of a transition towards new working practices and technological environments.

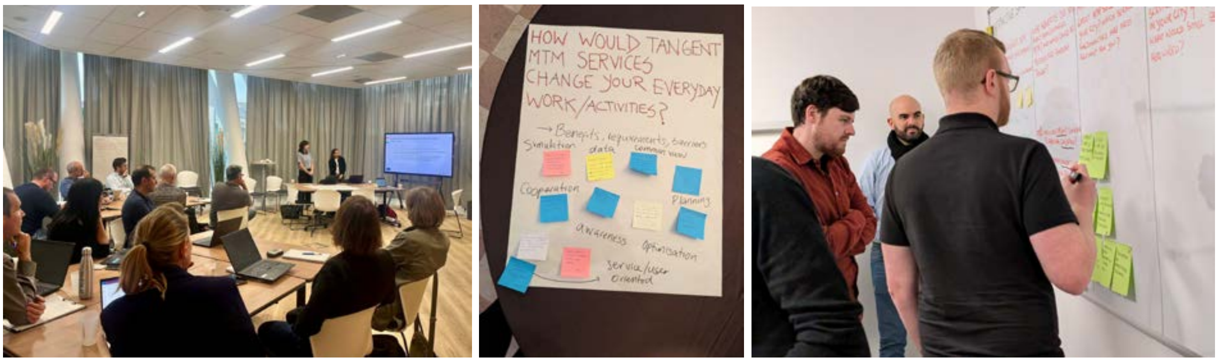


Figure 6: In-person workshops from Stage 3 workshops in Rennes, Lisbon, and Greater Manchester in 2024 (Source: Rupprecht Consult).

4 Models, Methods, and Other Processes

4.1 Intermodal Mobility Data

To orchestrate and coordinate various transport modes and systems, the project consortium collected, processed, and harmonised **large-scale, historical, and real-time intermodal mobility data** on transport networks, flows, and schedules in the four demonstrations. The data was captured by sensors deployed to monitor the transport network (road traffic, delays, disruptions, etc.) or generated by users and vehicles to determine the traffic conditions and deliver warnings and recommended services as part of the TANGENT dashboards.

Data interoperability is a challenging objective to enable communication and exchange of information effectively. Indeed, stakeholders adopt different (legacy) systems for data management and exchange that cannot be directly integrated or harmonised. Five major data interoperability challenges were identified and addressed in the TANGENT project: location, access, harmonisation, integration, and extraction of data.

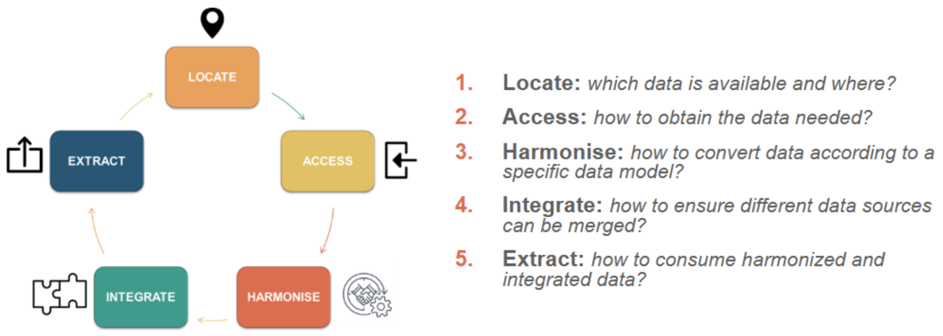


Figure 7: The data challenges addressed in TANGENT. (Source: Cefriel)

TANGENT designed and developed a comprehensive solution to address the data interoperability challenges addressed above and to fulfil the requirements of the project related to (1) the availability of historical data for the training of machine learning models to support traffic management, and (2) static and real-time data to empower a set of innovative applications for traffic managers.

The solution is composed of four main components:

- **Data Catalogue**: a digital platform enabling data-sharing through uniform descriptions of data sources;
- **Reference Conceptual Model**: a reference ontology for the transportation-related data handled within TANGENT based on standards recommended by EU Delegated Regulations and reusing existing ontologies. It is published online at: https://knowledge.c-innovationhub.com/tangent/schema;
- **Semantic Harmonisation and Fusion Pipelines**: to fulfil the requirements related to the integration of heterogeneous and intermodal data sources; and
- **Data API**: a uniform mechanism to facilitate access to data sources collected and harmonised.

4.2 Transport Prediction and Simulation Models

To provide accurate and timely information to traffic operators for multi-modal traffic management, the project developed **a system to monitor and predict traffic conditions in real-time**. This system that combines **data-driven and simulation-based approaches** includes predictions of traffic supply, estimation and prediction of travel demand, detection of congestion and prediction of their duration, and more. The system is based on robust **data collection and preparation** as it uses data from traffic sensors, travel patterns, and existing traffic models for the study areas. Before making any predictions, the data is cleaned and checked for issues like missing or low-quality data. The framework involves two key components: traffic demand and supply.

Traffic supply, which includes speed, flow, travel times, and public transport delays, were predicted in the TANGENT demonstrations using deep learning models and real-time traffic data. For example, in Rennes Metropole, bus data was predicted as trajectories were missing. Journey times therefore had to be calculated through prediction. Challenges linked to traffic supply forecasts include limited coverage of real-time data, corrupted or messy data, the dynamic nature of traffic, and real-time processing of the data into the dashboard. **Events or incidents** are detected by comparing current traffic flows to the predicted state. if there is a measurable difference, it flags it as a traffic anomaly and predicts how long the congestion may last.

In addition, TANGENT used **simulations** which are performed to predict and assess how traffic will behave across the entire network, notably by covering locations where real traffic observations are not available (i.e., traffic supply data). Simulations are based on travel demand and supply interactions where the system uses historical data, detected incidents, and their duration as inputs for the simulation predictions. This enables the generation of adequate response plans and traffic management strategies to improve the network's performance.

Finally**, demand estimation and prediction** are key to real-time traffic management frameworks**.** When traffic conditions for the entire network need to be assessed and simulated, demand is an essential input. It is based on historical demand matrices that are adjusted to represent average historical travel patterns during specific circumstances (e.g., recurrent congestion or specific events). When added to the simulation model, they predict real traffic conditions as realistically as possible. When a disruption occurs in the network the traffic conditions deviate from "normal", the underlying "normal" demand is not representative anymore and needs to be updated. Data-driven models can be trained for predicting future demand and adapting the base demand to real-time traffic conditions as data becomes available.

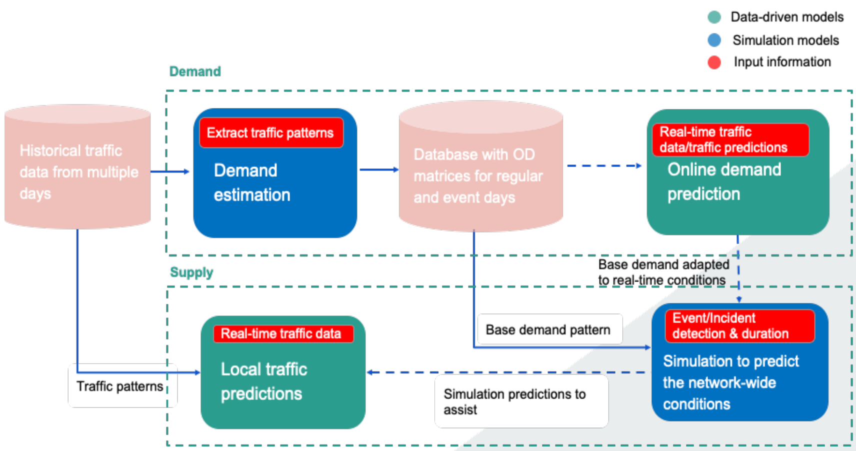


Figure 8: Real-time traffic management framework. (Source: Aimsun)

4.3 Travel Behaviour Modelling

Many factors affect travel decision making including cost, duration, mode choice and availability, new mobility services, personal factors and needs, perceptions, unpredicted events and disruptions, and more. To understand these, travel choice models were developed in TANGENT to identify factors that affect behavioural shift under various traffic management measures, and especially unexpected events- a factor so far under-researched. Modelling travel behaviour plays an integral role in predicting travel demand shifts during the pre-implementation modelling and assessment of traffic management strategies like dynamic congestion pricing and signal priority for public transit vehicles, as well as during extreme events.

TANGENT developed a **comprehensive quantitative modelling framework**, integrating econometric and machine learning models to capitalise on their complementarity-balancing interpretability and enhanced predictive accuracy. The models were trained on both Stated Preferences (SP) and Revealed Preferences (RP) data, allowing the anchoring of **questionnaire-based responses to the real travel patterns of commuters** in the four demonstrations. SP data was collected via Cefriel's CONEY, a chatbot designed to conduct surveys in a conversational format, with questions linked to their mobility profile, perception towards system-related attributes, stated preference, and evaluation of hypothetical travel scenarios (i.e., prioritisation of public transport in signalised intersections and application of a congestion charging scheme). RP data was obtained from commuters' actual trip trajectories, utilising the Google Maps Timeline tracking capabilities embedded in modern smartphones.

The accuracy of the developed models in predicting user behaviour and the ability to provide detailed insights into the socioeconomic profiles of commuters (for example, making the choice to pay an urban toll or opting for public transit if service quality increases), proves that these are **essential tools for policymakers** and can **support the optimisation of strategic decisions and resource allocation.**

4.4 Development of TANGENT's Smart Infrastructure Classification Index (SICI)

The following is extracted and adapted from TANGENT D6.3 SMART INFRASTRUCTURE INDEX CLASSIFICATION REPORT. FIRST RELEASE and D6.6 SMART INFRASTRUCTURE INDEX REPORT. SECOND RELEASE, which introduce TANGENT's own smart infrastructure classification, the Smart Infrastructure Classification Index (SICI).

To support advances in Connected, Cooperative, and Automated Mobility (CCAM), it is beneficial to have standardised procedures to evaluate the capabilities of infrastructure in supporting this shift by conveying what is available for end-users (including AVs), helping operators identify network sections that do not effectively support CCAM, and providing a tool for authorities and policymakers to plan the evolution of CCAM. In addition, when smart infrastructure is a consolidated reality, these standardised taxonomies and classifications can aid in infrastructure management, guide planning future infrastructure improvements and investments, and leverage higher levels of mobility automation.

To address this challenge, a literature review on the main existing smart infrastructure classification schemes was performed to identify the most relevant infrastructure characteristics and understand the shortcomings of these solutions, namely in their application to multimodal, urban and peri-urban scenarios. The consultation of TANGENT's Advisory Board allowed the consortium to swiftly adapt to the urban context while avoiding pitfalls from the previous indexes. D6.3 and D6.6 introduce and describe TANGENT's Smart Infrastructure Classification Index (SICI) and further explore applicability and how it was implemented within the TANGENT Tool. The SICI positions itself as a more holistic smart infrastructure classification index relative to existing classifications, while trying to keep the evaluation process quantitative, simple, clear, and easily reproducible.

This literature review was extended to also include the two Infrastructure Classification indexes born within the Multimodal Traffic Management Cluster (MTMC), simultaneously with TANGENT, the Smart Infrastructure Readiness Index (SIRI) from DIT4TraM and the Smart Road Infrastructure Classification Index (SRICI) from FRONTIER.

This report introduces the six categories considered for evaluating smart transport infrastructures, contextualizing them. The categories are: Physical Elements, Infrastructure Perception, Reference Information, Dynamic Information, Information Channels and Active Traffic Management.

The separate evaluation and scoring of these categories are fundamental to the concept behind SICI, as the different categories focus on different dimensions of maturity of smart infrastructure, which correlate but do not cancel each other out. Additionally, this addresses the fact that different stakeholders have different views on how CCAM should evolve, allowing evaluation of the transport network from different perspectives. Through a harmonised and more comprehensive classification, SICI can better support the future alignment between different stakeholders. The evaluation process was presented, and a detailed list of the evaluation criteria for each of the features in each SICI category was proposed. Both the process and criteria were designed in a simple way to aid in the ease of implementing SICI for a specific infrastructure / network.

The second deliverable lays out how TANGENT adopted SICI inside the TANGENT integrated tool and how it achieved high-level category scores for each Case Study as a whole, while allowing the analysis of the more detailed scoring at different levels of detail. It should be mentioned that only very specific SICI evaluation criteria had data available within the TANGENT Tool and that the focus of the project was not to achieve completeness of the index but to trial its usage.

There were several simplifications involved in the formulation of SICI that can create shortcomings in the future and will need to be addressed. By including the comparison to the MTMC indexes, a thorough and up-to-date overview of SICI's role within the TANGENT project is provided, reinforcing its role to support the transition towards Connected, Cooperative, and Automated Mobility (CCAM) effectively. Further details can be found in the deliverables.

4.5 Optimisation of transport operations

TANGENT developed a framework for **transport network-wide optimisation** using artificial intelligence techniques, transport modelling and simulation, and consensus reaching mechanisms to facilitate decision-making for new policies. Four functionalities were tested in the project.

To reduce congestion and pollution in urban areas through a decrease in private car use, an effective policy city can implement is ***Dynamic Congestion Pricing (DCP).*** It can reduce traffic in specific areas, promote carpooling and public transportation, restrict specific types of vehicles, reduce traffic at specific times and on specific occasions, and generate revenue. TANGENT developed new methodologies to determine the **optimal or near-optimal pricing policy**: how much the toll price should cost depending on the congestion level in a predefined zone. To establish an optimal pricing policy, the following performance indicators were considered: Level of congestion inside the DCP zone, level of congestion in the surrounding area of the DCP zone, total revenue obtained by the pricing policy, and reduction of system-wide emissions.

A barrier to increasing public transport (PT) use in cities is the first and last-mile of the journey, especially in areas that are not densely populated and where public transport service is infrequent. Demand Responsive Transport (DRT) can act as feeders or collectors for PT; therefore, the ***synchronisation of DRT and PT*** was tested to determine the **optimal or near-optimal DRT fleet and operational routes to serve the first and last-mile legs of a specific area.** It was assumed the users provided the origin and destination of their trips in advance, and their preferred time windows for departing and arriving. In this case, the performance indicators to be optimised when finding the best DRT fleet and operational routes are the percentage of demand served, the total emissions produced by the DRT fleet, the operational costs of the DRT service, and the average travel time for the passengers (considering the whole trip: first-mile + PT trip + last-mile).

Figure 9: City Passengers going onto a bus. (Source: Shutterstock (1468214126))

PT may also suffer from traffic congestion, traffic control schemes, and a lack of flexibility to react to sudden changes. To tackle these problems, TANGENT looked into the possibility that, upon certain planned or unplanned events (e.g. failure of a metro line), the frequency and/or capacity of some surface public transport lines and the traffic control plan on the roads on which these lines run are simultaneously readjusted to minimise the impact of an event in the transport network. The ***synchronisation of PT and traffic control*** was assessed to find the **optimal or near-optimal frequency and/or capacity of the public transport lines as well as the traffic control plans** for selected zones or arterials in which these lines run. In this case, the **performance indicators** to optimise were user costs, the operational cost of the public transport fleet, congestion in some predefined areas, and the reduction of the system-wide emissions.

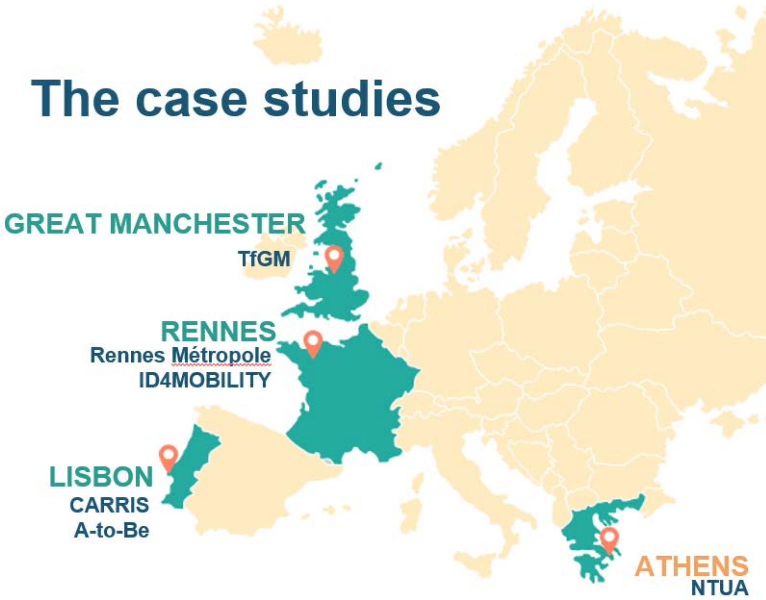
To develop new tools for traffic management for future mobility scenarios, ***Signal Vehicle Coupled Control with Connected and Automated Vehicles*** (CAVs) was evaluated. It aims to improve the traffic control performance by leveraging the exchange of information in real-time between signals and vehicles, and the simultaneous optimisation of signal timing/phases and CAVs trajectories and/or routes, to enhance the performance of the whole traffic network. The following assumptions were considered: there is a fleet of full CAVs which are connected to and can be managed by the Traffic Management Centre (TMC), and that the origin and destination of each CAV are known by the TMC. Between each origin and destination, there are one or more predefined paths. The objective was to optimise the path assignment for the complete CAV fleet and the traffic control plan on specific arterials of the considered network. In this case, the **performance indicators to optimise** were system-wide emissions, congestion in selected areas, total travel time difference between CAVs and conventional vehicles, and the total energy consumption of CAVs.

Figure 10: Connected Vehicles and traffic lights. (Source: Shutterstock (1651650295))

5 The Four City Demonstrations

TANGENT had four demonstration cities – Greater Manchester, Lisbon, Rennes Metropole, and Athens – in order to test, validate and evaluate the functionalities of the TANGENT Tool services. They were tested under three different scenarios, defined by the demonstrations:

- **Baseline scenario**: daily commuting during peak hours (all four cases)
- **Planned scenario**: football games, concerts, beginning of holidays, cultural or sports event
- **Unplanned scenario**: incidents, unplanned road work, diverted roads, floods



5.1 Lisbon Case Study

The Lisbon Case study focused on the western part of the city, encompassing 3 parishes: Belém, Ajuda and Alcântara. The planned events tested were a major **music festival** that attracts around 150,000 to 200,000 people to a venue in the case study area. The unplanned events included **incidents**, **strikes, and diverted traffic**.

The Lisbon case study offered a broader perspective on the **technical specifications and functionalities** essential for future system updates or changes to their traffic management system. Regarding data sources, the project helped **systematise Lisbon's existing real-time data sources**, including both open-data and proprietary sources, and evaluate each for their level of detail and reliability. Furthermore, interactions with other cities revealed **shared traffic management challenges and introduced Lisbon stakeholders to new solutions** in traffic management and data collection.

Through the TANGENT project, CARRIS explored an **integrated multimodal platform** offering a **real-time view of the city** of Lisbon. In sharing this tool with other stakeholders, it became evident that operators and traffic managers want and need to have a **common overview** of the mobility conditions and the incidents occurring in the city. Such information is crucial for **improving operational management and enhancing passenger communications**.

Following the project's conclusion, the Lisbon case study will continue **promoting the growth of a data-sharing culture among transportation stakeholders**. With the knowledge learned from TANGENT, efforts will focus on improving data collection and sharing methods, and on engaging other stakeholders to develop a more collaborative approach to traffic management.

5.2 Greater Manchester Case Study

The testing area was the western side of the Greater Manchester Regional Centre with portions of the Key Route Network (KRN). The planned events tested included **football games (Old Trafford)** and **concerts at the Manchester Arena Event**, while the unplanned events **were incidents and emergency roadwork.**

Transport for Greater Manchester (TfGM) benefited significantly from the TANGENT project. The collaboration with **technical partners on advanced tool and functionality development**, notably the data catalogue and TANGENT Dashboard, allowed TfGM to leverage top-tier expertise. This ensured the tools were tailored to meet the distinct needs of Greater Manchester's complex transport network.

TfGM's ongoing initiatives are also in line with TANGENT's goals, including the development of an Intelligent Transport Systems (ITS) platform and the goal of creating a common operational picture across multiple transport modes. By incorporating **predictive and forecasting capabilities**, TANGENT demonstrated how these tools can improve **operational responsiveness and foster better cross-departmental and multi-modal coordination**. Additionally, the project underscored the critical need for open, accurate, and standardised data, which will be essential as TfGM defines technical requirements for future systems and procures next-generation traffic management solutions.

5.3 Rennes Métropole Case Study

Rennes Métropole is a grouping of 43 municipalities and a Public Transport Authority, centred around the city of Rennes, the capital of the Brittany region. The case study in Rennes focused on the **congested "Route de Lorient":** a road that links to national roads, ring roads and highways, and brings users to an industrial area, a football stadium, the airport, the Rennes city centre, and more. The planned events studied were **football matches** at the Roazhon Park, the Rennes football stadium, and Friday **afternoons/evenings before holidays or long weekends**. The unplanned events identified for testing were unplanned **road works**, **accidents**, and **incidents** that could cause delay, lane closure, and/or traffic diversion.

TANGENT proved valuable for the case study by providing Rennes Métropole with a broader perspective on the technical requirements and functionalities needed for **future upgrades or changes to their traffic management system**. Rennes Métropole identified **key contacts among various network managers** (traffic and public transit) who contributed to evaluating the solution and shared datasets for collaboration. Interactions with other cities offered insights into the challenges faced by other European cities.

Following the project's conclusion, the Rennes case study will **continue advancing multimodal traffic management within the metropolitan area**. Efforts will focus on rethinking the traffic management system and its functionalities, fostering greater collaboration with the current supplier, improving data collection and sharing methods, and expanding stakeholder meetings to enhance multi-actor traffic management.

5.4 Athens Case Study (Virtual)

The Athens Case Study, led by the National Technical University of Athens, focused on **investigating future network-wide Traffic Management, considering also the existence of CAVs**. The Athens Case Study was a virtual case study implemented in the Athens Testbed. The Athens Testbed is the inner-ring urban road network of Athens: a dense (approx. 1300 nodes and 2600 edges), real-life urban road network, which consists of roads with both low and high functional class. Demand-wise, approximately 87,000 vehicles are inserted in the Athens Testbed during morning peak hour, based on data from 2023.

The scope of the Athens Case Study was a virtual testing, within **a simulation environment**. A variety of scenarios were implemented which **prove the positive impact that network-wide Traffic Management, in parallel with the deployment of CAVs**, can have towards improving the efficiency of urban road networks.

5.5 Overall testing of the TANGENT services and feedback

From April to September 2024, the dashboard functionalities and services usability, clarity, reliability, and accuracy were assessed internally in the demonstrations in comparison to their initial requirements. The demonstrations stated that the TANGENT services have the potential to **improve operational capabilities** through the **real-time insights**, which are key to respond efficiently when an incident or congestion occurs. They also stated the ability to **view the status of several transport modes on a single platform** as an added value. The dashboard's ability to **disseminate key elements on the traffic status** to all local stakeholders (same level of information) was valued, as well as the **high level of customisation** of the dashboard. They emphasised that **data integration across modes is essential.** Challenges are the availability and reliability of data that needs to be up-to-date, and the legal aspects and the ownership of the data. The following visual provides further **feedback on the use of the TANGENT dashboard.**

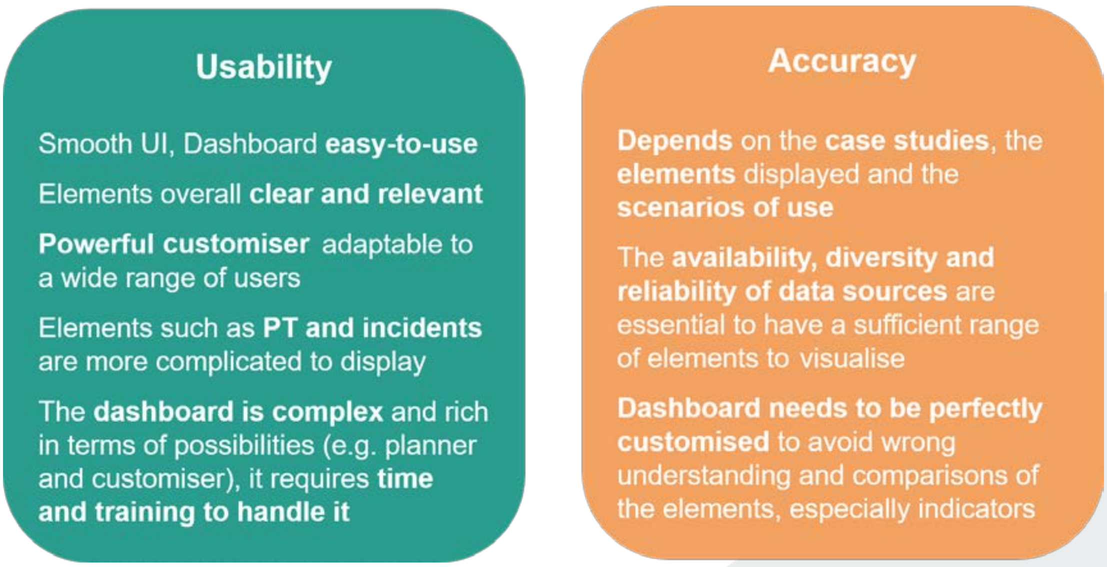


Figure 11: The results of the assessments of the dashboard by the four TANGENT demonstrations (Source: ID4Mobility)

Deep-dive into Transport for Greater Manchester's testing of the TANGENT services and feedback

Through the TANGENT project, TfGM, along with other case studies, established a **data catalogue** (produced by Cefriel) that facilitated their understanding of their data and how it can be used for the simulations, development of TANGENT tools and dashboard.

The **TANGENT dashboard** has been a useful tool within the Operational Control Centre environment, enabling monitoring of anomalies in traffic flow through the integration of a number of data sets including Waze, alerting control centre operators to take actions. This is particularly useful during planned and unplanned events. The dashboard provides a number of applications to aid traffic management, improves traffic flow, and provides decision support to the operational control centre team- which overall means response times to incidents and congestion are reduced, and information can be provided to customers on the best travel options.

The KPIs in the dashboard are customisable, allowing them to create bespoke indicators that are most important to the users. The indicators provide a summary of key network performance statistics such as traffic flow, speed, and delay, and were found particularly useful for senior leadership and for dissemination of information in quickly changing incident response scenarios.

Overall**,** the TANGENT tools have helped with TfGM's network management duty in a business-as-usual capacity. The project has helped frame our thinking on traffic management tools and how they are positioning themselves to develop a roadmap for the delivery of digital traffic management that ensures they are providing scalable, adaptable systems that will assist our readiness for future mobility.

6 Policy, Regulatory, and Planning Framework

TANGENT has shown that the successful implementation of Multimodal Traffic Management (MTM) solutions not only requires advanced tools and modelling capabilities, but also **a solid strategic and organisational foundation, through cooperative planning practices and a set of policies** to support MTM efforts.

Policies include those that could guide the development of clear protocols and requirements for data sharing or the exploitation of a common database, and a dashboard to encourage further data collection and integration. Beyond this, **investment in digital infrastructure** remains a key factor in enabling MTM solutions.

Moreover, TANGENT's experience has evidenced the importance of establishing **clear governance frameworks** that define roles and responsibilities among stakeholders, particularly during incidents. Cultural and operational differences among diverse stakeholder networks require harmonising protocols and a clear understanding of functions. This could involve developing policies that ensure all operators respond consistently and effectively to disruptions.

These requirements can be achieved with the **support of the Sustainable Urban Mobility Planning (SUMP) methodology**, which offers an effective framework for the implementation of innovative mobility solutions through integrated planning and can support local authorities in their efforts to improve the network traffic management solutions and encourage multi-actor cooperation.

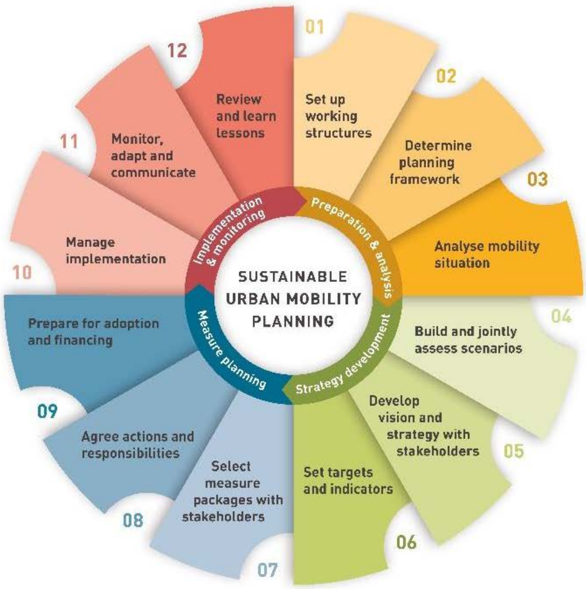


Figure 12: Sustainable Urban Mobility Planning Cycle. (Source: Rupprecht Consult)

SUMPs can facilitate the deployment of MTM and other C-ITS solutions in cities, allowing the development of all transport modes in an integrated manner using smart technologies and infrastructure to achieve cooperative management of the transport systems. Through its comprehensive approach to establishing collaboration structures among stakeholders, involving them throughout the planning process, and the definition of a common strategy, including agreed-upon objectives and policy priorities, the SUMP methodology can significantly contribute to the success of MTM solutions. Such a common strategic framework and policy goals are key elements in the definition of suitable criteria for the MTM solution's arbitration and optimisation models. They should also be guiding principles for the development of Response Plans (pre-established MTM measures for specific events or scenarios).

On the other hand, it is common for SUMPs to face serious challenges when it comes to the implementation phase and actively monitoring progress, maintaining stakeholder engagement, and commitment to the planned measures. The lack of up-to-date data or suitable channels for continuous communication can result in the cooperation structures weakening through time and, thus, jeopardise the implementation of the SUMP. A common dashboard with real-time data visualisation, established roles for cooperative traffic management, and a strategic baseline for the monitoring of results, based on indicators calculated through the MTM tool, are valuable instruments to encourage continuous engagement and cooperation among all involved actors throughout the SUMP's implementation phase. It facilitates the monitoring tasks and allows practitioners to flexibly test different scenarios (through the MTM tool simulation capabilities) and improvement strategies.

For more information see Deliverables: D1.7 Policy, regulatory and planning framework for MTM and D8.5 Policy Recommendations.

7 Key Takeaways from TANGENT

The TANGENT project concludes with the following overarching and high-level takeaways:

- Tools for facilitating the findability of heterogeneous data sources of transport and mobility are ready. Dynamic and real-time data is required to efficiently respond to events affecting the transport network and optimise the transport flows.
- Enhanced solutions combine data-driven and simulation-based approaches for proactive real-time traffic management under recurrent and non-recurrent situations.
- Collaboration and data sharing among different stakeholders will improve evidence-based decision-making processes for transport operators.
- New governance models for traffic management need to be set up for a coordinated management of transport operations, considering the needs and priorities of the different transport agents.
- New regulations will boost the implementation of novel traffic management systems for collaborative decision-making.

Figure 13: TANGENT Consortium and participants at the final event. (Source: Conference participant Codruta Bastucescu Codruta)

8 Conclusion

TANGENT contributed to developing **Next Generation Traffic Management Systems that do not focus on a single agency or mode**. Rather, TANGENT's dashboard focuses on intuitively bringing together traffic and transport managers across agencies, thus favouring multimodality, while integrating novel tools such as forecasting, simulation, and response plans. As the dashboard is easy to customise and improve over time, traffic managers will gradually take ownership of the services offered by the project.

The text within this deliverable represents the key processes and findings of the projects in a straight forward overview geared towards the general public, with details and links provided to further inform experts and local practitioners.

9 The TANGENT Library

Below are some of the key deliverables from the project. Once finalised, public deliverables can be found on the project website under the 'Resources' section: https://tangent-h2020.eu/deliverables/

Multi-actor co-creation strategies - led by Rupprecht Consult

- D1.1 Multi-actor co-creation strategies for each Case study.
- D1.2 NTM needs assessment and system requirements.
- D1.6 Multi-actor cooperation models for NTM. Second release
- D1.7 Policy, regulatory and planning framework for TNM. Second release

Data processing, harmonisation and governance - led by Cefriel

- D2.1 Data requirements and available data sources
- D2.2 Data-sharing governance model

Travel behaviour modelling - led by NTUA

- D3.1 Travel behaviour: state-of-the-art, current and future mobility patterns
- D3.2 Travel choice modelling (set of models, code). First release
- D3.3 In-depth analysis of travel behaviour
- D3.4 Travel choice modelling (set of models, code). Second release

Traffic predictions and modelling - led by IMEC and Aimsun

- D4.1 Report on the relevant state-of-the-art approaches for traffic predictions and simulations
- D4.4 Report on the detection and impact analysis of traffic events

Optimisation of transport network management - led by Deusto

- D5.1 Analysis of current approaches in optimization of transport network management

Tool integration and architecture - led by A-to-Be

- D6.3 Smart infrastructure index report. First release
- D6.6 Smart infrastructure index report. Second release

Demonstrations in Four Cities - led by ID4Mobility

- D7.3 Assessment of the testing results in the Case Study of Rennes
- D7.4 Assessment of the testing results in the Case Study of Lisbon
- D7.5 Assessment of the testing results in the Case Study of Greater Manchester
- D7.6 Assessment of the testing results in the Case Study of Athens
- D7.7 Impact assessment report.

Policy and Dissemination - led by POLIS and Rupprecht Consult

- D8.5 Policy recommendations
- The TANGENT Tool: an explainer video: https://www.youtube.com/watch?v=lrwu79lIx4k