TANGENT

ASSESSMENT OF THE TESTING RESULTS IN THE CASE STUDY OF RENNES

D7.3

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Authors	Lucie Tristant (ID4MOBILITY) Frédérique Baudouin (Rennes Métropole) Ana V. Silva (A-to-Be) Marco Grassi (CEFRIEL) Marco Comerio (CEFRIEL) Mario Scrocca (CEFRIEL) Athina Tympakianaki (Aimsun) Ynte Vanderhoydonc (imec) Mohammadmahdi Rahimiasl (imec) Arka Ghosh (Deusto) Antonio David Masegosa Arredondo (Deusto)
Internal reviewers	Charis Chalkiadakis (NTUA) Marios Giouroukelis (NTUA)
Document approval	Not applicable

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Executive summary

Rennes Métropole is a grouping of 43 municipalities, centred around the city of Rennes, the capital of the Brittany region. It was composed of 451,762 inhabitants in 2018 (of which 217,728 in Rennes proper) and is experiencing significant population growth, with a forecast of 100,000 inhabitants additional in 2040. The goal of Métropoles in France is to build a better metropolitan area around the biggest cities, notably by synchronising the transport system. Rennes Métropole, as the Public Transport Authority, defines the overall transport strategy in its territory through its Urban Transport Plan and consequently organises the public transport policy in its 43 municipalities. The main policy objective is to reduce by 10% the overall number of trips by private car (in Km) between 2010 and 2030. Actions include strengthening the use of car-sharing, cycling and public transport and better managing the use of private cars (speed limitation, mitigating air pollution, and transport network optimisation).

Rennes is one of the case studies of TANGENT to further experiment on multimodal traffic management, rethink their tools and policies on the field in the metropolis. The case study focused on one of the most congested areas of Rennes Métropole: the RN 24 (national road) and the Lorient road, which is an industrial and commercial area, with the Rennes Stadium, which connects the city centre to the ring road and the national road towards the Atlantic coast.

Rennes has assessed the tools and the development made during the TANGENT project, applying some proper methodologies: after a great collaboration with the technical partners to review the accuracy of the results of their subsystems, Rennes case study tested the overall tool and its services under a variety of scenarios, defined during the first part of TANGENT project. The services tested are the following: Service 1 “Enhanced information service for multimodal transport management”, Service 2 “Real-time Traffic Management Services”, and Service 3 “Transport network optimization for Transport Authorities”. The main lessons learned of TANGENT from Rennes case study are the involvement of the local stakeholders, the importance of the availability and the reliability of data sources, and, more generally, having a broader vision on the technical specifications and functionalities Rennes Métropole will require when they will consider changing or updating our system.

This deliverable presents the methodology and the results of these testing activities, the lessons learned for Rennes case study and their next steps after the end of the project.

Key words

Traffic Management, Public Transport, multimodality, dashboard, prediction, response plans, case study, Rennes

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List of abbreviations and acronyms

Acronym	Meaning
AMQP	Advanced Message Queuing Protocol
CIM	Cooperative Incident Management
CS	Case Study
CSV	Comma-Separated Values
DIRO	Direction Interdépartementale des Routes de l'Ouest
DRT	Demand Responsive Transport
DTA	Dynamic Traffic Assignment
EC	European Commission
GA	Grant Agreement
HTML	HyperText Markup Language
KCONG	Knowledge Catalog and Governance
KPI	Key Performance Indicator
LoS	Level of Service
NAP	National Access Point
OP	Other Partners

Acronym	Meaning
R&D	Research & Development
RDF	Resource Description Framework
RN	Route Nationale
SCS	Stakeholder Cooperation Survey
SNLB	Smart Network Load Balance
TBS	Travel Behaviour Survey
TC	Traffic Control
TMB	TANGENT Data Catalogue Management Board
TMS	Traffic Management System
WP	Work Package

1 Introduction

1.1 Attainment of the objectives and explanation of deviations

The main objective of this deliverable is to present the results of TANGENT for the case study of Rennes. In relation with WP7 “FUTURE TRANSPORT CASE STUDIES”, this deliverable mainly provides the outputs of T7.2 “Operation of the tests: testing of subsystems” and T7.3 “Upscaling and full operation: testing of the overall system”, compared to the initial expectations presented by the Rennes case study during T7.1 “Definition of Case Studies, stakeholders’ engagement and tests preparation”, in the deliverables D7.1 “Definition of the Case Studies, testing methodology and stakeholders' & users' engagement campaign” and D7.2 “System deployment and testing specifications”. In these documents were highlighted Rennes case study presentation and requirements, the testing environment and the scenarios under which the tests will be applied.

More specifically, the objective of this deliverable is to present the results of the tests performed with Rennes case study for the 3 services of TANGENT, assessed under the following scenarios: baseline, planned and unplanned events. As further explained in this deliverable, some tests are not concluded yet, due to a higher-than-expected technical complexity of one module. The testing activity will be carried out until the end of the project at the latest.

1.2 Intended audience

This deliverable is public. First, the document can be retained, reused and disseminated by Rennes Métropole, to exploit the results of TANGENT. Then, it can be consulted by the local stakeholders involved in the activities (workshops, demonstrations, tests) of the project who are not part of the consortium. More broadly, this deliverable can be consulted by any interested party: stakeholders involved in traffic and transport management, whether they are techno providers, other metropolises or transport operators, researchers, or other R&D projects.

1.3 Structure of the deliverable and links with other work packages/deliverables

This deliverable is structured with four major sections:

- The first one is a short presentation of the case study for the reader to understand the context of TANGENT and the tests applied to Rennes
- The second section, “Testing of the subsystems”, intends to present the results of the subsystems tests: before having a consolidated platform with all the functionalities, the technical partners have developed their subsystems. In order to assess the accuracy of their developments, they have conducted some tests with Rennes Métropole. This section presents the methodology and the results of each subsystem tested
- The third section, “Testing of the overall system”, presents the tests of the consolidated system, which integrates the previously developed subsystems as functionalities of the overall tool. The testing methodology is presented, as well as the tests results for Rennes, per functionality, under a variety of scenarios
- The fourth and last section presents the lessons learned of Rennes case study in the TANGENT project, more particularly after the testing activities of the subsystems and tools, and the next steps for the partner after the end of the project

The deliverable D7.3 is closely linked to other work packages and deliverables:

- In WP7, this document is linked to D7.1 “Definition of the Case Studies, testing methodology and stakeholders' & users' engagement campaign” and D7.2 “System deployment and testing specifications”, where Rennes case study description and requirements have been described during the first part of the project. It is also linked to the other case studies deliverables D7.4, D7.5, D7.6, as some of the methodologies and testing activities implemented are common to the case studies. D7.7, which presents the impact assessment, is a complementary document in which the Rennes KPIs of the project are being presented and analysed
- This document is also linked with the WP1 workshops, notably the Stage 3 stakeholders' workshop in Rennes, during which a demonstration of the tool has been made, and feedback from the local stakeholders have been given
- D7.3 is extremely linked with WP6, and more specifically to the document D6.5 “TANGENT tool development and integration. Second release”, in which a description of the overall tool, the dashboard, the functionalities, the technical testing can be found. This document is referred to in several sections in D7.3

2 Presentation of Rennes case study

Rennes Métropole is a grouping of 43 municipalities, centred around the city of Rennes, the capital of the Brittany region. It was composed of 451,762 inhabitants in 2018 (of which 217,728 in Rennes proper) and is experiencing significant population growth, with a forecast of additional 100,000 inhabitants in 2040. The goal of Métropoles in France is to build a better metropolitan area around the biggest cities, notably by synchronising the transport system.

Rennes Métropole, as the Public Transport Authority, defines the overall transport strategy in its territory through its Urban Transport Plan and consequently organises the public transport policy in its 43 municipalities. The main policy objective is to reduce by 10% the overall number of trips by private car (in kilometers) between 2010 and 2030. Actions include strengthening the use of car-sharing, cycling and public transport and better managing the use of private cars (speed limitation, mitigating air pollution, and transport network optimisation).

The case study in Rennes focused on a specific area which is particularly congested: the “Route de Lorient” or RN 24 (National Road 24). It is a penetrating road towards an industrial area but also the way to access (from the West) the football stadium, the Hospital, the city centre, and it is located near the exhibition centre and the airport. It is also a transit area for travellers and freight as a gate between Brittany and the rest of France.

The main challenge of the route de Lorient area is that traffic is heterogeneous as it connects national roads to the ring roads and highways, resulting in congestion on certain days and hours (in particular Fridays afternoon and specifically in summer with a lot of tourists). Leisure traffic, business traffic and freight transport are mixed.

Figure 1: Test area of Rennes case study and zones of interest

The following scenarios were selected for testing the TANGENT tools:

- The **baseline scenario** of this case study is located in the Route de Lorient RN 24 area, including some facilities such as the stadium “Roazhon Park”, during typical working days, especially during peak hours in the morning (7:00 - 9:00) and the afternoon (17:00 - 19:00). It concerns the traffic and all the public transport services located in the area selected.
- The **planned events** defined are the following:
    - **Football matches** at the Roazhon Park, the Rennes football stadium, which is located in the area selected. When a football match is held, the stadium can host up to 25,000 people. Even if some of the viewers use the public transports to come to the event, a majority of the spectators participate in the congestion of the roads around the stadium, and consequently of the RN 24 too. Two categories of end users are affected: people attending the matches and regular users suffering from congestion during their daily activities.
    - **Friday afternoons/evenings before holidays or long weekends**: The Route de Lorient is the main road that leads to the nearest ocean (coast of Morbihan, Brittany), very popular with the inhabitants of Rennes Metropolis. Friday evenings before holidays, especially Easter Holiday, and before long week-ends, such as Ascension Day or Pentecost, are the moments when the RN 24 is fully congested, even without road disruptions, such as accidents or road works.
- The **unplanned events** identified for testing are unplanned **road works**, **accidents**, **incidents**, that could cause delay, lane closure and/or traffic diversion.

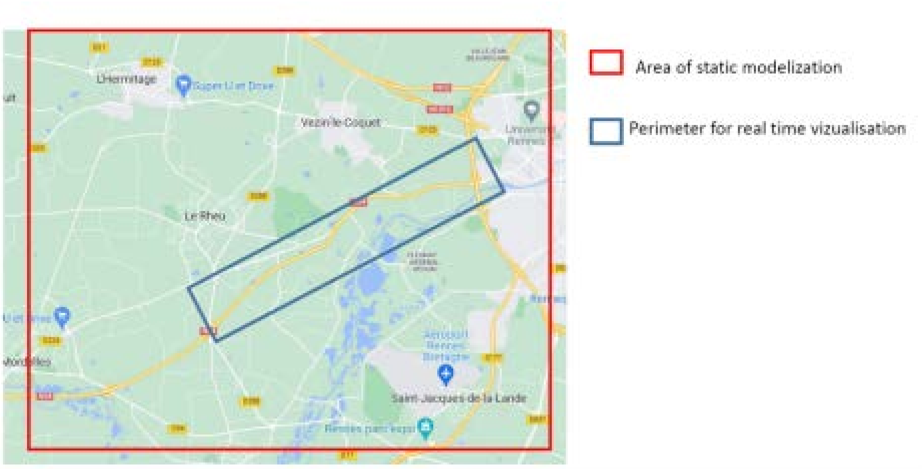


Figure 2: Visualisation and modelisation zone of Rennes case study

The main transport and traffic stakeholders of this area are the following actors:

- Rennes Métropole: Mobility department and Traffic control department
- KEOLIS Rennes: Rennes Métropole bus operator
- Brittany Region: transport managers of the regional coaches of the BreizhGo network
- KEOLIS Armor: transport operators of the BreizhGo coaches
- DIR Ouest (Direction Interdépartementale des Routes de l’Ouest): managers of the national road network in Brittany and Pays-de-la-Loire

3 Testing of the subsystems

This section describes the testing activities carried out during T7.2 "Operation of the tests: testing of subsystems", in relation with the technical partners and the first release of their subsystems. The methodology used is based on the "Applied Learning Cycle": once the technical partners produced the first release of their subsystems, they have organised tests with the case studies to assess the accuracy of their results. The results of these testing activities and the feedback from the case studies were used to improve the second release of their subsystems. Each technical partner produces a different type of subsystem; consequently, they have provided a testing methodology adapted to the elements to assess.

Each following subsection presents the subsystem to be tested, the methodology of the test and the results of the testing activity. A great amount of the following elements is common to the deliverables of the other case studies, mainly the non-virtual ones (D7.4 for Lisbon, D7.5 for Greater Manchester). The decision was made to keep and duplicate these sections in all the mentioned deliverables rather than referring to other documents. This way, it maintains consistency in each document, and ensures a complete deliverable for each city, which, after the end of the project, they can use and disseminate as a whole in their local ecosystem.

1.4 Data Catalogue (WP2)

The TANGENT Solution for Data Harmonisation and Fusion represents the subsystem developed within WP2 and integrated into the overall TANGENT solution. The first release of the solution is described in D2.3, and the final one, incorporating the feedback received during its testing, is in D2.4. The main components of the TANGENT Solution for Data Harmonisation and Fusion are:

- the *TANGENT Data Catalogue*: a digital platform enabling data-sharing among different stakeholders;
- the *TANGENT Reference Conceptual Model*: defining a reference ontology for the transportation-related data handled within TANGENT;
- the *Semantic Harmonisation and Fusion Pipelines* to fulfil the integration requirements associated with TANGENT data sources;
- the *TANGENT Data API*: a uniform mechanism to access data sources collected and harmonised by WP2.

The testing of the WP2 subsystem mainly focused on the TANGENT Data Catalogue, which provides a user interface designed to be directly accessible by relevant stakeholders. The testing of the other components has been performed (i) with TANGENT partners from a technical perspective to enable the integration of the different subsystems and (ii) indirectly by stakeholders involved in the testing of other subsystems integrated with the WP2 solution.

The TANGENT Data Catalogue is developed using the Knowledge Catalog and Governance (KCONG) framework by CEFRIEL. KCONG provides a customizable platform for defining and managing digital asset catalogues, accessible online via a web browser. It supports various digital asset types, each characterized by specific metadata descriptors for user interaction. KCONG allows programmatic access to the list of assets and their metadata, which can be serialized in RDF for advanced querying and automated processing. It also enables the configuration of governance processes for digital assets using the BPMN formalism.

For the TANGENT Data Catalogue, a customized KCONG instance includes:

- organization of digital assets based on TANGENT case studies;
- a Data Source asset type to describe datasets and data services, adhering to the TangentDCAT-AP metadata specification (see D2.2);
- integration of BPMN processes to support TANGENT Data-Sharing Governance rules (see D2.2).

3.1.1 Methodology

The methodology for the TANGENT Data Catalogue considered two distinct types of testing.

The first type involves gathering feedback on the initial version of the TANGENT Data Catalogue. This feedback-driven testing aims to identify areas for improvement to ensure the second and final release of the TANGENT Data Catalogue meets users' requirements. Given that the TANGENT Data Catalogue is a software artefact used uniformly by project partners, the feedback gathered through its testing methodology is not specific to any single use case. Instead, we collected and analysed anonymous data from all participating partners across use cases to obtain a comprehensive assessment of the catalogue's usability and functionality. By analysing this feedback, we identified common issues and areas for improvement that were used to enhance the overall user experience in the final release of the WP2 solution described in D2.4.

The second type of testing focuses on the catalogue's practical usage within the project. This in-project testing evaluates how effectively the TANGENT Data Catalogue serves its intended purpose in real-world scenarios, ensuring its functionality aligns with the users' needs and expectations.

3.1.1.1 User testing of the TANGENT Data Catalogue

The first version of the TANGENT Data Catalogue, documented in D2.3, was released to partners at M20. To gather opinions and feedback from real users of the catalogue, we designed a set of practical hands-on tasks to be performed by partners on the first version of the Data Catalogue as testing activities within WP7. This testing activity took place from 24th July to 6th September 2023. For the Rennes case study, partners from Rennes were involved.

Users were introduced to the platform by a short video tutorial explaining the basics of the TANGENT Data Catalogue. Then the users were asked to perform a set of tasks to test the catalogue's intended usage and functionalities. As an immediate follow-up to these tasks, users were asked to respond to a survey to collect explicit and implicit feedback. To improve the quality of the feedback received the survey was made anonymous. Explicit feedback was provided by users in the form of a free text response to an open-ended question. Implicit feedback was collected by asking closed questions related to one of the steps required to complete a task. For instance, if a user provides an incorrect answer to a closed question, it could suggest that the user finds the catalogue’s usage unclear, serving as implicit feedback.

A slightly different set of tasks and accompanying surveys was prepared for case study leaders and other partners considering their expected usage of the catalogue. Indeed, case study leaders are expected to use the catalogue to add, edit and browse data sources, while the other users mainly browse available data sources. As such, the tasks and questionnaire were designed to reflect this difference.

As an example, here we discuss a task and the set of associated questions. This task was posed to both case study leaders and technical partners.

Task 1 - Search and analysis of a specific data source

Scenario:

Imagine you need to determine if there was a roadblock in a specific street in Rennes ten days ago. You are invited to check if the "REN_TRAF_11" data source satisfies your needs.

Your assignment is:

Please search the "REN_TRAF_11" data source in the data catalogue and read its metadata description to assess its relevance for addressing the need described in the above scenario.

Answers and follow-up questions:

Did you succeed in finding the REN_TRAF_11 data source?

- *Yes*
    - *Please, describe the steps you did to find the REN_TRAF_11 data source.*
    - *Based on the metadata description, do you think that REN_TRAF_11 data source can be used for addressing the need described in the above scenario? Please, justify your answer.*
- *No*
    - *Please describe any problems you encountered while searching for the data source.*

Through this question, several pieces of information can be gathered. By responding "Yes", we first establish that the user was able to perform the task correctly. The follow-up question then gathers details on how the user performed the task, specifically through which series of steps. This answer is crucial as it reveals whether the user was correctly guided through the intended user experience via the catalogue's user interface. If the user followed an unintended path to complete the task, we can use this information to redesign and improve the user experience. The next follow-up question aims to determine if the adopted metadata profile is clear to the user and if it can be used to solve a task that mirrors a potential real-world use case. The most important information is the one gathered when the user is not able to perform the task. This is crucial, as this information is the main driver for significant changes in the catalogue.

Case study (CS) users and other partners (OP) were assigned various tasks. CS users were given more tasks compared to OP users because they have a more active role in utilizing the catalogue, including adding and editing data sources. In contrast, OP users primarily engage in searching and browsing the catalogue. Feedback from both user groups was collected on the following tasks:

- Searching for a specific data source and analyse its metadata description (CS, OP)
- Searching for a data source that satisfies a specific data requirement (CS, OP)
- Free exploration of the data catalogue and usage of its functionalities (CS)
- Adding and publishing a new data source into the data catalogue (CS)
- Usage of the dashboard functionality to check the status of data sources (CS, OP)

The questions asked to users after these tasks were designed in the same spirit as the previously described task. Similarly, the answers to these questions were used in a similar vein to drive improvements to the catalogue.

3.1.1.2 In-project testing of the TANGENT Data Catalogue

The TANGENT Data Catalogue is designed to manage the diverse data sources collected from the project's four case studies. This catalogue is not merely a static repository of data and metadata, it is intended to serve as a dynamic, evolving archive that adapts to the project's needs. To facilitate this adaptability and support the project's potential developments, a life cycle has been established for the data sources. Each data source can exist in one of several states, transitioning between them based on specific user actions and conditions set by the TANGENT Data Catalogue Management Board (TMB). The TMB oversees the data quality and governance, ensuring the catalogue remains a robust and responsive tool throughout the project's duration. The list of admissible statuses is the following:

- *Submitted*: When a data source is inserted by a user into the catalogue.
- *Published*: When a data source is reviewed by the TMB and approved for publication.
- *Rejected*: When a data source is rejected after a review by the TMB because it is found to not be useful or applicable to the project.
- *Incomplete*: When a data source lacks certain required metadata fields that have not been filled out by the user. The data source is sent back to the user with a request for further information.
- *Not accessible*: A specific case of incomplete metadata where the data source description lacks the access URL to the actual data it describes.

Regarding the in-project testing activity, we report on the number of data sources collected through the TANGENT Data Catalogue and approved for usage within the TANGENT project for the Rennes Case Study.

3.1.2 Actions achieved and results

In the following, we report the aggregated results obtained for the user testing of the TANGENT Data Catalogue and the results of the in-project testing for the Rennes case study.

3.1.2.1 User testing of the TANGENT Data Catalogue

The user testing activity involved 14 partners acting as case study leaders and 9 other partners. From these groups, the survey aimed at gathering constructive feedback for the TANGENT Data Catalogue received responses from 9 out of 14 demo leaders and 3 out of 9 other partners. The testing activity was conducted using the first version of the TANGENT Data Catalogue, described in detail in D2.3 and shown in Figure 3 below.

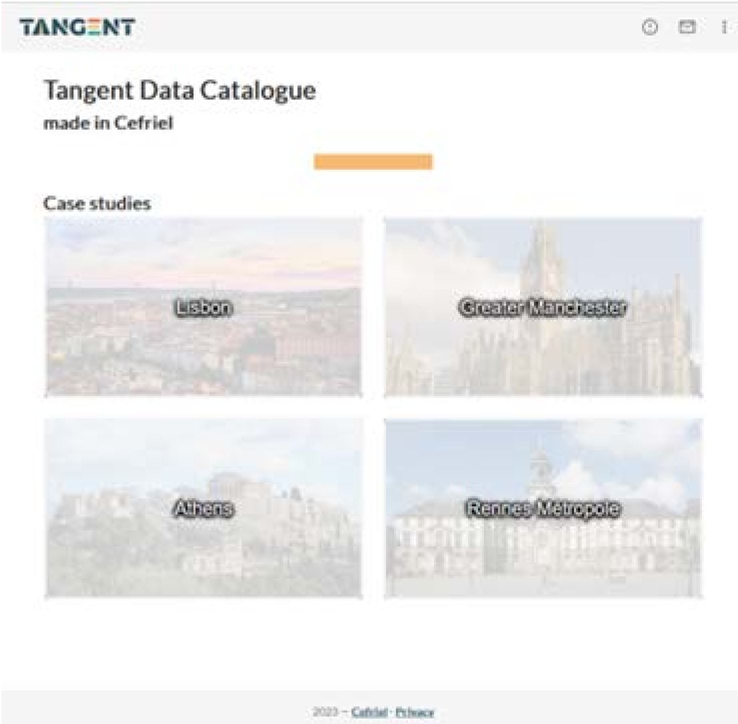


Figure 3: Homepage of the first version of the TANGENT Data Catalogue

After analysing the current survey responses on the testing of the TANGENT data catalogue, the main areas for improvement have been identified as follows:

- **Search Capabilities and Interface**: Numerous feedbacks indicated the need for enhanced search functionality, specifically the ability to search by metadata attributes that are not currently available as filter options. Additionally, the filtering capabilities offered through the user interface could be made less confusing and more user-friendly.
- **Dashboard Information and Interactivity**: The information displayed on the dashboard needs to be expanded and made more interactive. Users have expressed a desire for a more detailed and engaging dashboard experience.
- **Action Feedback**: Certain actions, such as submitting a data source for publication, currently lack feedback mechanisms that inform the user of the action's result. Providing clear and immediate feedback for these actions would improve the overall user experience.

Based on the feedback we gathered, it became evident that a small but notable portion of users experienced difficulty in successfully completing one of the tasks associated with locating a specific data source. This feedback was collected through both quantitative and qualitative methods. Quantitatively, we measured how many users were able to find the data source. Qualitatively, we invited users to provide open-ended feedback detailing the challenges they faced during this task. This dual approach allowed us to capture not only the extent of the issue but also the specific problems encountered, offering a comprehensive understanding of the user experience and the obstacles they encountered. The answers received for task 2 serve as an excellent example of this quantitative aspect, as is shown in Figure 4.

Scenario: A project partner tells you that a data source satisfies the "WEATHER_DATA" data requirement for your case study.

Your assignment is: Try to find the data source in the data catalogue. Read its metadata description carefully.

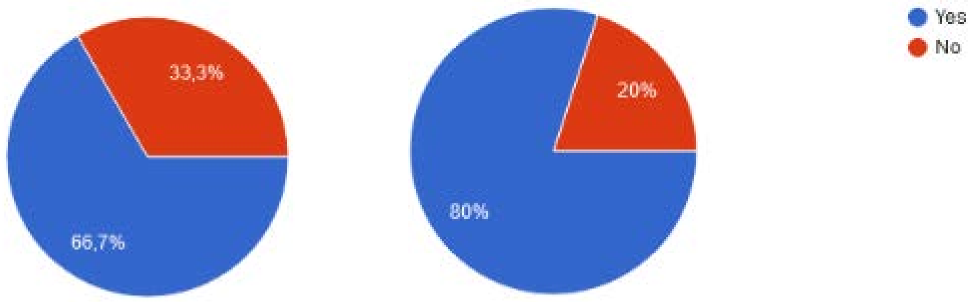


Figure 4: Left: the percentage of case study leaders who completed task 2; Right: the percentage for other partners

By addressing these issues, the final version of the TANGENT Data Catalogue improves upon the first release by introducing new functionalities and improving the user experience. For example, the homepage has been changed to show the latest uploaded data sources, which helps users know the latest changes in the catalogue. Additionally, because users often access the catalogue to search for a specific asset, a search box and corresponding search functionality have been added to the homepage.

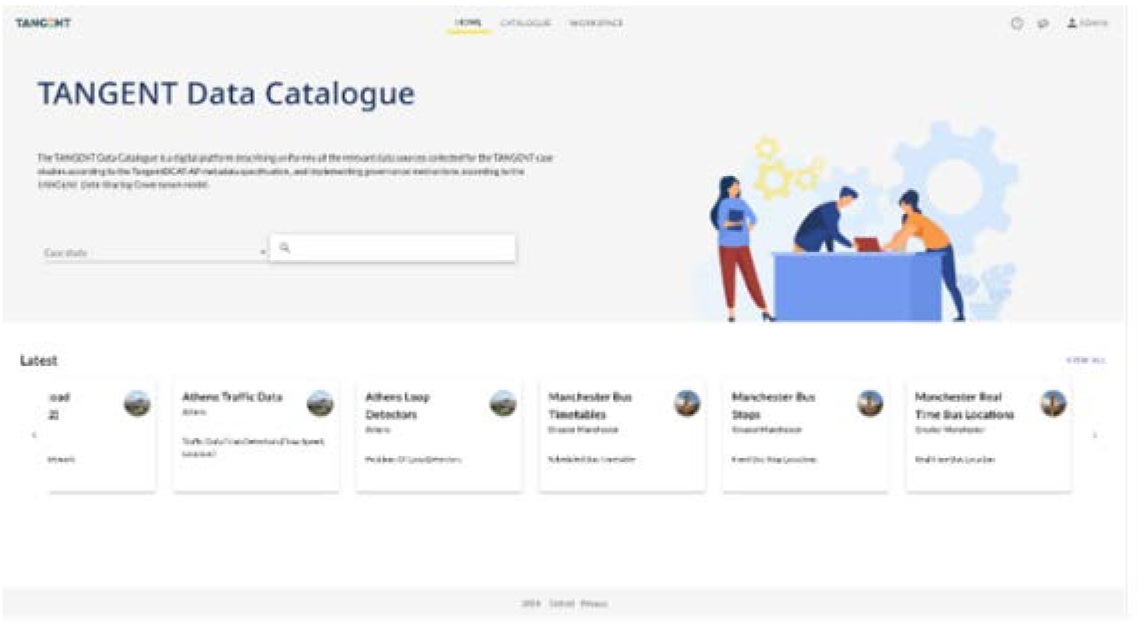


Figure 5: Homepage of the final version of the TANGENT Data Catalogue

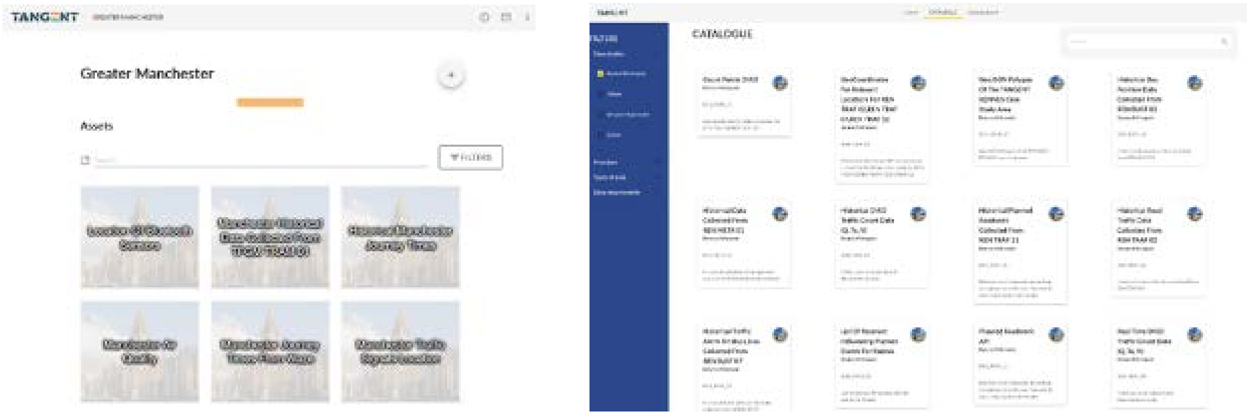


Figure 6: Search functionalities in the different versions of the Tangent Data Catalogue

A site-wide change has been made to separate different functionalities offered by the TANGENT Data Catalogue. As can be seen in the top part of Figure 5, the final release of the catalogue is divided into three main areas: the home, the catalogue and the workspace. As previously described, the homepage is designed to bring the user up to date with the latest changes and offer the shortest possible path to one of the most common interactions with the catalogue, i.e., searching. The catalogue area, shown in Figure 6, allows the user to browse all the data sources available in the catalogue and perform more fine-grained searches. Indeed, as searching and filtering were identified as the main areas of interest during the testing of the first release of the data catalogue, the UI and UX for this functionality were particular points of focus. While the previous version of this page was found to be confusing to users, especially because it was not readily apparent what filters were currently active, the new and improved version clearly shows the active filters on the left side of the page and the used keyword in the search box. Additionally, with this layout, more results can be displayed, making it easier for users to manage searches that retrieve an extensive set of results. Lastly, the workspace area is entered when acting on a single data source or to access an overview of the state of the whole catalogue or the state of the data sources owned by the current user.

3.1.2.2 In-project testing of the TANGENT Data Catalogue

For the Rennes case study, a total of 51 data sources were collected and submitted through the TANGENT Data Catalogue. After careful review and discussion with relevant project partners, the TANGENT Data Catalogue Management Board (TMB) determined that 19 of these data sources were not relevant and subsequently rejected them. Of the remaining data sources, 27 met the project's data quality requirements and were approved for use. Two data sources remained inaccessible and were not utilised by any partners, while three others were submitted with incomplete metadata.

3.2 Choice model for Synchronisation of Public transport and traffic control (WP3)

The principal output of WP3 is the travel choice module, an analytical tool for modelling travel decision-making under various mobility scenarios. The module, the development of which is thoroughly described in D3.2 and schematically described in Figure 7, builds upon input data elicited using the Travel Behavior Survey (TBS), a structured stated-preferences questionnaire that captures commuters' sociodemographic traits, travel patterns, perceptions of system-level attributes, and preferences for different travel options. At its output, the machine learning and econometric models at its core predict mode choice decisions and identify significant factors influencing commuter decisions.

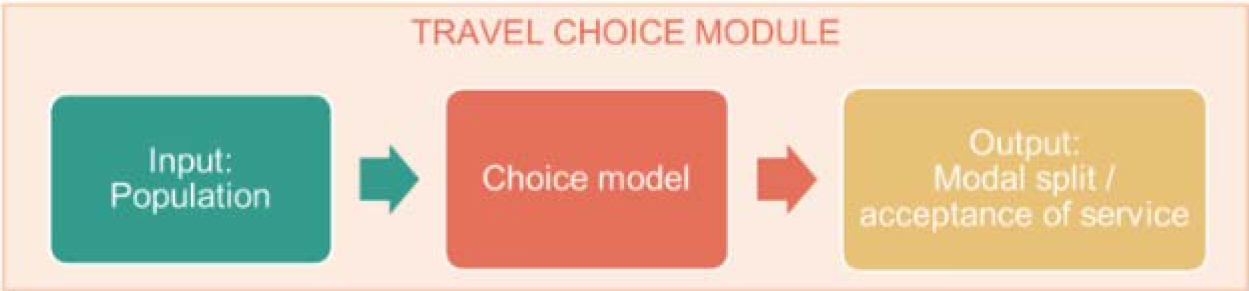


Figure 7: Travel Choice Module inputs & outputs

Given the design of the modelling framework, the testing of the module aims to ensure that all interface points between the module and the population whose behaviour is modelled fulfil expectations.

- Upstream, the survey's ability to effectively capture commuter behaviours must be assessed, best achieved through recipient feedback on its clarity, relevance, and effort needed.
- Downstream, it is necessary to evaluate whether the model's predictions align with common intuitions about travel behaviour in specific cities, with local commuters being again the most qualified evaluators.

As a result, a four-step testing methodology for the WP3 travel behaviour module is developed based on commuter feedback and presented in the sections that follow.

The collected user feedback is critically analysed, offering valuable insights for the development of similar mode choice modules. This methodology is further discussed in the section that follows. Given that the consolidated testing process for all case studies, the sections that follow are virtually identical for D7.3/4/5/6.

3.2.1 Methodology

3.2.1.1 Step A: Testing sample collection

During the initial phase of testing, the Travel Behavior Survey (TBS) was distributed to commuters from each case study city, including Rennes. The objectives of this phase are to:

- Familiarise testers with the questionnaire's content and design by having them take the survey themselves.
- Provide the necessary data for executing the travel behaviour module (Step B).
- Obtain the contact points of testers (email addresses) for the distribution of the feedback survey of Step C.

The TBS questionnaire is included in the Annex of D3.2.

To collect the necessary sample, each case study was asked to identify 10 commuters from various age, gender, profession, and usual transport mode groups who had not taken the survey before. With their contact details, the testers were contacted by NTUA with instructions on how to complete the TBS.

3.2.1.2 Step B: Execution of the travel behaviour module

Following the collection of testers' responses, the mode choice models in the travel behaviour module were launched, and their predictions about the factors affecting mode choices were converted into simple, non-technical language. The text communicated to the testers is provided below.

One of the key advantages of the models that we have created is that they are able to reveal the factors that affect commuter’s travel choices. Specifically, we have found that:

- The probability to use a private car over public transport is higher among younger commuters and among commuters with higher incomes.
- Increased satisfaction with the public transit system correlates with a higher likelihood of choosing public transportation over a private car.
- Rising costs and extended travel times, whether for cars or public transport, diminish the appeal of these modes, leading to a shift towards alternative travel options.

3.2.1.3 Step C: Feedback Survey

As an immediate follow-up to these tasks, users were asked to complete a second feedback survey to assess the clarity, interpretability, and intuitiveness of the questions, the time and effort necessary to complete the TBS, and opinions on whether the modelling insights are deemed logical and in line with the testers' expectations.

The survey contained 10 questions, with an estimated completion time of 5 minutes. To ensure honesty in the responses, the survey was anonymous. With the contact details from Phase A, NTUA directly disseminated the feedback survey from 14/02/2024 to 19/02/2024.

Tester feedback was collected using closed questions with predetermined, multiple-choice or scale-based answers. The first question of the questionnaire is provided as an example below.

On a scale of 1 to 5, how easy was it to understand the purpose of the questionnaire?

Figure 8: Example of a question from the TBS

For specific questions requiring in-depth, qualitative insights that closed-ended questions could not capture, respondents were requested to provide their answers in a free text format to an open-ended question, as illustrated below.

Can you point out some of the questions that you found confusing or ambiguous?

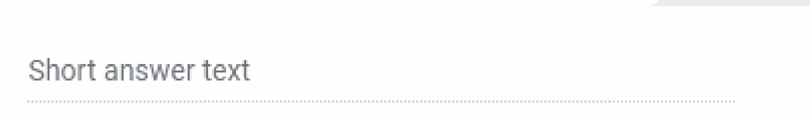


Figure 9: Free text format for open-ended questions

3.2.1.4 Step D: Reporting on the results

The feedback collected during the testing is presented in the "Results" section that follows. Some results have already been presented internally to the consortium during the WP7 bi-weekly meetings dedicated to subsystem testing and the consortium's monthly audio meetings.

3.2.2 Actions achieved and results

A total of 42 commuters from all case studies have been contacted by case study leaders and NTUA, out of which 11 have responded to the feedback survey.

Their responses are pooled together, translated into English and analysed below on a question-by-question basis.

Initially, respondents were asked to evaluate how easy it was to understand the purpose of the questionnaire (Figure 10), rating their experience on a scale from 1 (not clear at all) to 5 (very clear). The majority (81.9%) evaluated their understanding as either 4 or 5, suggesting the effectiveness of the introductory materials and instructions provided with the questionnaire.

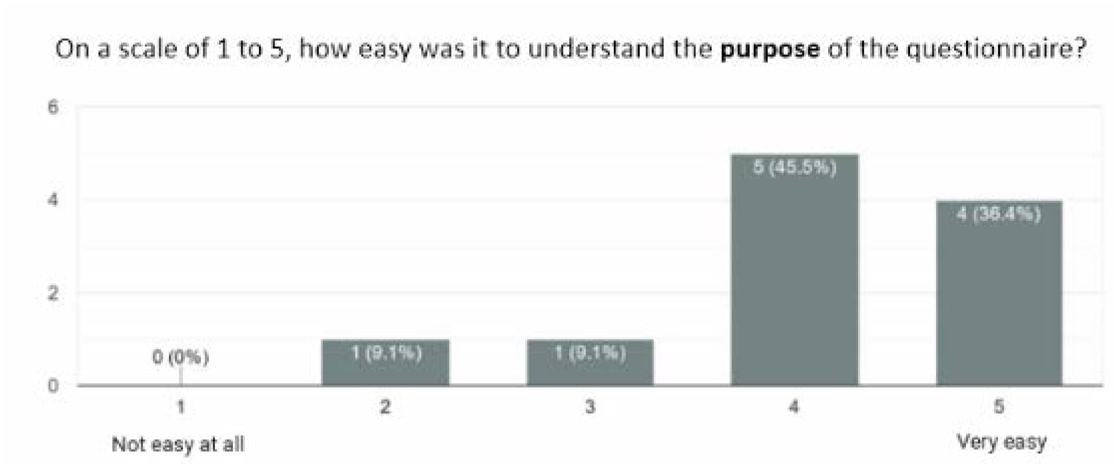


Figure 10: On a scale of 1 to 5, how easy was it to understand the purpose of the questionnaire?

This good understanding of the overall questionnaire can also be attributed to its questions being clear and intuitive. In the relevant question (Figure 11), where an evaluation of 1 suggests that questions were not clear at all and an evaluation of 5 suggests that questions were very clear, the majority of respondents (63.7%) responded with 4 or 5, while respondents (27.3%) found the questions to be moderately clear by selecting "3".

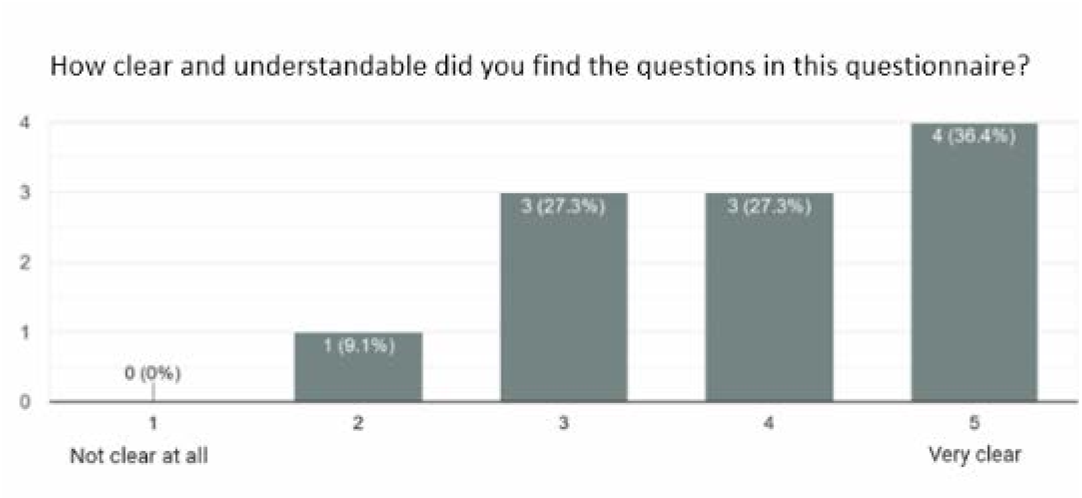


Figure 11: How clear and understandable did you find the questions in this questionnaire?

Two comments were also received in response to the open-ended question on how the overall clarity of the questionnaire can be improved. One respondent suggested the inclusion of a working-from-home option, and a second one suggested that the scale of some questions was somewhat unclear. This feedback can be attributed to Google Forms' practice of providing linguistic interpretations only for the extreme values (1 and 5), leaving the middle scale values as numbers, which can result in some ambiguity.

On a follow-up question of whether the TBS questions were in-context, the vast majority of respondents (81.8%) found all the questions to be relevant, suggesting that the survey was contextually appropriate.

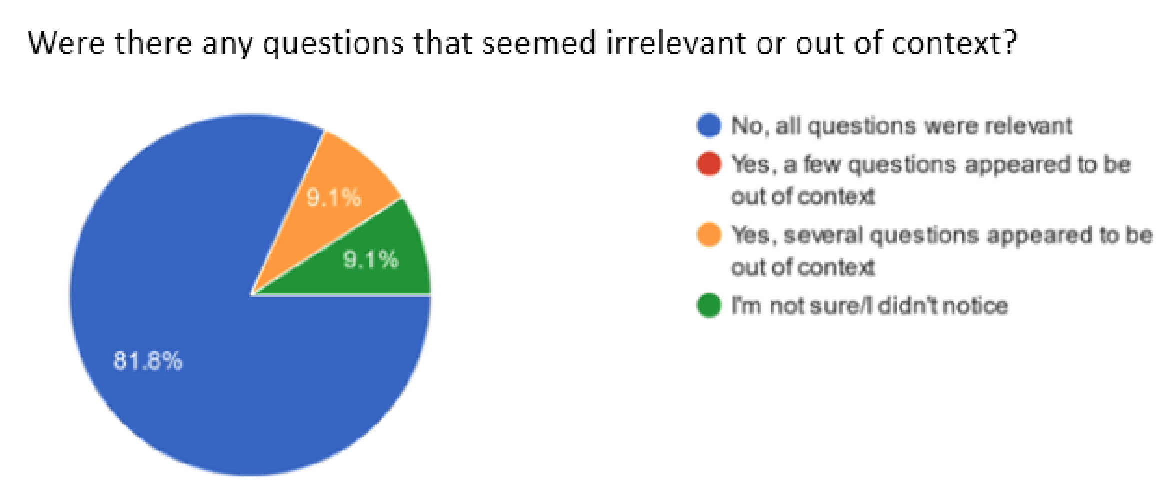


Figure 12: Question: Were there any questions that seemed irrelevant or out of context?

On the overall layout and formatting of the questionnaire (Figure 13), the majority of respondents (54.6%) rated it as either 4 or 5 (good or excellent). Another 36.4% rated it as satisfactory.

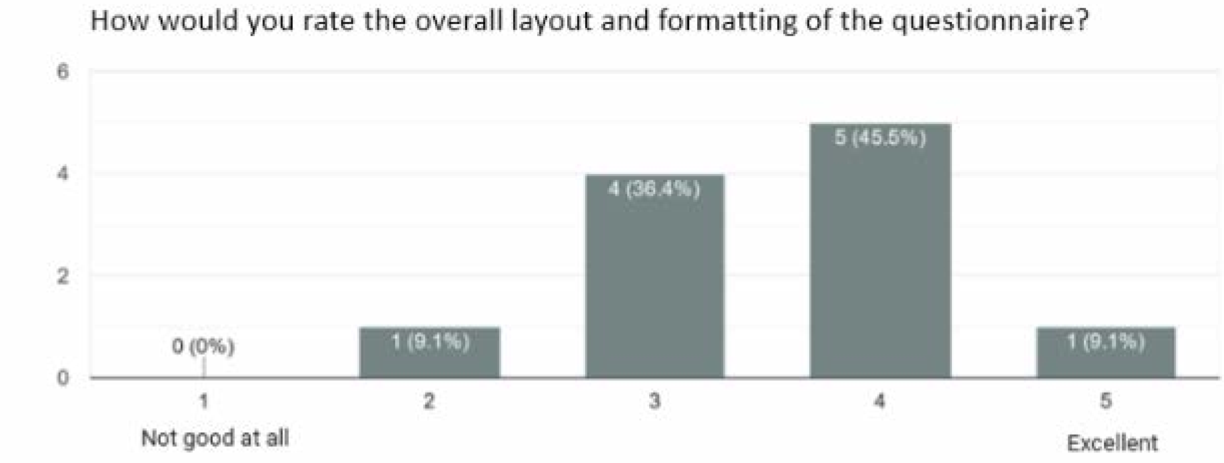


Figure 13: How would you rate the overall layout and formatting of the questionnaire?

Regarding the length and completion time of the questionnaire (Figure 14), most respondents perceived the survey as either appropriate or somewhat lengthy (chart on the left). While this feedback indicates a potential need to shorten the survey to enhance participant satisfaction, the suggestion must be weighed against the benefit that a longer questionnaire allows for the elicitation of more detailed information concerning commuters' mode choice decisions. Considering that 91% of respondents completed the survey within the estimated 15-minute timeframe deemed necessary by the study team (chart on the right), it can be concluded that the completion time was appropriate for the questionnaire's length.

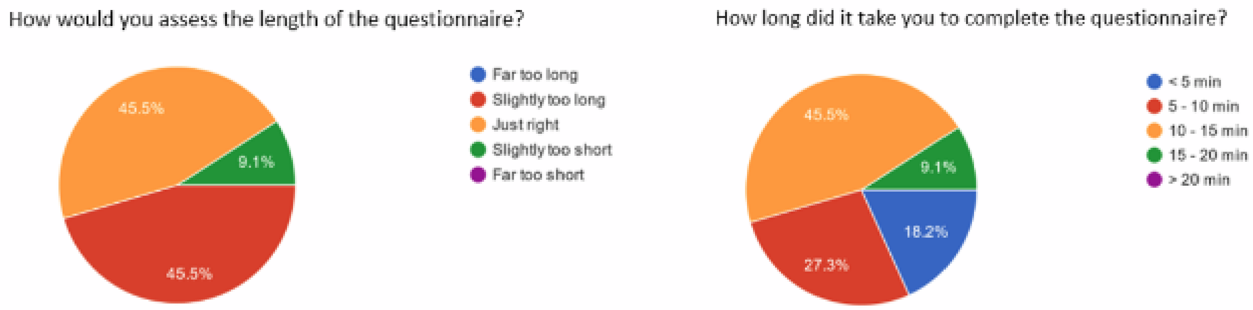


Figure 14: How would you rate the length and completion time of the questionnaire?

Finally, two respondents emphasised the need to revisit and edit previous answers in future questionnaires response to a general open-ended question that elicits overall comments or suggestions on the content and format of the questionnaire. They highlighted that once a page of responses was submitted, it was not possible to return and make corrections.

Modelling insights

In the concluding section of the questionnaire, participants assessed the factors influencing travel choice decisions, as presented in Section B. The overall feedback (Figure 15) indicates that most respondents found the results logical and consistent with their expectations regarding transportation choices, with 63.7% rating their agreement as 4 or 5 (indicating complete agreement with the analysis). Three respondents (27.3%) rated their agreement as 3, suggesting neutrality while one respondent expressed total disagreement but did not provide an explanation in the follow-up question.

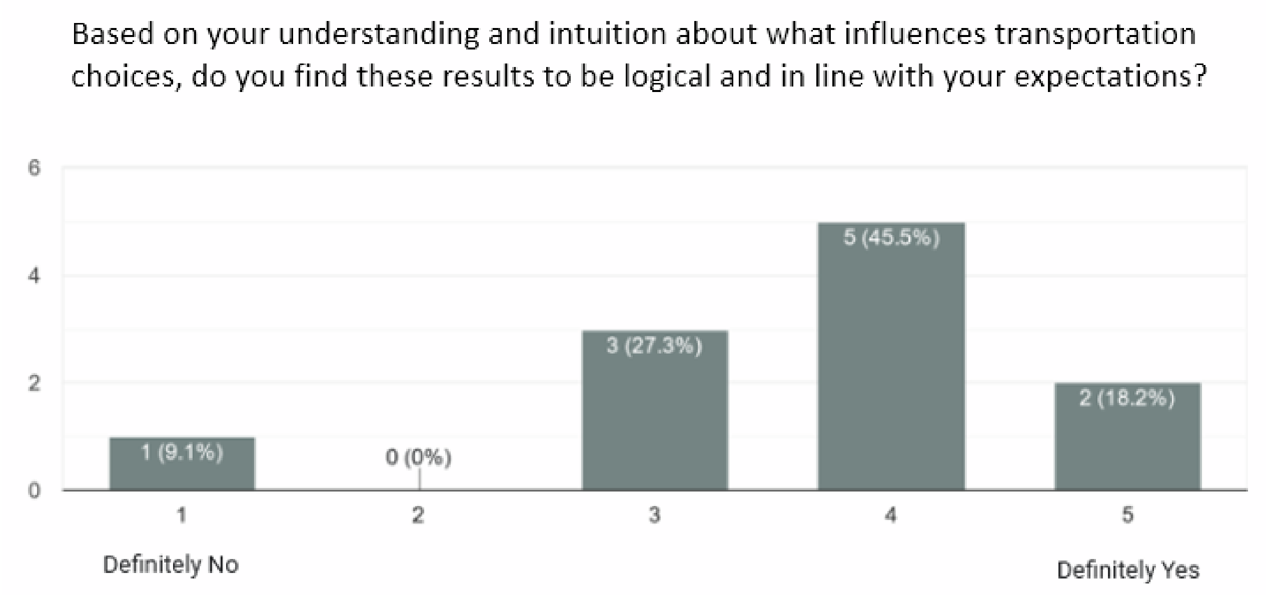


Figure 15: Based on your understanding and intuition about what influences transportation choices, do you find these results to be logical and in line with your expectations?

Concluding, the open-ended question on whether there are additional factors that significantly influence travel choice decisions and could be examined in future models received 5 comments. These comments mentioned the frequency, adherence, reliability, accessibility, and comfort of public transport, as well as the ability to work from home.

3.3 Supply Forecasting & Critical conditions (WP4)

In WP4, deep learning methods were developed to forecast traffic supply. The forecasting methods are applied to the four case studies of the TANGENT project. Results are considered per case study, and are described via different steps, including data preprocessing, training the models, determining forecasting accuracy, etc. in Deliverable 4.2 "Overview of the developed traffic supply forecasting approaches with benchmarks". The developed anomaly detection algorithm is included in Deliverable 4.4 "Report on the detection and impact analysis of traffic events", where the results were shown for the case studies of Greater Manchester and Athens. The applied algorithm is similar for Rennes.

For the case study of Rennes, results from 2 datasets were included in D4.2, namely travel times and speeds from floating car data and a dataset for public transport. The floating car dataset spans from April until September 2023, while the dataset for public transport consists of 2,409,223 bus trajectories that span from 2023-06-08 05:26:00 to 2023-11-05 21:59:00, representing 12 routes.

3.3.1 Methodology

Both supply forecasting and anomaly detection were tested by the case study leaders. The testing methodology is described in this section.

Predictive model building:

- Build models for the different datasets of Rennes for supply forecasting and anomaly detection, as described in D4.2 and D4.4
- Collection and analysis of the results in interactive maps
- Share results and main conclusions with case study leaders

Feedback:

- The case study leaders provide feedback based on the maps
- In the second stage this feedback is based on the live dashboard
- Meeting with case study leaders to discuss the feedback

Details regarding the steps above are included below:

Before the supply forecasting and anomaly detection results were added to the live dashboard, the results were shared for testing purposes with the case study leaders. Folders with maps were shared, together with guidelines on how to provide feedback related to the testing.

Supply forecasting: access to results
The testing folder contains two Excel files through which you can provide feedback. The folders and documents with results are: ● REN_TRAF_12_Travel_Time ● REN_TRAF_12_SPEED ● REN_BUST_10_Testing In the two first folders you'll find an HTML file alongside a "timeseries" folder. The HTML file serves as a map, pinpointing the sensors used in the dataset. Clicking on the blue markers will display the sensor's name and prediction error for various horizons. Each prediction horizon represents a 3-minute interval. For instance, horizon 1 corresponds to a 3-minute prediction, while horizon 12 equates to a 36-minute prediction. The error is represented as MAE. This is a mean absolute error. It gives a straightforward estimate of the accuracy of the model, as it has the same units of measurement as the actual value. It is the average of the absolute errors, where the absolute error refers to the absolute difference between the prediction and the true value of an observation. Inside the "timeseries" folder, you can access the actual time series data for predictions and their corresponding ground truths. This data encompasses all sensors and prediction horizons. The folder contains interactive HTML files, allowing you to zoom in and out and pan across the time series. Missing values are represented by 0 in the ground truth. You find the individual MAEs for each sensor detailed in the charts as well. Keep in mind that the displayed graphs represent designs intended solely for the testing phase. The final appearance of the A-to-Be-developed dashboard will of course differ. We kindly request that feedback focus on content rather than visual aesthetics. The REN_BUST_10_Testing is different from the two folders above. That's a CSV file specifically for bus trajectories. It contains a route ID, a time stamp, the ground truth of the travel time and the predictions, together with the absolute error. We didn't map these on a map because it considers trajectories and not specific sensor locations.

Table 1: Supply forecasting: access to results

Supply forecasting: procedure for testing & providing feedback
The Excel files for feedback (Supply_forecasting_Testing_RENNES and Supply_Forecasting_Testing_RENNES_BUS) contain this information as well, together with a possible procedure for you to follow. Use the columns to write down the dates and times that you checked, list the location that you were interested in, and give the output of the algorithm (e.g. the travel time or speed) together with the desired result. Was this the result you expected?

Table 2: Supply forecasting: procedure for testing & providing feedback

Similarly, results related to anomaly detection were shared.

Anomaly detection: access to results
After unzipping the files from the testing folder, you'll find a "timeseries" folder. Inside this folder, you can access the time series data for horizon 1 predictions (red charts), their corresponding ground truths (blue charts), normalized anomaly scores (in brown), and detected anomalies in orange vertical lines. Lower anomaly scores represent a higher chance of anomalies. Missing values are represented by 0 in the ground truth. You can use the same map provided for supply forecasting to extract the location of each sensor.

Table 3: Anomaly detection: access to results

Anomaly detection: procedure for testing & providing feedback
Similarly, as for supply forecasting, Excel files for feedback are included in the folder. Specifically, for the feedback on anomaly detection, we can adjust the sensitivity of the current algorithm or explore alternative methods to optimize detection accuracy. Therefore, these are the most relevant for testing at this point in the project.

Table 4: Anomaly detection: procedure for testing & providing feedback

The technical leaders and case study leaders decided to discuss the feedback during a meeting (details described in the following section).

3.3.2 Actions achieved and results

Feedback on the provided results was handled in a meeting between the technical and case study leaders. The case study leaders had a concern related to the traffic speed forecasting. This concern is

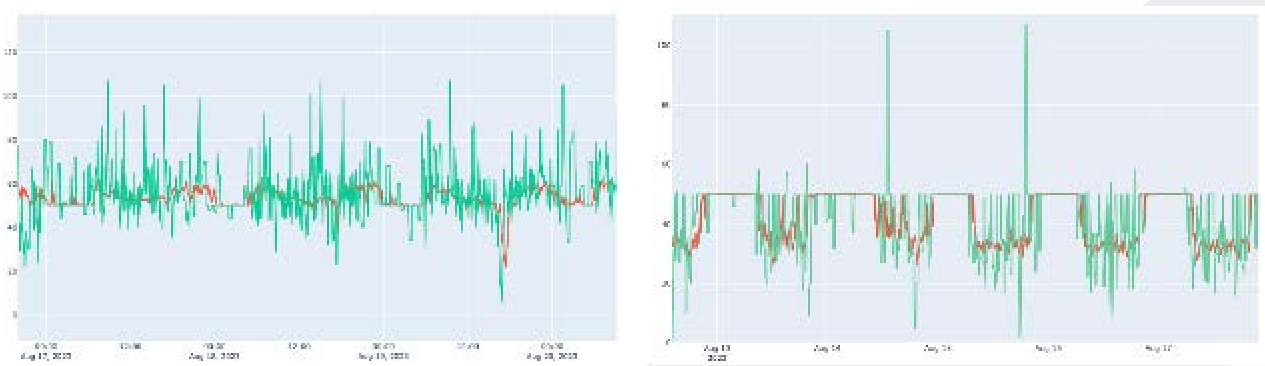


Figure 16: Comparison of traffic speed predictions (red) with observations (green)

depicted in the figure below. It shows speed observations in green, while predictions are depicted in red. The predictions contained too much fluctuation according to the case study leaders. The technical partners note that this is typical in floating car data, as can be seen in the observations as well. However, given that the preference of the case study leaders is on global trends in the traffic patterns, an extra denoising step in the data preprocessing of traffic speed prediction was added. This denoising step is similar to the one proposed for Greater Manchester (as described in D4.2). The aforementioned are illustrated in Figure 16.

The effect of denoising is shown in the figures below, both for travel time and speed. The observations are depicted in blue, while the denoised data is shown in red.

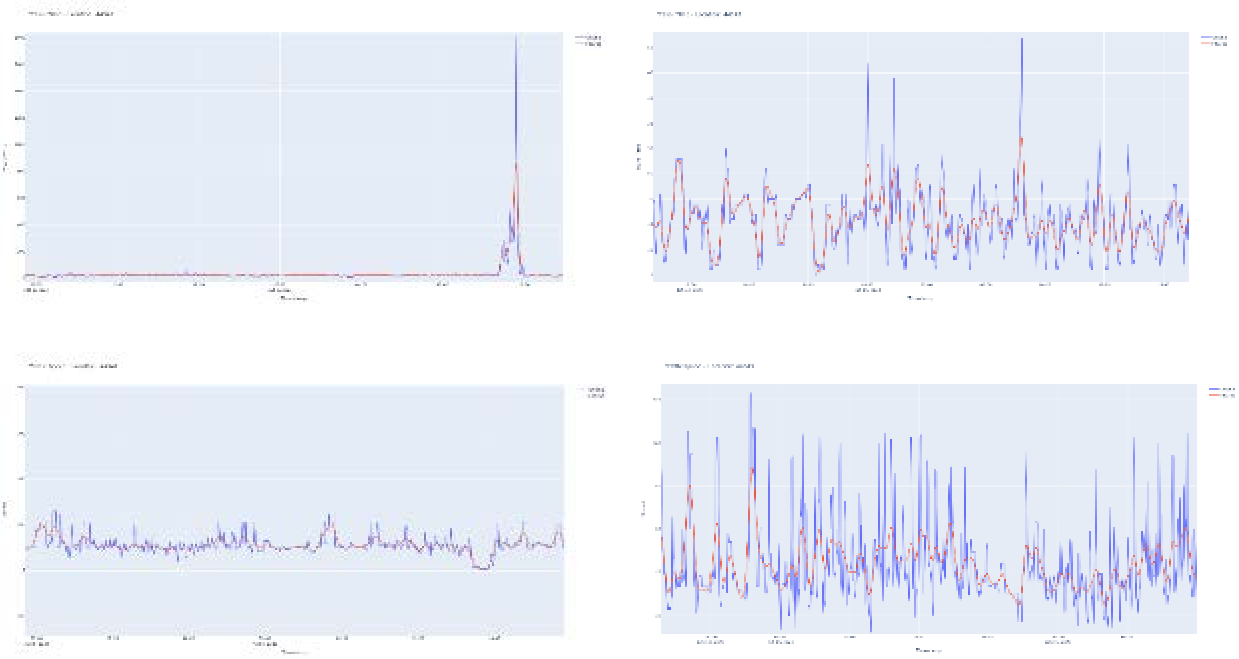


Figure 17: Effect of denoising on observations in travel time and speed

Another concern from the case study leaders was the focus on August in the test set. This might indeed not be the best month to test upon, however, it gives an idea on the generalisation of the model towards vacation periods. Furthermore, once the results of the predictive models are incorporated in the live dashboard, all dates are available to test on.

Deployment toward the live dashboard resulted in retraining of the models. An overlap of the historical and the real-time segments were considered, and models were retrained on those overlapping segments.

Once the results became available in the live dashboard, the case study leaders of Rennes could check the results in a more visual way, with maps showing predicted congestion, average speeds and delays, etc.

This led to the following feedback: "Reading the indicators on the right, they forecast a decrease of the speed, so more congestions, which is the opposite of the trends in the maps" and "As we are getting closer to the evening peak hour, it would make more sense that the later we are, the more congestions we have." This is visualised in the figure below.

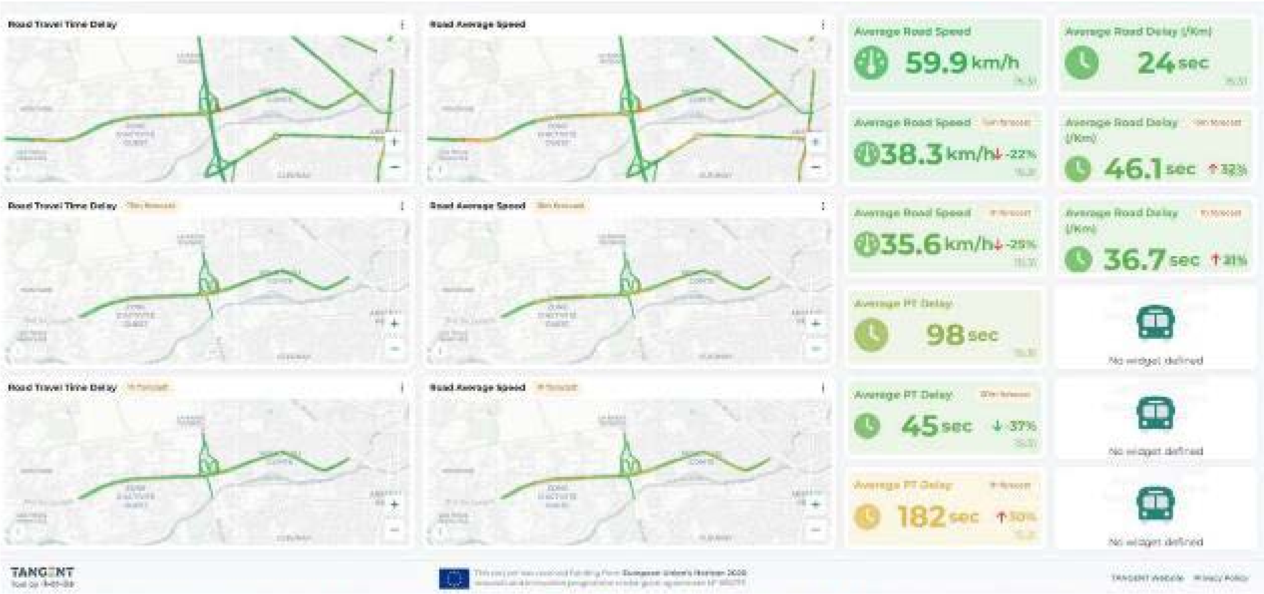


Figure 18: Testing in the live dashboard: contradiction maps and indicators

Looking at the observations (shown in green in Figure 16, and in blue in Figure 17), we can see the sharp fluctuations of these observations. However, in the denoised dataset these fluctuations are smoothened. In the dashboard, all these values are depicted as is (the raw observations). This means that when such a fluctuation is visualised, it is often extreme red/green in the dashboard, while the values in the predictions are not that extreme. As shown in the indicators on the right, average road speed and travel time and the corresponding predictions correctly identify congestion.
Furthermore, and even more important, the observations in real-time monitoring include more segments than the predictions. Historical data of these segments weren't available when the models were trained, therefore averages over all these segments aren't comparable at this point.

3.4 Transport model building for simulation-based analysis (WP7)

An existing transport model for Rennes was re-calibrated by AIMSUN for the needs of the case study. The demand and supply of the Rennes transport model were calibrated for the scope of the case study.

3.4.1 Performed transport modelling activities

3.4.1.1 Model building

Import of the existing macroscopic VISUM model into the Aimsun Next software:

- Geometry verification, connectivity checks and corrections

- Performed traffic assignment and validate the results against the ones obtained by the VISUM model
- Validated the model against real traffic counts (hourly counts) after import to identify re-calibration needs of the baseline demand

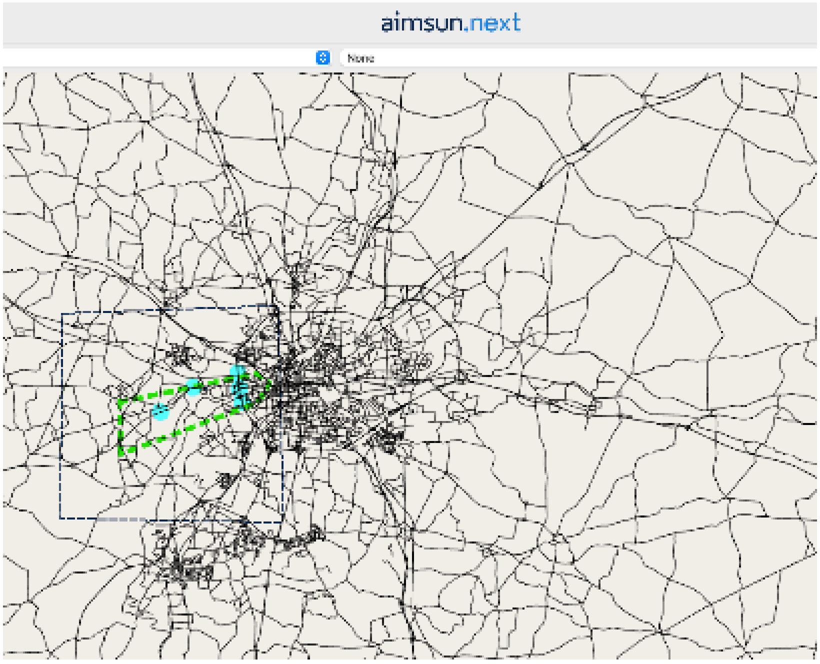


Figure 19: Rennes transport model in AIMSUN Next

Coding of traffic signals based on the signal plans provided by Rennes Metropole (eight signalized intersections) for the RN24 national road. These signal plans are then optimized for the synchronization of public transport and traffic control (WP5).

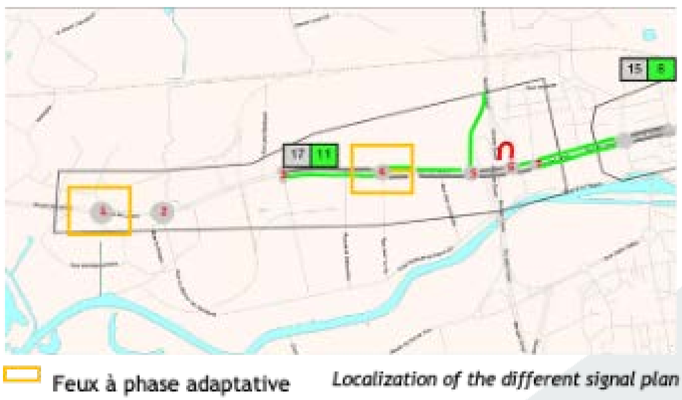


Figure 20: Signal plans for the test area

3.4.1.2 Dynamic traffic assignment

The available transport model was converted from a macroscopic to a hybrid macroscopic and mesoscopic model. More specifically, a hybrid dynamic traffic assignment modelling framework is adopted for the case study of Rennes in which the route choice set is determined by dynamic path assignment for the whole large-scale network, while traffic supply is simulated with dynamic mesoscopic model in specific area of interest and the static macroscopic model in the remainder network. This approach is beneficial for large-scale networks used in strategic transport planning where infrastructure changes or new mobility services require realistic knowledge of traffic conditions and travel times but may have a wider influence in terms of rerouting in the network. The usage of the hybrid model improves the run times when simulation of large-scale networks is needed, however, the analysis focuses on a smaller study area.

3.4.1.3 Public transport lines

- Coding of public transport lines and schedules based on information received by Rennes Metropole

3.4.1.4 Data collection and demand estimations

- Data collected by CEFRIEL between 03-04-2023 and 30-06-2023 from 21 detector locations
- Data filtering and analysis was performed to create the input data that were used to adjust the demands that represent four scenarios for the Rennes case study:
    - Two baseline scenarios corresponding to the morning peak and evening peak hours
    - Two planned event scenarios, one for days with football matches and another for Fridays before holidays

The following demand matrices were estimated using the historical traffic count measurements from 2023:

- Two demand matrices corresponding to morning (7:00 – 9:00) and evening peak (17:00 – 19:00), representing regular travel patterns (average conditions for weekdays). These demands are considered as the baseline scenarios.
- Two demand matrices corresponding to days with planned events: football matches (14:00 – 23:00) and a Friday before long holiday weekends (14:00 – 20:00), respectively.

The calibrated model is provided as input to WP5 for the simulation-based optimizations as well as for the implementation of the WHAT-IF scenarios.

3.4.2 Preparation of what-if scenarios

3.4.2.1 Preliminary results of what-if scenarios simulations

Table 5 provides a summary of the examined What-If scenarios for Rennes. Rennes case study is interested in studying the potential impact of a dedicated lane for carpooling on RN24, aiming to reduce the impacts of traffic congestion on this route.

What-If simulation scenarios	Description	Demand shift
1. Baseline morning peak scenario	Baseline scenario for the demand that corresponds to the morning peak (7:00 - 9:00)	Total number of car trips: 78467 Number of car trips on R24: 3586
2. Baseline afternoon peak scenario	Baseline scenario for the demand that corresponds to the evening peak (17:00 - 19:00)	Total number of car trips: 54568 Number of car trips on R24: 2545
3. Carpooling Scenario - 15% and 50km/h speed limit, morning peak	This scenario assumes that 15% of the trips crossing R24 (in both directions) will use a dedicated carpooling lane. Two passengers per car are assumed. A speed limit of 50 km/h is applied to the carpooling lane, whereas 90 km/h speed limit is applied to a reserved public transport lane in one of the road sections along R24	Carpooling trips on R24 (15%): 381 Simulated carpooling trips on R24: 190 (assuming 2 passengers/car)
4. Carpooling Scenario - 15% and 50km/h speed limit, afternoon peak		
5. Carpooling Scenario - 15% and 70km/h speed limit, morning peak	Same assumptions as above with the speed limit at 70 km/h	Carpooling trips on R24 (15%): 538 Simulated carpooling trips: 269 (assuming 2 passengers/car)
6. Carpooling Scenario - 15% and 70km/h speed limit, evening peak		
7. Carpooling Scenario - 30% and 70km/h speeds limit, afternoon peak	This scenario assumes that 30% of the trips crossing R24 (in both directions) will use a dedicated carpooling lane. Two passengers per car are assumed. A speed limit of 70 km/h is applied to the carpooling lane, whereas 90 km/h speed limit is applied to a reserved public transport lane in one of the road sections along R24	Carpooling trips on R24 (30%): 824 Simulated carpooling demand on R24: 412 (assuming 2 passengers/car)

Table 5: Summary of the examined What-If scenarios for Rennes

The Figure 21 below depicts the modelled and calibrated network of Rennes in the Aimsun Next simulation software. The red-shaded area represents the part of the network which is modelled as a static (macroscopic) traffic flow resolution. The blue-shared area depicts the model area that includes the R24 and is modelled with mesoscopic traffic flow resolution to better capture the traffic dynamics.

It should be noted that in all simulation experiments the route choices were kept fixed and same as in the baseline scenarios. The hypothesis is that non-carpooling trips will not switch to alternative routes from the Day 1 of the implementation of the new policy, rather they will keep their usual routes. The trips that are shifted to carpooling are vehicles that are using R24 in the baseline scenario for their trips. Hence, as carpooling vehicles they will keep the same routes and choose the carpooling lane to reach their destination.

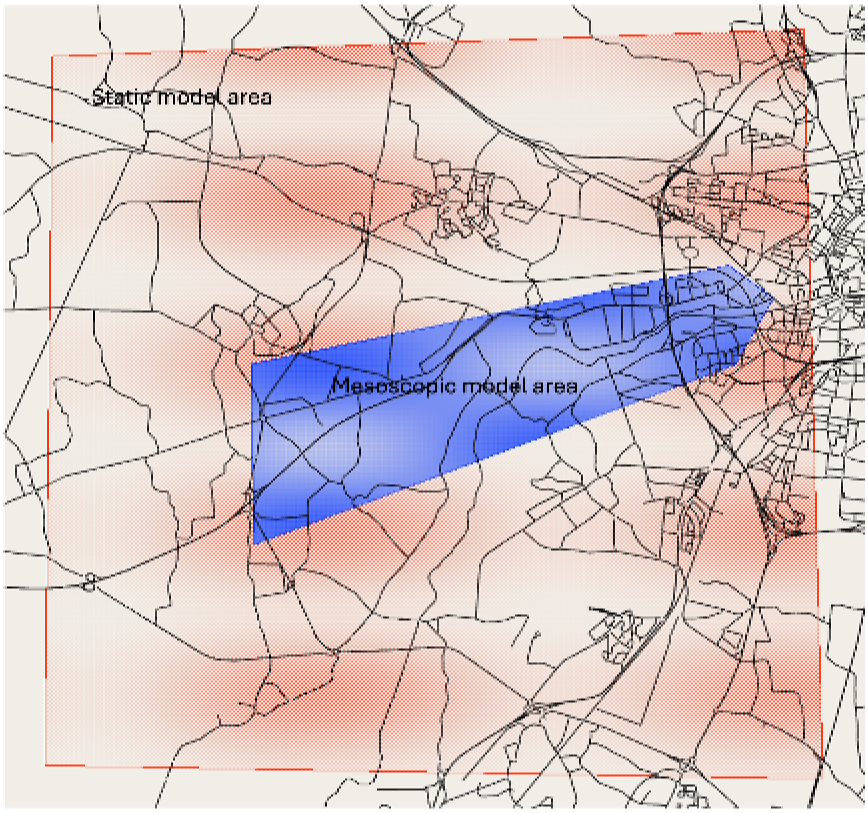


Figure 21: Modelled Rennes network in the Aimsun Next software

3.4.2.2 Preliminary results for the macroscopic (static) study area

Table 6 summarises some key network-wide statistics for three scenarios related to the afternoon peak demand. The values in the parenthesis indicate the percentage difference compared to the baseline scenario. The results show slight improvement at the network level with 50% of the trips of R24 shifting to carpooling, while for the 15% carpooling scenario the difference is zero.

Network-wide KPI	Baseline Afternoon Peak Scenario	Carpooling 15% - Afternoon peak scenario	Carpooling 30% - Afternoon peak scenario
Network occupancy (%)	10	10 (0%)	10 (-2%)
Total Network Distance (km)	433724	433754 (0%)	427011 (-2%)
Total Network Time (min)	4,20E+06	4,20E+06 (0%)	4,07E+06 (-2%)
Total Network Speed (km/h)	5,84	5,84 (0%)	5,94 (2%)

Table 6: Network-wide KPIs for baseline afternoon and carpooling scenarios

Table 7 summarises some key network-wide statistics for two scenarios related to the morning peak demand. The values in the parenthesis indicate the percentage difference compared to the baseline scenario. The results show slight improvement at the network level with 15% of the trips of R24 shifting to carpooling.

Network-wide KPI	Baseline Morning Peak Scenario	Carpooling 15% - Morning peak scenario
Network occupancy (%)	14,11	14,02 (-1%)
Total Network Distance (km)	5,43E+05	539097 (-1%)
Total Network Time (min)	8,25E+06	8,12E+06 (-2%)
Total Network Speed (km/h)	3,7	3,75 (1%)

Table 7: Network-wide KPIs for baseline morning and carpooling scenarios

3.4.2.3 Preliminary results for the mesoscopic study area

Table 8 summarises some key statistics for the R24 (mesoscopic) area for four scenarios related to the afternoon peak demand. In particular, the Baseline scenario is compared against three scenarios where carpooling is introduced on R24. Two scenarios assume that 15% of the trips crossing R24 in both directions are using carpooling with 70 km/h and 50 km/h speeds limits applied, respectively. The last scenario assumes that 30% of the trips will shift to carpooling and a 70 km/h speed limit.

The values in the parenthesis indicate the percent increase or decrease of each KPI compared to the baseline scenario. The results indicate that no significant improvement in terms of network-wide performance are observed when 15% of trips that use R24 are switching to carpooling.

R24 KPI	Baseline Afternoon Peak Scenario	Carpooling 15% - 70km/h speed limit	Carpooling 15% - 50km/h speed limit	Carpooling 30% - 70km/h speed limit
Average Delay time - All vehicles (sec/km)	28,01	29 (+4%)	29,16 (+4%)	25,42 (-9%)
Average Delay time - Bus (sec/km)	26,69	27,91 (+5%)	27,96 (+5%)	24,79 (-7%)
Average Density - All vehicles (veh/km)	5,1	5,08 (0%)	5,1 (0%)	4,62 (-9%)
Mean queue - All vehicles (veh)	322	323,61 (+1%)	324,54 (+1%)	271,64 (-16%)
Average Travel time - All vehicles (sec/km)	74,14	75,15 (1%)	75,3 (+2%)	71,51 (-4%)
Average Travel time - Bus (sec/km)	105,44	106,66 (1%)	106,71 (+1%)	103,54 (-2%)
Average Speed - All vehicles (km/h)	66,32	65,58 (-1%)	65,48 (-1%)	65,91 (-1%)

Table 8: Network-wide key performance indicators for baseline and carpooling scenarios for the afternoon peak demand

Table 9 summarises some key statistics for the R24 (mesoscopic) area for three scenarios related to the morning peak demand. The baseline scenario is compared against two scenarios where carpooling is introduced on R24. The carpooling scenarios assume that 15% of the trips crossing R24 in both directions are using carpooling with 70 km/h and 50 km/h speeds limits applied, respectively.

The values in the parenthesis indicate the percent increase or decrease of each KPI compared to the baseline scenario. The results indicate no significant improvement in terms of network-wide performance with the introduction of carpooling. It is observed that the average delay time increases, which may be attributed to the lowered speed limits on the carpooling lane.

R24 KPI	Baseline Morning Peak Scenario	Carpooling 15%, 50 km/h speed limit	Carpooling 15%, 70 km/h speed limit
Average Delay time - All vehicles (sec/km)	7,8	8,28 (+6%)	8,18 (+5%)
Average Delay time - Bus (sec/km)	10,18	11,59 (+14%)	10,26 (+1%)

R24 KPI	Baseline Morning Peak Scenario	Carpooling 15%, 50 km/h speed limit	Carpooling 15%, 70 km/h speed limit
Average Density - All vehicles (veh/km)	3,31	3,32 (0%)	3,27 (-1%)
Mean queue - All vehicles (veh)	65,32	66,62 (+2%)	65,24 (0%)
Average Travel time - All vehicles (sec/km)	58,68	59,12 (1%)	59,04 (1%)
Average Travel time - Bus (sec/km)	74,41	74,96 (1%)	73,85 (-1%)
Average Speed - All vehicles (km/h)	67,5	67,22 (0%)	67,28 (0%)

Table 9: Network-wide key performance indicators for baseline and carpooling scenarios for the morning peak demand

Figure 22- 24 depict simulation snapshots of the simulated speeds for the afternoon demand and for the following scenarios: 1. Baseline, 2. Carpooling 15% and 70 km/h speeds limit, 3 Carpooling 30% and 70 km/h speed limit. The simulated section speeds indicate, practically, no improvement when 15% of the trips on R24 shift to carpooling, while a noteworthy increase of the section speeds is observed when the demand shifted to carpooling increases to 50%.

Overall, the performed simulation analyses indicate that a 15% demand shift to carpooling, of the total number of trips that are crossing R24, is not sufficient in order to have significant improvements of the network traffic conditions. It is noteworthy that this percentage represents a negligible reduction of the total car trips in the network of Rennes, at most 1%. Nevertheless, the scenario that assumed 30% demand shift (of the trips on R24) to carpooling shows promising results in terms of potential congestion reduction.

Figure 23: Simulated speeds 15 % carpooling

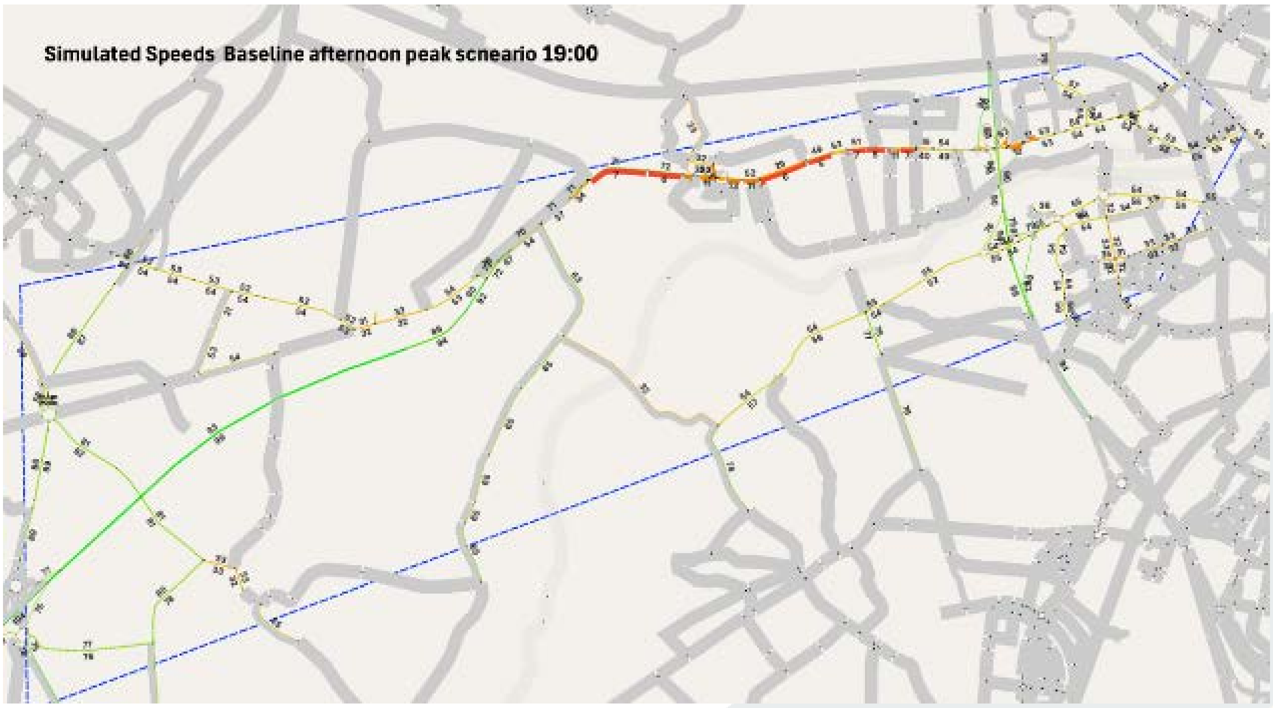


Figure 22: Simulated speeds baseline afternoon peak scenario

Figure 24: Simulated speeds 50 % carpooling

3.5 Synchronisation of public transport and traffic control (WP5)

The objective of this module is to test and validate the effect of changing PT line frequency and corresponding signal timings for intersections of interest to facilitate improved traffic flow and emission conditions.

3.5.1 Methodology

3.5.1.1 Preparation Phase: Testing schematic and transport model finalisation

A document containing submodule testing specificities were shared with the stakeholder during the initial phase of the testing process. This document had consolidated fields for gathering information like simulation area, traffic node details, simulation scenario details and public transport line of interest. After getting the response from the stakeholder regarding the testing requirement specifications, the transport model is suitably adjusted and the testing process commenced. After the testing phase is complete a report is generated with the test result and will be sent to the case study stakeholders for their approval and further validation.

3.5.1.2 Testing Framework

The testing framework for the project focuses on the Aimsun model for the Route de Lorient area in Rennes, incorporating four public transport bus lines and one signalised node with seven signal phases. This setup utilises a fixed traffic control plan to evaluate the system's response under various conditions. The testing process involves running a PPS (Planned and Predicted Scenario) to analyse how well the system performs when adapting to different scenarios. The results are compared against a baseline scenario, allowing for a clear evaluation of how interventions, such as adjusting bus frequencies or signal timings, improve traffic flow and public transport efficiency.

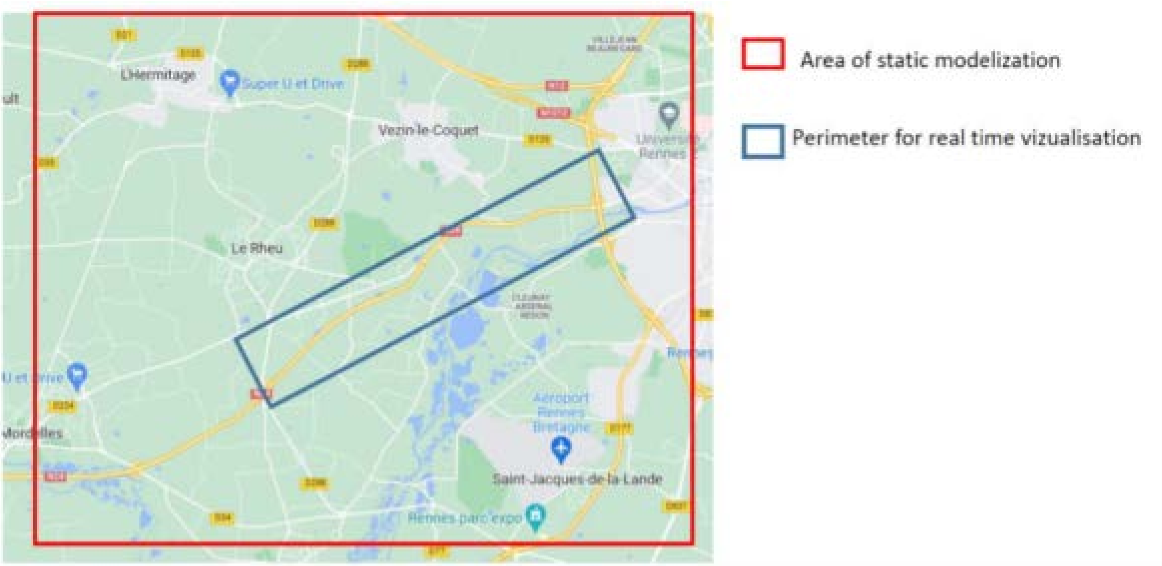


Figure 25: Map view of Route de Lorient

Figure 26: Considered Intersection in AIMSUN Next Model

In this testing operation we have utilised the relative KPI improvement as the optimization objective and the general formulae for that follows as

KPI_relateive_improvement = (KPI_baseline - KPI_optimized)/KPI_baseline

Optimization Phase:

In this phase based on the finalised transport model and stakeholder specified inputs we have executed the optimization process for predefined KPI specificity and after the optimization process concluded results were collected from the system for creation of report to be shared with the stakeholder and for further validation

3.5.2 Actions achieved and results

The goal for the optimization process is to improve the congestion in the system along with the system wide emissions so in the baseline scenario the density was 8.4 veh/km where as in the optimized scenario it changed to 7.01 veh/km, for overall flow, in baseline scenario it was 3043 veh/h and in optimized scenario it increased to 3039.16 veh/h. Overall speed was 36.25 km/h in the baseline scenario and in optimized it became 44.97 km/h and the total distance travelled was 1797.07 km in the baseline scenario and in the optimized scenario it became 1794.14 km and travel time was 125.4sec/km in baseline whereas in the optimised scenario it became 99.98 sec/km.

After analysing the raw values of the underlying indicators, we can see that density decreased by 13.88% after optimization but traffic flow marginally decreased by 0.01%, indicatively this signifies about better traffic conditions in the optimized scenario. The overall distance travelled decreased marginally by 0.03% w.r.t. Baseline scenario and the travel time decreased by 14.75% than the baseline which again depicts that the optimized scenario is less congested and much efficient in traffic flow with respect to the baseline scenario for the event day simulation. The speed also improved by 8.60% with respect to the baseline scenario which further signifies better traffic conditions in the optimized scenario.

Figure 27 shows the pictorial depiction of the considered intersection for baseline vs optimised scenario comparison.

Figure 27: Delay time visual comparison for considered intersection: Left: baseline, Right: PuT + TC Optimisation

3.6 Consensus Mechanism (WP5)

The goal of Task 5.4, is to develop a comprehensive, automated decision-support tool designed to aid decision-making and foster consensus among stakeholders with divergent opinions. Drawing from actual stakeholder preferences and cooperation patterns obtained through structured surveys, our work, detailed in D5.4 proposes a framework that realistically models the key stages of the consensus-reaching process, until the reach of consensus between stakeholders.

For testing the modelling framework, the same four-step methodology described in section 2.2.1 used for testing the WP3 module, was followed. The adaptation of this methodology to the specificities of the consensus mechanism is outlined below:

3.6.1 Methodology

3.6.1.1 Step A: Testing sample collection

During the initial phase of testing, the stakeholder cooperation survey (SCS) was distributed to commuters from each case study city, including Rennes. The SCS questionnaire is included in the Annex of D5.4. To collect the necessary sample, each case study was asked to identify 3 stakeholders. Unlike WP3, case study contact persons directly provided the survey material to stakeholders and collected the completed questionnaires, which were then forwarded to NTUA.

3.6.1.2 Step B: Execution of the consensus mechanism

The consensus mechanism is applied and its output, in terms of consensual opinions regarding stakeholder priorities when a particular traffic management strategy is implemented, is communicated to participants.

Given that not all strategies are relevant to all stakeholders (since the entity they represent might not be involved in the decision-making process for one or more TMS), the opinions communicated were individualised and determined by their responses to the TBS in Step A. For example, the material communicated to the testers who responded that DRT-PT is relevant for their city and organisations, are provided below (Figure 28):

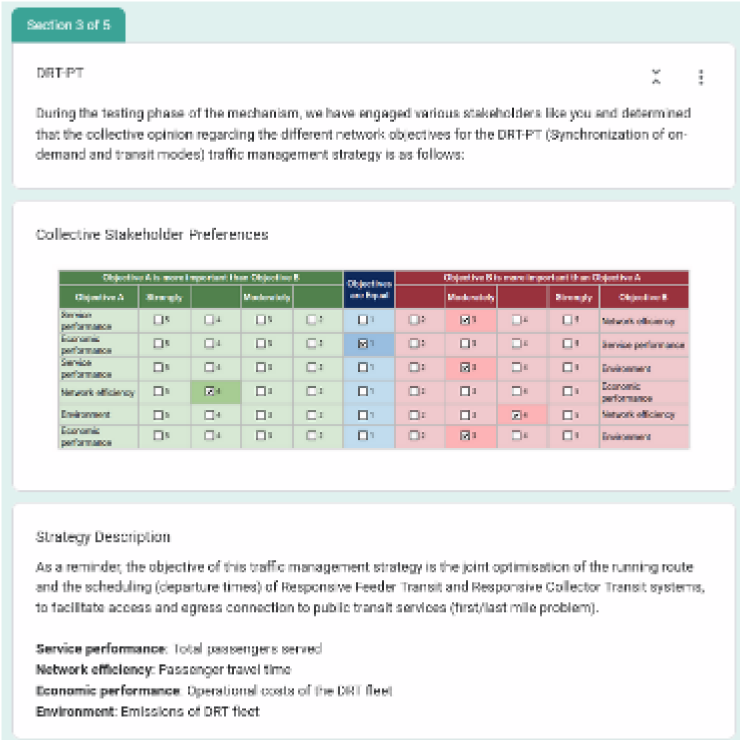


Figure 28: DRT-PT: Communication of opinion modelling results

3.6.1.3 Step C: Feedback Survey

As with the testing of WP3 modules, stakeholders were contacted again by NTUA to complete a follow up feedback survey to assess both the questionnaire and the results of the opinion modelling. The distribution of the survey occurred from 19/02/2024 to 28/02/2024. The complete feedback questionnaire is included in the Annex.

3.6.1.4 Step D: Reporting on the results

The feedback collected during the testing is presented in the "Results" section that follows. Some interim results have already been presented internally to the consortium during the WP7 bi-weekly meetings dedicated to subsystem testing and the consortium's monthly audio meetings.

3.6.2 Actions achieved and results

A total of 12 stakeholders from all case studies, including 3 from the Rennes case study, were contacted by case studies and NTUA. Six stakeholders from all case studies responded to the feedback survey, and their responses are pooled together and analysed below.

Stakeholders found the questions of the survey to be rather straightforward and understandable (Figure 29).

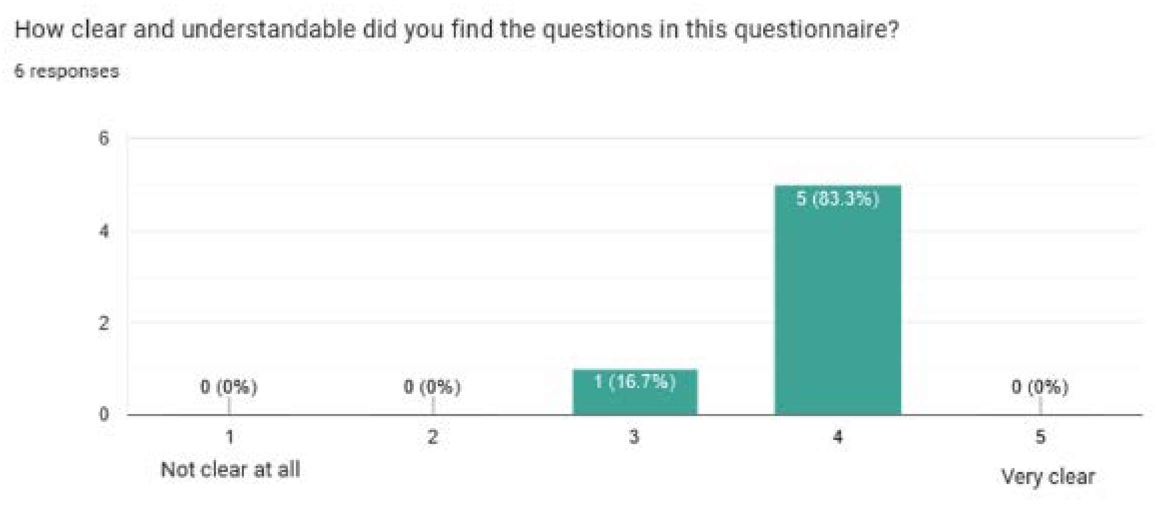


Figure 29: How clear and understandable did you find the questions in this questionnaire?

Perhaps unexpectedly then, 50% of respondents considered that a few questions appeared to be out of context (Figure 30). This issue is attributed to two factors: first, the survey elicited both stakeholder preferences and the institutional relationships between the entities they represent. Although related, these themes are distinct, which is uncommon in similar surveys that are highly focused. Additionally, the indicators used for eliciting relationships, such as the frequency of data exchanges between entities, do not directly reveal their relevance to the overall philosophy of the questionnaire.

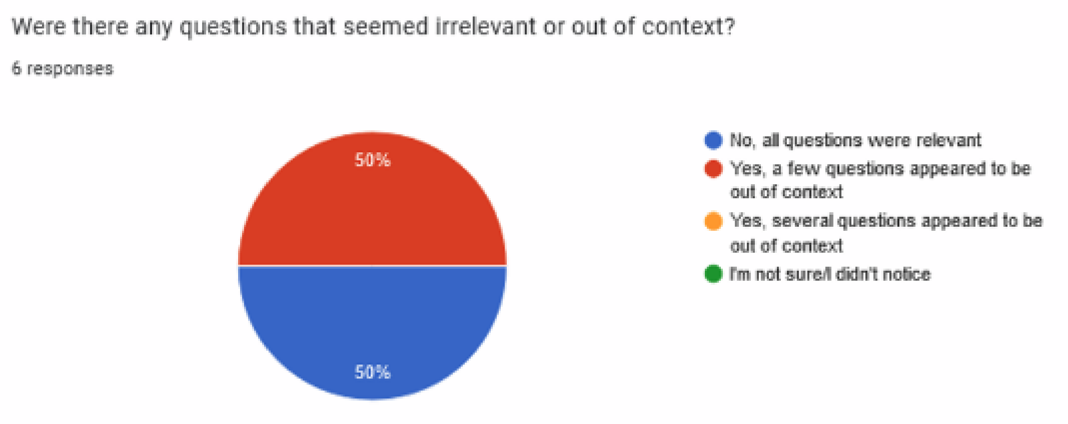


Figure 30: Were there any questions that seemed irrelevant or out of context?

Nevertheless, the instructions provided with the questionnaire were deemed adequate by participants (Figure 31).

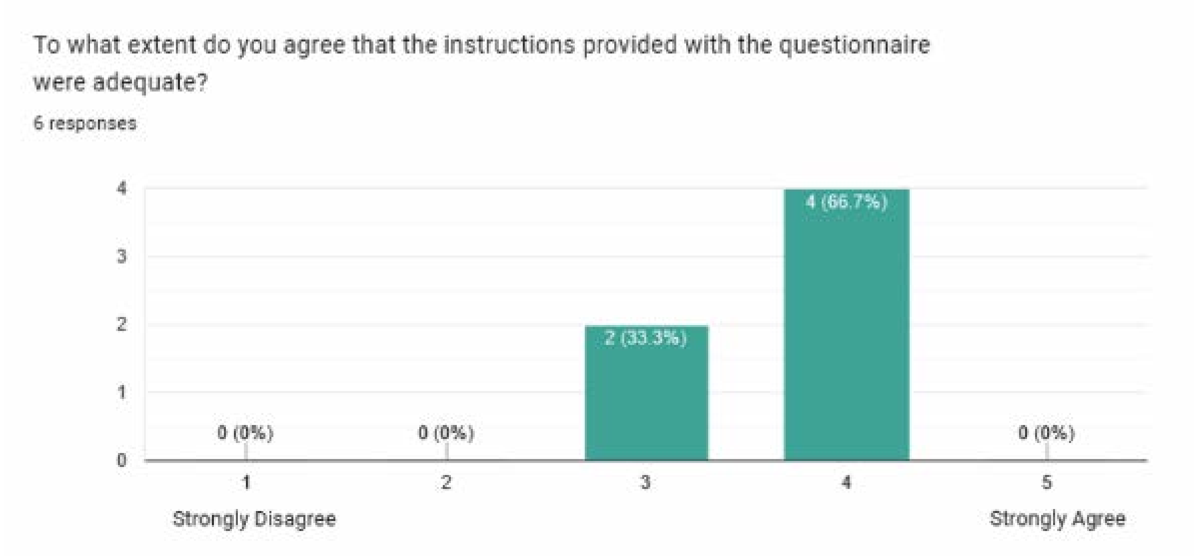


Figure 31: To what extent do you agree that the instructions provided with the questionnaire were adequate?

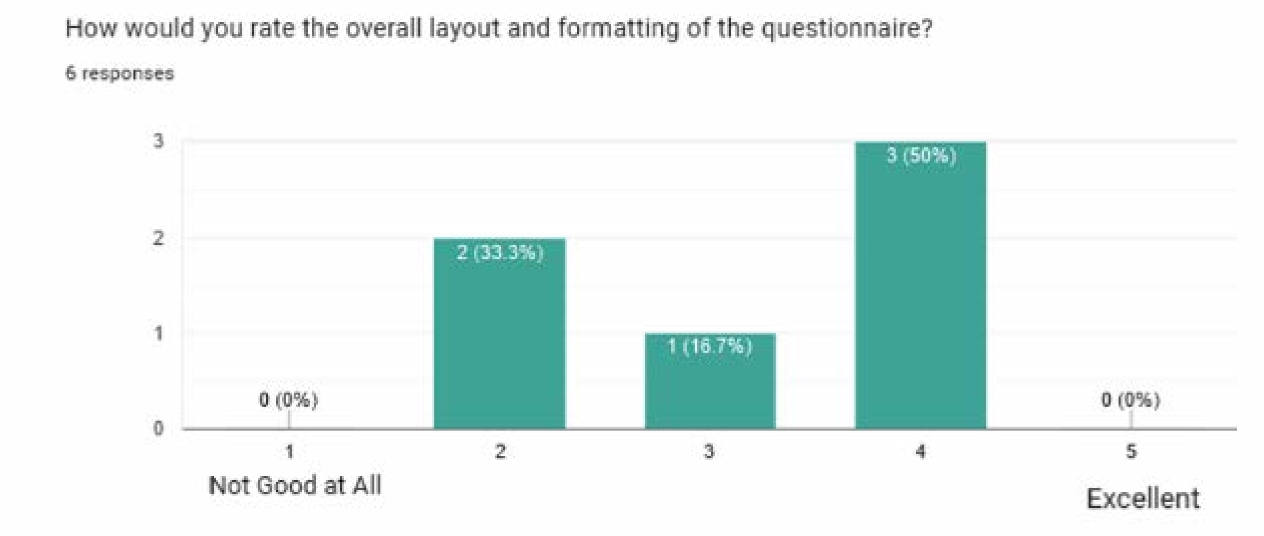


Figure 32: How would you rate the overall layout and formatting of the questionnaire?

Opinions were more mixed regarding the overall formatting of the questionnaire. Unlike traditional question design (multiple-choice, open-ended, etc.), the need to provide institutional relationship information by filling a matrix in an Excel format (Figure 33) requires more cognitive effort and may not be immediately intuitive.

Stakeholder Category	Stakeholder Name	**B1**. Communication frequency	**B2**. Integration	**B3**. Data
Government & Authorities				
European Union				
Ministry of transport	Department for Transport	4. 1-2 times/year	2. Partnership: We work together as a formal team with specified responsibilities to achieve common program goals (note: responsibility for each organization is usually outlined in a Memorandum of Understanding or other agreement).	4. Degree 4 – Seamless sharing of information: Universal interpretation of information through data processing based on cooperating applications
Other national ministry				
Regional government				
Local authority				
Neighbouring city	Local councils surrounding Greater Manchester and those across (mainly) North of England	4. 1-2 times/year	3. Collaboration: We work side-by-side and actively pursue opportunities to work together as an informal team (i.e., do not establish a formal agreement; work together "in the spirit of collaboration").	1. Degree 1 – Unstructured data exchange: Exchange of human-interpretable unstructured data such as the text found in operational estimates, analyses and papers
Local transport authority				

Figure 33: Stakeholder relations matrix

The length of the questionnaire was also deemed excessive (Figure 34), with 67% of respondents finding it too long. This result was anticipated during internal test runs of the survey. The decision to proceed was based on the following: this survey targeted the few stakeholders knowledgeable about the decision-making, cooperation, and communication patterns among stakeholders involved in the transport network's management. For instance, the 14 questionnaires collected in the Stakeholder Cooperation Survey contrast with the 1859 responses across the four case studies for the TBS, aimed at the general population. To compensate for the few respondents, we opted to demand more cognitive effort from participating stakeholders, facilitated by case study leaders who primarily distributed the questionnaire within their professional circles. Thus, the 14 questionnaires documented 248 cooperation instances and 46 opinion matrices, numbers suitable for the opinion modelling. This cognitive load was significant for some respondents, as noted by two respondents in open-ended questions on general comments or suggestions on the questionnaire content and format.

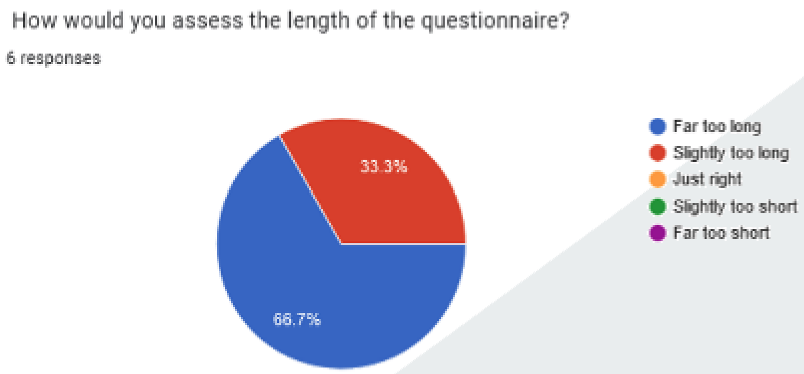


Figure 34: How would you assess the length of the questionnaire?

This cognitive load is also reflected in the fact that most (50%) participants completed the questionnaire in 25 to 30 minutes (Figure 35). For reference, the survey was initially timed at 25 minutes, a duration that most participants did not significantly exceed.

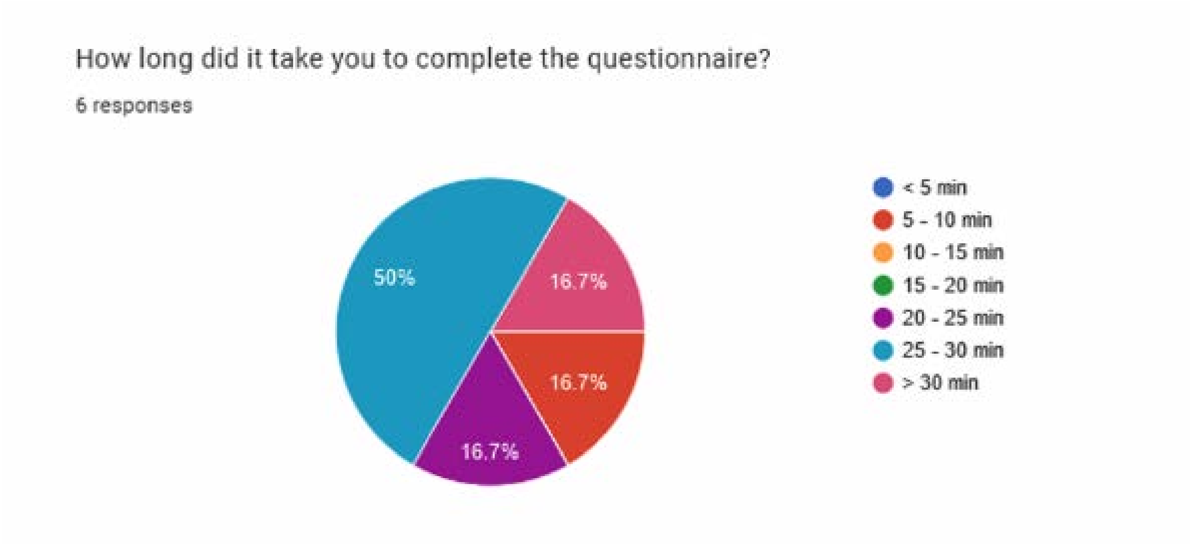


Figure 35: How long did it take you to complete the questionnaire?

3.6.2.1 Modelling insights

As discussed in D5.4, the opinion modification of the consensual preferences has two main objectives. First, the original opinions of the stakeholders must be preserved to the greatest extent possible, ensuring that each stakeholder's unique perspectives and insights are respected and incorporated into the decision-making process. Second, the consensual collective preference must be accepted by all stakeholders, as this sense of ownership enhances the legitimacy of the decision-making process and ensures that the policies (in this case, traffic management strategies) are more likely to be effectively implemented.

The consensus mechanism successfully achieves both objectives, as stakeholders have explicitly accepted the legitimacy of the consensual opinion (Figure 37) and feel that the consensual opinion is not significantly divergent from their own (Figure 36). This result serves as a robust indicator of the consensus mechanism's capacity to determine the true consensual opinion.

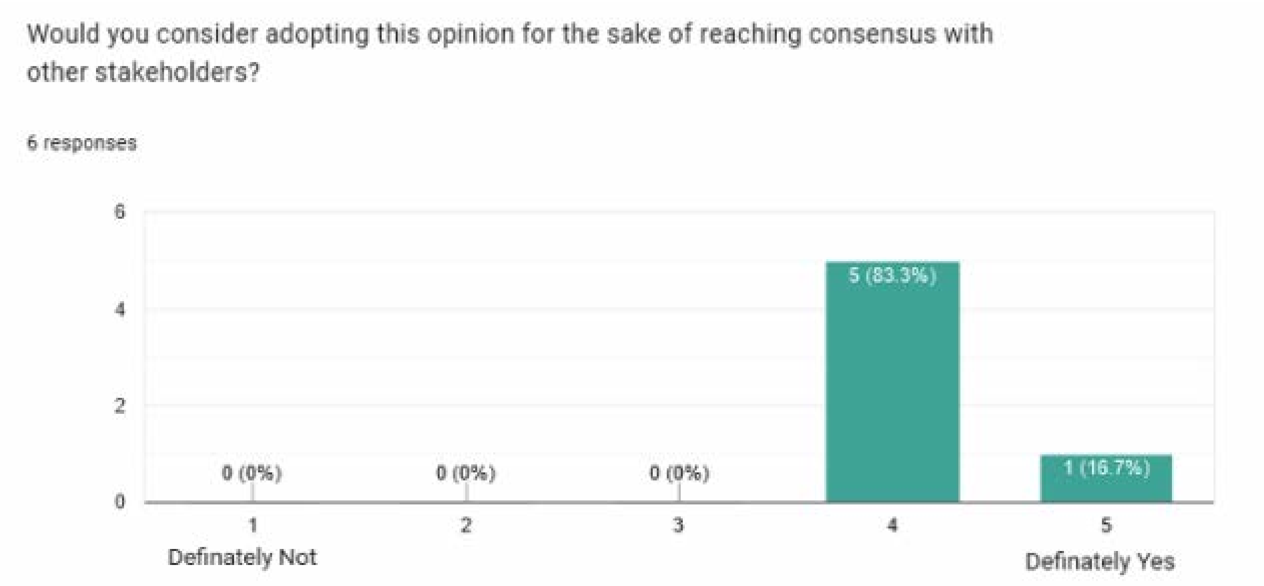


Figure 37: Would you consider adopting this opinion for the sake of reaching consensus with other stakeholders?

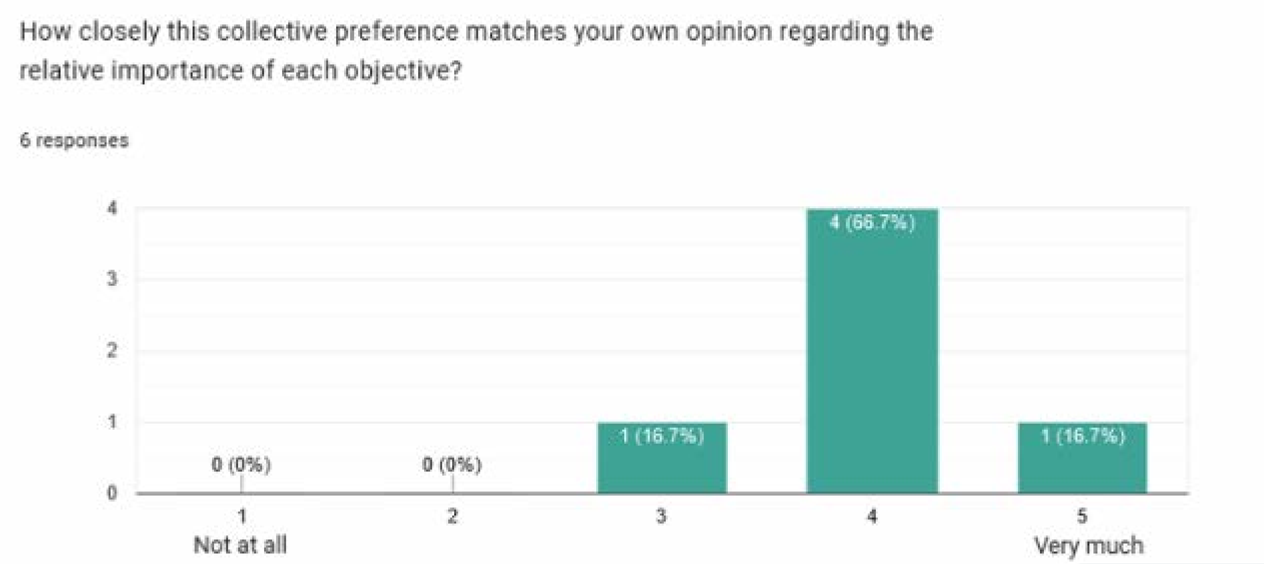


Figure 36: How closely this collective preference matches your own opinion regarding the relative importance of each objective?

Ultimately, stakeholders exhibit general trust in the consensus mechanism's operation, as depicted by the responses to the corresponding question (Figure 38).

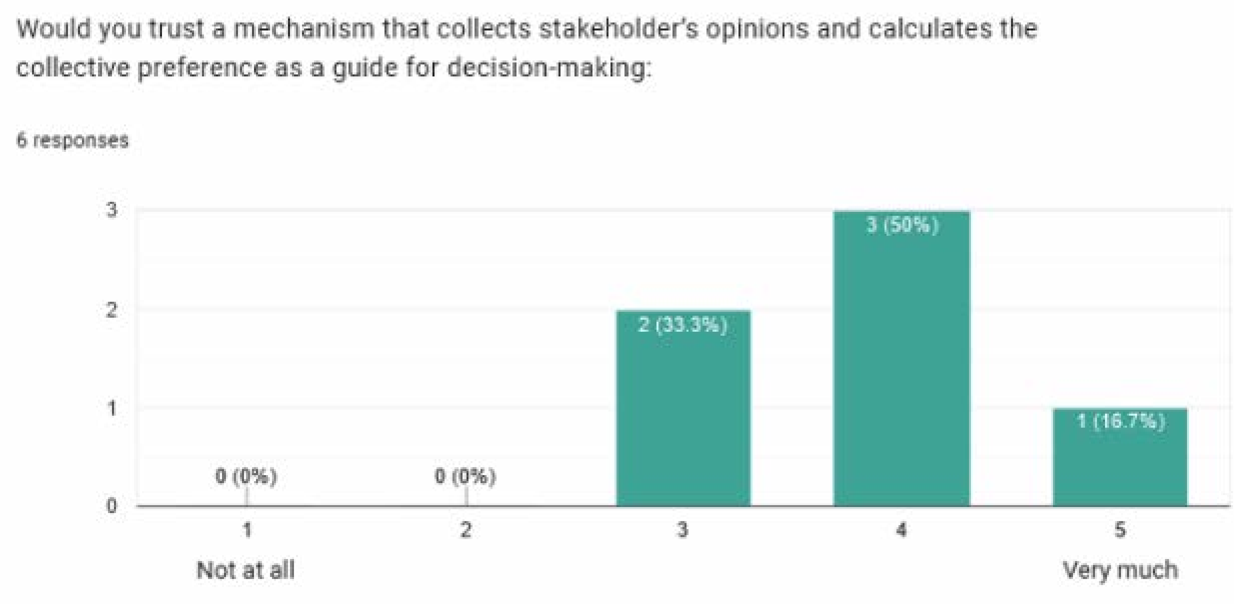


Figure 38: Would you trust a mechanism that collects stakeholder's opinions and calculates the collective preference as a guide for decision-making?

4 Testing of the overall system

The testing activities of the overall system aim to assess the functionalities of the three services of the TANGENT tool. They are related to the WP7, more specifically to T7.3 “Upscaling and full operation: testing of the overall system”. The test phase of the overall system is divided in two subtasks:

- **"Subtask 7.3.1 Technical upscaling and full operation of TANGENT tools"**: Technical tests to assess the proper integration of the subsystems provided by the technical partners and developed under WP2, WP3, WP4 and WP5.
- **"Subtask 7.3.2 Non-technical testing and business models’ evaluation"**: Performance, usability, acceptability testing to be performed by the potential end-users of the tools: the case studies.

The test period is also framed by the WP6: Task 6.4 “Integration and development of TANGENT decision-making support tool for coordinated traffic and transport” (M16-M37) and deliverables D6.2 “TANGENT tool development and integration - 1st release” (M32) and D6.5 “TANGENT tool development and integration - 2nd release” (M37).

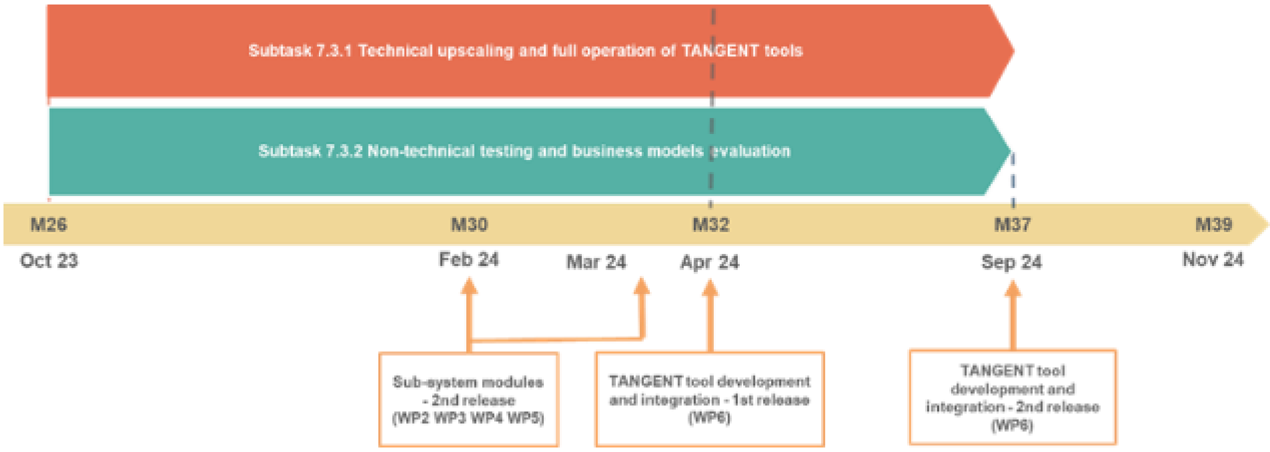


Figure 39: Timeline of WP7 testing activities

The above figure represents the global timeline of the testing of the overall system. The top section represents the execution of Subtask 7.3.1, where the technical testing of the overall tool’s integration has been done progressively, in strict collaboration between the WP6 leader and the technical partner responsible for the subsystem under integration. The bottom section represents the execution of Subtask 7.3.2.

The two T7.3 subtasks are closely linked, and are fully interconnected with WP6 work on subsystem integration (Task 6.4 “Integration and development of TANGENT decision-making support tool for coordinated traffic and transport management”). WP6 itself is dependent on the progress of technical partners in the development of the subsystems. Therefore, the non-technical testing of each functionality by the case studies could only start when its development and integration were completed. The tests were therefore sequential.

During the first months of the project, Rennes Métropole, in collaboration with WP1 and WP7 partners, defined its case study and the services to be implemented and tested under various scenarios, according to the city's challenges and interests. It can be found in D7.1 Definition of the case studies, testing methodology and stakeholders' & users' engagement campaign, and D7.2 System deployment and testing specifications. The services and functionalities related to Rennes case study are listed in the following table.

Service	Functionality	Scenario	Real-time or simulation/virtually
Service 1: Enhanced information service for multimodal transport management	Current state of the network	Daily Commuting Planned Events Unplanned Events	On-Site
	Future state of the network	Daily Commuting Planned Events Unplanned Events	On-site
Service 2: Real Time Traffic Management Services	Synchronization of Public Transport and Traffic Control	Daily Commuting Planned Events Unplanned Events	Virtually
	Informing the Transport Passengers	Daily Commuting Planned Events Unplanned Events	On-site
Service 3: Simulation of pre-defined scenarios	Simulation of the following scenario: What-if one of the lanes is dedicated to carpooling?	not relevant	Virtually

Table 10: Services and functionalities related to Rennes case study

4.1 Methodology

4.1.1 Technical testing

The technical testing activities were tackled between the technical partners who developed the different subsystems and A-to-Be, responsible for the integration of the functionalities and the development of the TANGENT global tool.

Therefore, the technical tests have been performed in the scope of T6.4 “Integration and development of TANGENT decision-making support tool for coordinated traffic and transport management”.

The validation of the results of the subsystems has been done under T7.2, as described in section 3. “Testing of the subsystems”. During T7.3 “Upscaling and full operation: testing of the overall system”, some discussions and meetings were held when necessary between the technical partners and Rennes case study, e.g. when the case study had a doubt on the reliability of the elements displayed.

A description of the dashboard and functionalities is further described in D6.5 “TANGENT tool development and integration. Second release”.

4.1.2 Non-technical testing

From April to September 2024, the tests have been run to assess the different functionalities added progressively on the TANGENT integrated tool. The objective was to continuously carry out the testing until the complete tool and all its functionalities were tested and validated before the end of T7.3 "Upscaling and full operation: testing of the overall system".

4.1.2.1 Launch of the non-technical testing phase

On March 13th 2024 (M31) during the TMC, the WP6 leader performed a live session launching the TANGENT Dashboard, which has been continuously running since. At this time, the platform featured the first functionality integrated: the current state of the network (Service 1). All partners requesting access were granted credentials to use the platform, according to their assigned role.

4.1.2.2 Implementation of the non-technical tests

When a technical partner finished the development of a functionality, adapted for the TANGENT tool specificities, the WP6 integrated it on the Dashboard, and non-technical testing was initiated with the non-virtual case studies, organised in test phases called "Steps".

For instance, Step 1 was launched on April 3rd until April 29th, in order to test the functionality "Current state of the network" in Daily Commuting scenarios. After April 29th, the functionality remained active within the integrated tool until the end of the project, but the core of its testing was considered finished after that period. This methodology has been iterated for all functionalities, until all the services and functionalities were integrated and tested: the whole TANGENT tool was completely tested. In addition, the TANGENT tool has built-in feedback functionality, which has allowed users to provide comments and report issues, extending the testing window of each functionality to the entire usage period.

According to the functionality assessed, one of the two following types of format was used:

- A questionnaire sent to the case studies that have access to the Dashboard
- A virtual meeting with the case studies that have access to the Dashboard

In both cases, the participants needed to go to the TANGENT tool and perform some operations to evaluate various aspects of the platform and the functionality under test.

These tests aimed to assess three aspects of the Dashboard:

- **Usability and reliability**: Evaluate the user-friendliness and the clarity of the Dashboard and the functionality
- **Accuracy of the information**: Assess the correctness of the elements displayed, in a qualitative way
- **Compliance with initial requirements**: Review and update of the expectations listed in deliverable D7.2 before February 2023

The questions have been iterated for each step of the testing and adapted to the functionality under evaluation, with the support of the relevant technical partner when needed.

A demonstration of the solution has been done twice, before and during the WP1 Stage 3 stakeholders' workshop, during which the major stakeholders of Rennes mobility were gathered: Rennes Métropole (Mobility, Data and Traffic Management services), KEOLIS Rennes, Brittany Region for the regional

BreizhGo coaches, their operator KEOLIS Armor, and the DIR Ouest (national road managers). This demonstration phase coupled with the workshop brought feedback about the tool and the functionalities, complementary to the ones realised iteratively.

The table below summarises the elements tested and their testing time slots for the Rennes case study.

Service	Functionality	Scenario	Non-technical testing dates	Step
Service 1	Current state of the network	Baseline scenario	April 3 to April 29, 2024	1
		Planned Event Unplanned Event	September 2024	2
	Future state forecasting	Baseline scenario	29th April to 15th of May, 2024	3
		Planned Event Unplanned Event	July / October 2024	4
Service 2	SNLB: Informing the Transport Passenger[2] (Dissemination Plan)	Baseline scenario	May 15 to September 2, 2024	5
		Planned / Unplanned Event	September / October 2024	6
	Planner features: Synchronisation of Traffic Control & Public Transport	All	October / November 2024	7
Service 3	Simulation of predefined scenarios	What if scenarios	October / November 2024	8

Table 11: Functionalities tested for Rennes case study

4.2 Tests results

This section presents the results of the testing activity of Rennes case study, who has assessed the different functionalities of TANGENT under different scenarios. All the tests have first been done for the baseline scenario, which corresponds to typical days during the week, especially during peak hours. Then, the TANGENT solution has been evaluated under some planned and unplanned events, several functionalities simultaneously.

4.2.1 Tests under baseline scenario (daily commuting)

4.2.1.1 Current state of the network

The first step of the testing aimed at assessing the dashboard of TANGENT and the first functionality of Service 1: **Current state of the network**, during daily commuting.

To this purpose, a questionnaire was sent to Rennes Métropole, using Google Forms. The questions can be found in Annex I.

As this was the first time the partners were asked to review some parts of the TANGENT tool, specific questions about some elements related to the Dashboard in general, not targeting the functionality assessed, were also asked.

4.2.1.1.1 Respondents

For this functionality, one respondent answered the questionnaire:

- Mobility Department Manager, Rennes Métropole

Other stakeholders shared their feedback during online and on-site meetings and demonstrations of the tool, and are aligned with the results presented in this section.

4.2.1.1.2 Results

<u>Usability and reliability</u>

The respondent thinks that the amount of information on the dashboard is correct, but the elements displayed (maps and figures) are only mediumly clear and relevant. The information on live traffic and incidents is considered easy to understand, but the live public transport information clarity is average.

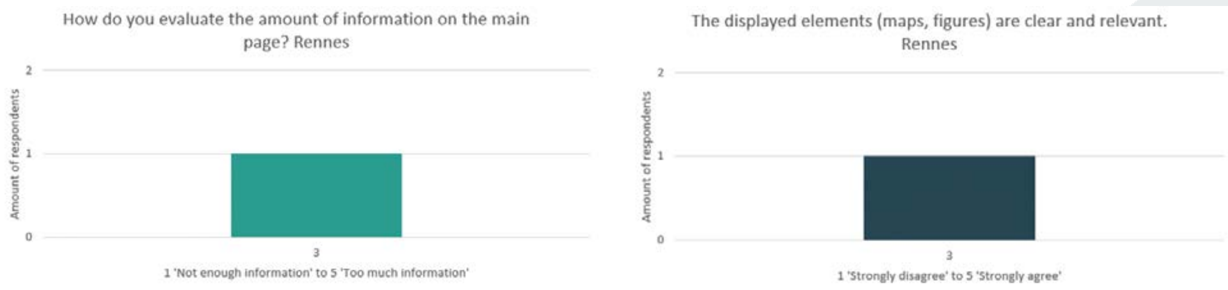


Figure 40: Clarity of the dashboard

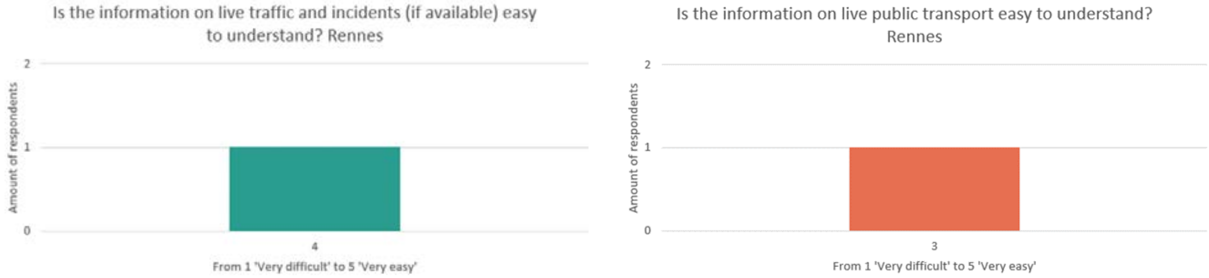


Figure 41: Information on the dashboard easy-to-understand

The customization option is easy to parameter: however, a comment specifies that a layer to select or unselect the public transport lines would have been appreciated.

On the general use of the tool, it is assessed as a little bit complex, but easy to use, and the respondent imagines that most people would learn to use the tool easily.

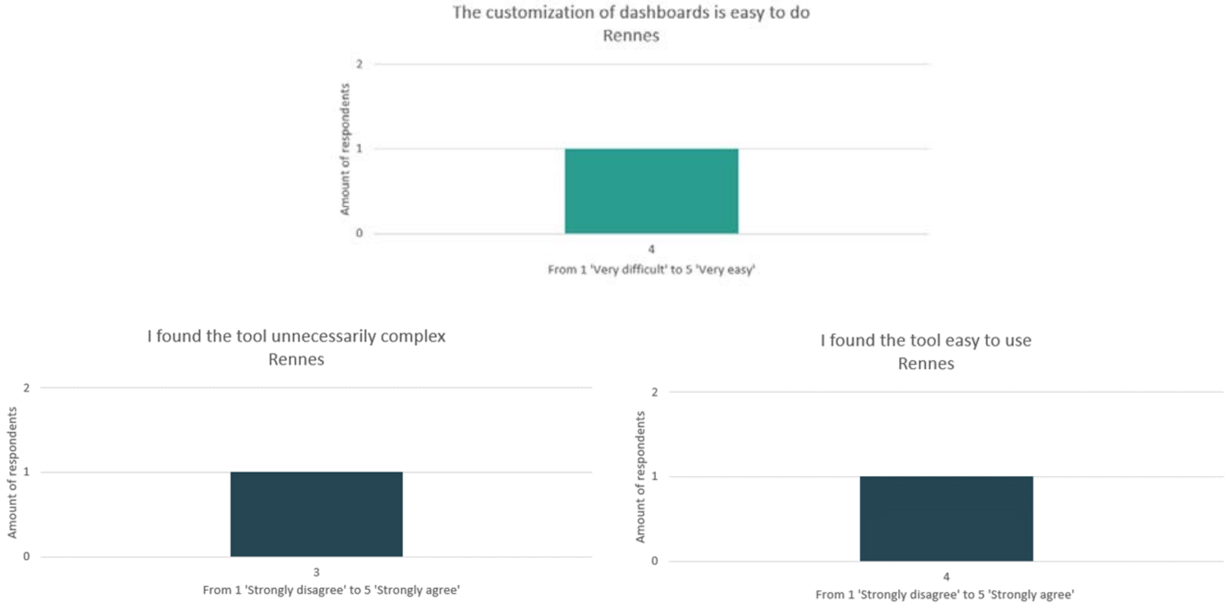
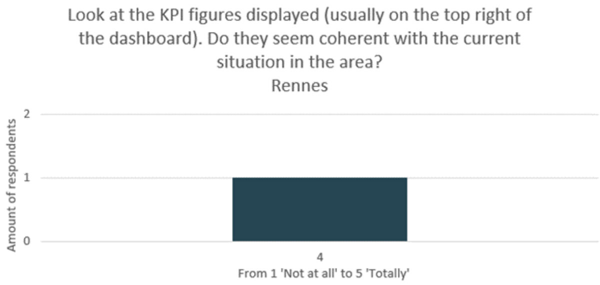
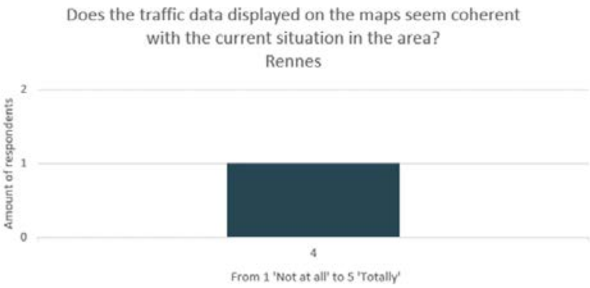


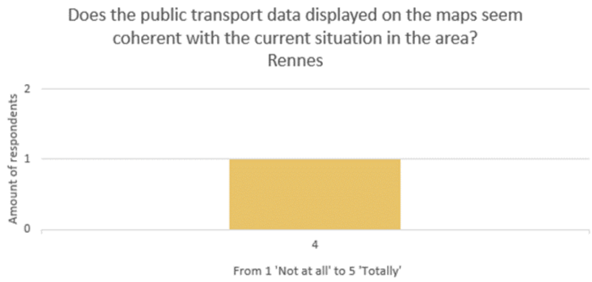
Figure 42: Complexity of the dashboard and the customizer

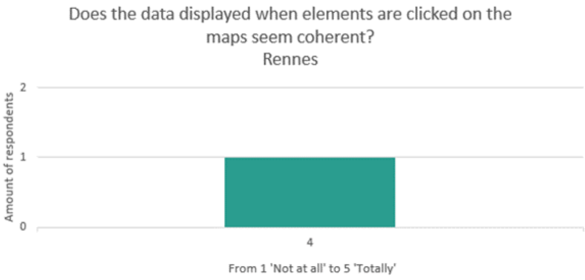
Accuracy of the information

Regarding the correctness of the elements displayed, the KPIs and the traffic data displayed on the maps seem coherent with the current situation in the area. The same result occurs for the public transport data displayed on the maps, and the data displayed when the elements are clicked on the map.









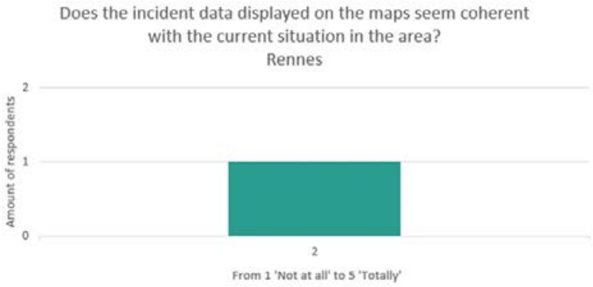


Figure 43: Coherence of the KPIs and the maps displayed

However, the incident data displayed on the maps do not seem coherent with the current situation. This is detailed by the comment noted by the respondent: no traffic incident data was displayed on the map.

Compliance with initial requirements

To the question “Do you think the city data sources are well covered?”, the respondent answered “Neutral”, with a comment explaining that the traffic data from Rennes Métropole and the BreizhGo regional coach’s data weren’t used, which gives a partial result and wouldn’t permit a global supervision for distinct traffic managers and public transport operators.

For the Rennes case study, Rennes Métropole and ID4MOBILITY have defined 5 expectations at the beginning of the project, related to this functionality (current state of the network). The following feedback has been shared by the respondent:

Expectations	Not met	Partially met	Totally met
Expectation 1: Visualise the current traffic and the congestion in the area defined			X
Expectation 2: See the state of the public transport (buses in the area)		X	
Expectation 3: Notice the delay of the various services (buses, shuttles)			X
Expectation 4: Visualise the planned elements that disrupt the traffic (road works, blocked road, etc.)	X		
Expectation 5: Display traffic and public transport statistics and choose the granularity		X	

Table 12: Assessment of the expectations of Rennes for the functionality "Current state of the network"

The expectation 4 is not met at all, because no incident data was displayed on the dashboard.

Overall, the respondent from Rennes Métropole is satisfied with the first functionality implemented, with some elements highlighted for improvement, such as the visualisation of public transport current status, the use of the data sources provided at the beginning of the project, and the visualisation of incidents.

4.2.1.2 Future state of the network

The step 2 of the testing aimed at assessing the second functionality of Service 1: **Future state of the network**, during daily commuting.

To this purpose, a meeting was organised between Rennes Métropole, A-to-Be, and ID4MOBILITY.

4.2.1.2.1 Results

Usability and reliability

- Visualising the future state of traffic conditions is particularly interesting because this feature does not exist in other existing traffic management tools (road or TC) currently available.
- The use case, restricted to the Lorient road section, has therefore led to a specific modelling on the Lorient road sector.
- The stakeholders who participated in the global demonstrations agreed that, for a partnership traffic management tool, a visualisation on the entire network would be necessary.

Accuracy of the information

The colours used for the forecasts presented in the tool give the impression that the information is not consistent with the actual observation that can be made on the evolution of traffic conditions. The indicators on average speed changes are more realistic. Furthermore, the comparison between the real-time KPIs and the forecasting seemed wrong. Indeed, as mentioned in 2.3 “Forecasting and Critical Conditions”, the observations in real-time monitoring include more segments than the predictions. Historical data of these segments weren’t available when the models were trained, therefore averages over all these segments aren’t comparable at this point. At this point, it is crucial to allow the case studies to parameter the KPIs to specific geographic regions, such as the case study area, to enable coherent comparison of the elements displayed.

Compliance with initial requirements

The visualisation tool is generally in line with what was expected, as it also makes it possible to highlight indicators on the evolution of average speeds in this sector.

4.2.1.3 SNLB: Informing the transport passengers

Step 3 of the testing aimed at assessing one of the functionalities of Service 2: **SNLB - Informing the Transport Passengers**.

Once integrated in the dashboard, the objective of this functionality is to allow the traffic and public transport managers to create dissemination plans that can be activated by a list of designated profiles. Once a dissemination plan is activated, it triggers when the previously defined triggering conditions are reached and displays the parameterized message and real-time data on the chosen dashboard, to the chosen profiles.

The functionality and the steps of the dissemination plan creation are further described in D6.5.

The first assessment of this functionality was performed through an online meeting with the following partners: Rennes Métropole, A-to-Be and ID4MOBILITY. First, A-to-Be presented the functionality with a demonstration on the platform, creating a dissemination plan. Then, Rennes Métropole tested the functionality and created their own dissemination plans and finally, the city asked several questions and shared feedback.

Rennes was the first case study to assess this functionality.

Feedback from Rennes Métropole:

- Interest in the functionality to:
    - Highlight the Public Transport lines that have delay
    - Communicate with the DIRO (Direction interdépartementale des routes Ouest) that is in charge of road management of a portion of the test area, to change the traffic plans and the priorities to the PT
    - Indicate the need to change the traffic plans for scenarios that are not planned
- Propositions of evolutions:
    - Have the possibility to parameter a combination of conditions (OR or AND)
    - Integrate the forecasted data as conditions of triggering
    - Select a narrower geographical zone by zooming in
- Difficulties / Questions:
    - What is the difference between “Minimum Level of Service” (LoS) and “Triggering conditions”, when indicating the triggering conditions to parameter a dissemination plan?

The feedback from Rennes Métropole gives elements to iterate and improve the functionality in order to match the needs and challenges of the case studies. It also gives elements to propose to the other case studies, during their tests. Once the three non-virtual case studies have provided their comments, the evolution proposals that emerged most frequently and that are the most relevant were studied to be integrated in the next iteration.

Common section to D7.3, D7.4, D7.5 (the Rennes, Lisbon and Greater Manchester case studies deliverables)

The testing meetings with each non-virtual case study to test this functionality were extremely useful to highlight common improvements to implement on the Dashboard, in order to improve SNLB - Informing the Transport Passengers. The following elements were implemented:

- Geographic filtering is now available in the Customizer, in order to create a Dashboard with maps and indicators focused on some specific geographic areas. It can then be used for this functionality: the user can parameter a dashboard on a specific area and choose it when creating a dissemination plan. It is also relevant for the previous functionality tested “Future state of the network”, for which the users can define specific indicators both for real-time and forecast, and compare the two types of KPIs.
- The trigger conditions can be defined using any indicator widget. This allows the use of Forecasts and filtered data as triggering conditions too.
- It is possible to add more than one triggering condition and define the parameters of these several conditions: conjunction (“and”) or disjunction (“or”)
- Data filtering: in the same way as the geographic filtering, when creating a new map or a new indicator in the Customizer, the user can select the data he is interested in visualising
- The messages of the dissemination plan are published in an AMQP Exchange, allowing integration with other systems for further distribution

End of the common section

4.2.1.4 CIM: Synchronisation of Public Transport and Traffic Control

Due to a higher-than-expected technical complexity of the module developed in WP5, required by the functionality Synchronisation of Public Transport and Traffic Control, its testing can only be reported by mid-November 2024.

4.2.1.5 Simulation of predefined scenarios: What-if one of the lanes was dedicated to car-pooling?

Due to a higher-than-expected technical complexity of the module developed in WP5, required by the functionality What-if simulations, its testing can only be reported by mid-November 2024.

However, some tests were carried out offline (i.e., not integrated in the dashboard yet) in collaboration with AIMSUN and Rennes Métropole, as explained in section 2.4.2. “Preliminary results of what-of scenarios simulations”.

These results were very useful for the case study to carry out a first assessment of the relevance of the what-if simulations and the parameters in input for the different scenarios simulated.

4.2.2 Tests during specific events

The planned events for Rennes case study have been defined as football games at Rennes Stadium (Roazhon Park) and the beginning of holidays and long weekends.

The following functionalities have been assessed simultaneously during defined planned events:

- Service 1: Current state of the network: traffic and public transport
- Service 1: Future state of the network: traffic and public transport
- Service 2: SNLB: Informing the transport passengers: Dissemination Plan to spot congestion and high PT delays

This test has been notably performed during a football game, on a Saturday evening. The football match happened on October 5th, from 21:00 to 23:00. To assess the reliability of the platform, the same elements have been monitored the week after the planned event, a Saturday evening, with no event in Rennes.

The first screenshot below (Figure 44) displays the dashboard during the football game, the second (Figure 45) the week after, with no event, both around 19:00. The dashboards show that, even two hours before the event, differences can be spotted, mainly on the PT delay on the indicators.

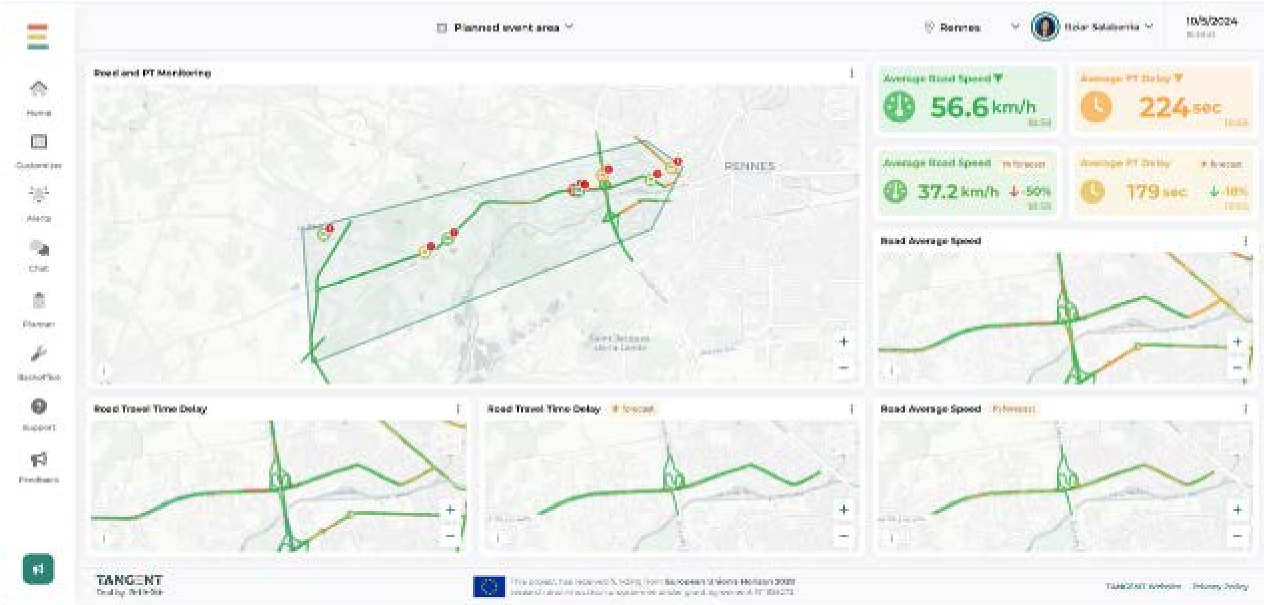


Figure 44: Rennes dashboard during a planned event (football game) at 19:00

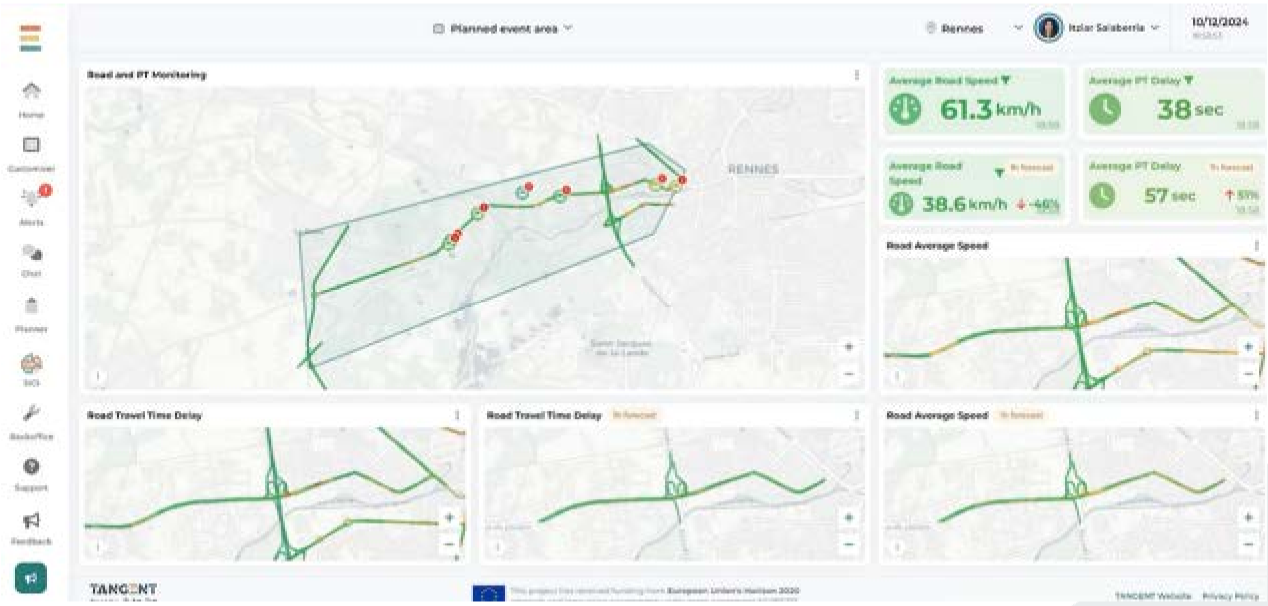


Figure 45: Rennes dashboard during a baseline scenario at 19:00

At 19:25 on the match day, one of the dissemination plans triggered, identifying extremely high delays of the buses in the area:

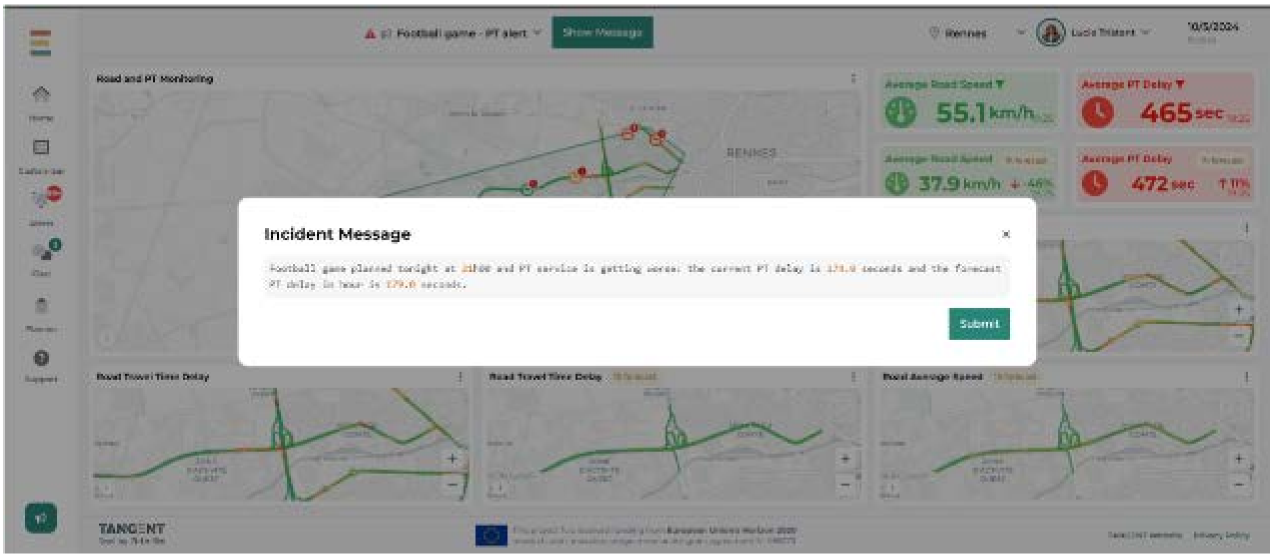


Figure 46: Dashboard during a planned event with the functionality "Dissemination Plan" triggered

This previous image highlighted the increased PT delay that has doubled in half an hour.

An hour before the event, the situation is even worse, while during a non-match day, no high delay is to be noticed.

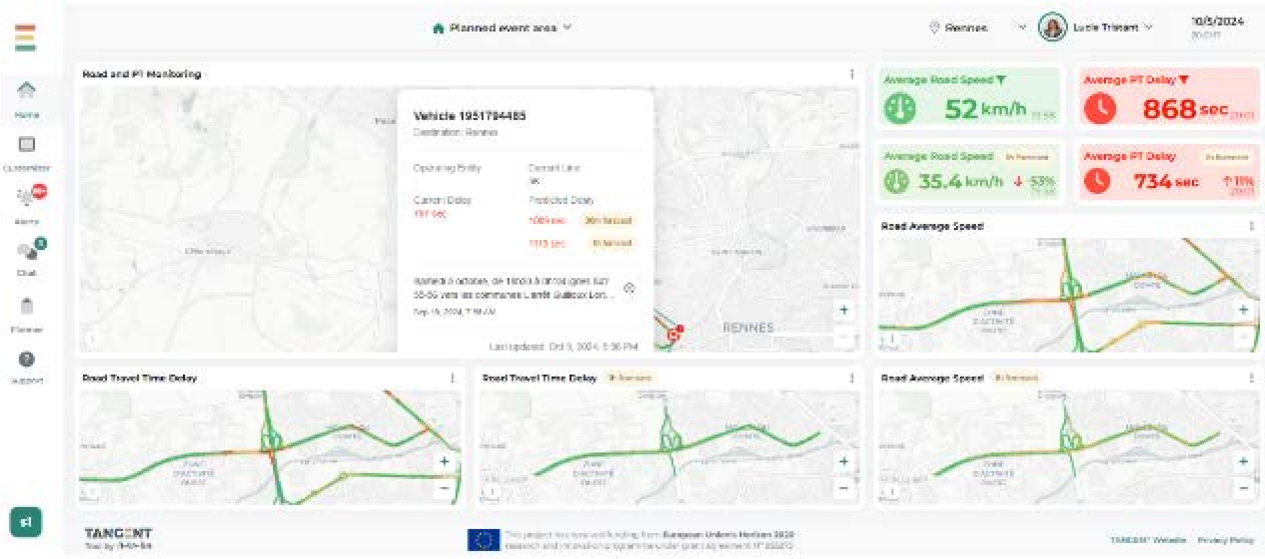


Figure 47: Dashboard during a planned event at 20:00

Figure 48: Dashboard during a baseline scenario at 20:00

At around 21:30, once the match has started, the situation is getting better, with a more normal road speed, and less delay for PT.

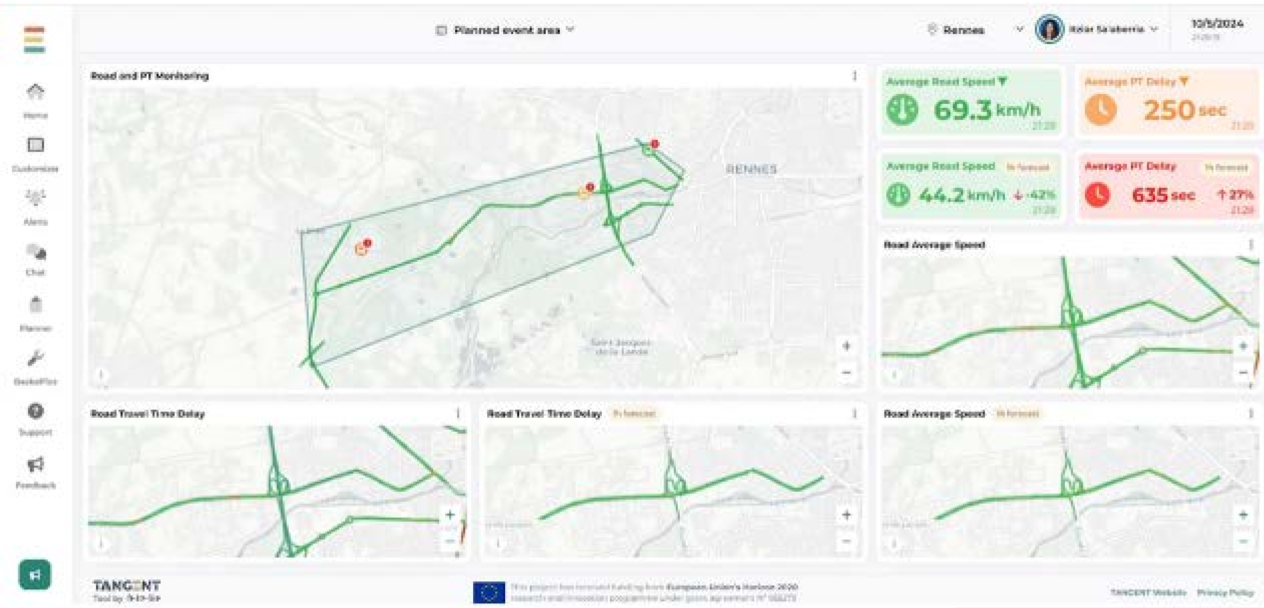


Figure 49: Dashboard during a planned event at 21:30

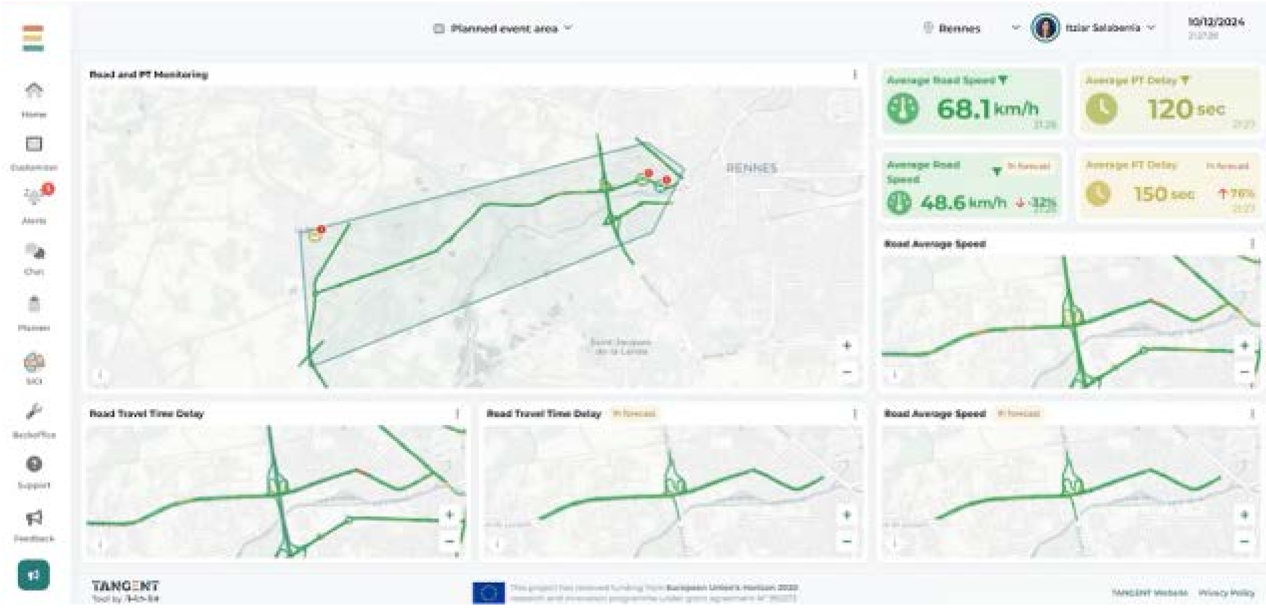


Figure 50: Dashboard during a baseline scenario at 21:30

Usability and reliability

The dashboard allows the users to easily spot the changes of traffic and PT during the planned event. The operators are used to the tool, they have then customised the dashboard to observe the desired elements. The indicators seem more appropriate to notice a sudden or gradual change in the quality of the offer, this is mainly due to the traffic that is less impacted than the buses and still appears green or orange.

The message programmed in the dissemination plan triggered when it was supposed to, following the real-time KPIs.

Accuracy of the information

The PT delays were indeed encountered by KEOLIS Rennes buses. It seems that the expected speed road should have been lower before the beginning of the game. This could be explained by the area that consider the ring road (from north to south), which average speed is higher than the other streets (90 km/h versus 50 km/h), and, although some congestion might have happened at the exits of the ring road, the other lane was not totally congested. The average speed might not represent the issues encountered.

The other remark that can be done is about the predictions of the PT delays: they seem less reliable during a planned event such as a football game, compared to a baseline situation with no event. This is because only data-driven predictions are incorporated in the live dashboard. As data-driven predictions, based on deep learning models, train on historical data, they can only predict accurately on data it has regularly seen before. Given that events are scarce in the historical dataset in comparison to normal traffic patterns, the deep learning models aren't designed to give accurate predictions during non-recurrent events. As described in D4.6 "Framework for real-time traffic monitoring and forecasting", it was never intended to use data-driven predictions during those events. They are used to detect events as anomalies (e.g., non-recurrent congestion) as described in D4.4 "Report on the detection and impact analysis of traffic events". Herein, the congestion evolution was furthermore quantified through congestion duration modelling. Subsequently, simulation models allow the representation of an occurring incident and its replication in a simulation environment in near real-time. Therefore, in such situations, data-driven supply prediction models can benefit considerably from the incorporation of information from simulation-based predictions, as shown in D4.6 for the case study of Athens in the case of heavy rainfall and consequential flooding events.

5 Lessons learned and next steps

5.1 The lessons learned from TANGENT for Rennes case study

5.1.1 Multi-actor collaboration on traffic management

TANGENT, and especially the demonstrations and the workshops in relation to WP1, has enabled Rennes Metropole to specifically identify the interlocutors between the various network managers (traffic and PT) between Rennes Metropole, the DIRO and the Brittany Region.

It also made it possible to take time, within the framework of these workshops, to share the common needs, and the possibilities offered by the tool, or to be continued on specific partnership.

A dashboard such as TANGENT could definitely be a great tool to help organising a multi-actor collaboration

5.1.2 Data sharing / availability / reliability

The various stakeholders (Region, DIRO, Rennes Metropole) easily contributed to make their data available. The majority of them are also accessible in open data on the National Access Point (NAP).

A large amount of data was thus made available to the project's technical partners.

However, technical partners have reported difficulties in exploiting some of it, leading to a more limited visualisation than could have been expected.

A general feedback exchange with the technical partners highlighted some difficulties due to missing or incomplete metadata descriptions.

Consequently, technical partners were unable to accurately map this information to another standard, such as DATEX II, because it lacks clarity on the possible values for this field.

5.1.3 Functionalities of TANGENT

5.1.3.1 Current State of the Network

The functionality to view traffic conditions in real time for buses and general traffic was highly appreciated by the various operators (roads and public transport), notably with the layers of data sources from various transport modes, which allows all the stakeholders to be aware of the situation of the network. This feature does not exist today in Traffic management tools the stakeholders have.

5.1.3.2 Future State of the Network

For BreizhGo (regional) coaches, this feature is interesting because it allows having a certain flexibility in the choice of routes. The operator can adapt the route or adjust certain bus departures according to the preview of traffic conditions.

5.1.3.3 Dissemination Plan

Interesting but not yet fully mature between the different network operators. The messages to be coordinated are not easily automated, which requires a certain adaptation to different situations.

In addition, for public transport on the STAR network, there are limited capacities for adaptation since the route is fixed.

It would be interesting to share the work forecasts. The API is available but has not, to date, been uploaded and able to be tested to the tool.

5.1.3.4 Synchronisation of PT and TC

This has not been tested yet for the Rennes Case study

5.1.3.5 "What-if scenarios"

This has not been tested yet for the Rennes Case study

5.1.4 TANGENT Dashboard

If a dashboard like TANGENT was on the market, it would be more adapted if it was integrated to our management system (such as being integrated/merged with our current management system). In terms of market, it would be more adapted to Rennes use case to have the TANGENT tool integrated in one of the traffic management systems whose companies respond to the calls for tender of the metropolis.

5.1.5 TANGENT project in general

The project helped Rennes to have a broader vision on the technical specifications and functionalities Rennes Métropole will require when they will consider changing or updating our system.

The interactions with the other cities were interesting to discover the challenges of other European cities. It would have been interesting to have more crossed-discussions with the 4 case studies.

5.2 Next steps after the end of the project

After the end of the project, Rennes case study will take into consideration the results and lessons learned of the project to move forward and continue to improve the multimodal traffic management in the Rennes metropolis. In short term, the following will be done:

- Rethink the traffic management system and its usage (to be more collaborative / add functionality with our current supplier/ …) in Rennes Métropole
- Rethink the way the data is collected or shared
- Increase working groups or meetings with the local stakeholders to improve the multi-actor traffic management

6 Conclusions

The deliverable D7.3 aimed at presenting the activities of Rennes case study during the development and the assessments of the subsystems and overall systems created by the technical partners. In this way, the first part of the activities consisted in testing the subsystems in collaboration with the technical partners, to assess the accuracy of their results. The technical partners have shared their testing methodologies, which differ according to the elements to assess (surveys, meetings, document and mail exchanges), and their results. The second part of the Rennes case study activities is related to the assessment of the overall tool, in which the subsystems have been integrated gradually to create the functionalities of the platform. The functionalities have been evaluated by the case study with the support of the relevant partners, to assess the usability and reliability of the dashboard and the functionalities, the accuracy of the elements displayed, and the compliance with the initial requirements defined at the beginning of the project.

The iterative methodology used to evaluate functionality enabled the tool to be improved and modified to meet the needs of the case study in a specific and customised way. Globally, the testing activities have shown that the dashboard easy-to-use, the elements displayed are clear and relevant. The customizer is powerful and offers a great adaptation. Some elements, such as public transports and incidents are more complicated to display in a user-friendly way. The dashboard is complex and rich in terms of possibilities (e.g. planner and customizer), which requires time and training to handle it properly. The assessment of a few functionalities is still pending, due to higher-than-expected technical complexity of a module developed, the testing activity will continue until the end of the project. This highlights the issues that can be encountered in Research & Development projects, especially with a low TRL.

Key lessons were learned by Rennes case study, first about the involvement of local stakeholders. The testing activities have allowed Rennes to clearly identify the relevant interlocutors between the various network managers (traffic and PT) between Rennes Metropole, the DIRO and the Brittany Region, but also with transport operators, locally for the urban buses, and regionally for the regional coaches. Even if Rennes was already in contact with them, the different demonstration sessions allowed to set up a working and collaborative process that will continue after the end of the project.

Another lesson learned is the importance of the availability and the reliability of data sources. Even if a large amount of open data sets from various sources has been shared with the technical partners, some elements didn’t appear on the dashboard, mainly because the technical partners have reported difficulties in exploiting some data sources.

The testing activities enabled the case study to have a broader vision on the technical specifications and functionalities Rennes Métropole could require when they will consider changing or updating our system.

The main next steps for the case study are to rethink the tools and the traffic management system and its usage (to be more collaborative / add functionality with our current supplier/ …), but also to reconsider the way the data is collected or shared and increase working groups or meetings with the local stakeholders to improve the multi-actor traffic management.

7 References

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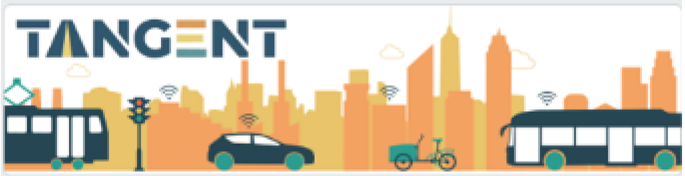
Annex I: Online survey for the testing of the functionality "Current state of the network"



TANGENT - Testing of the dashboard: STEP 1

From April to September, several tests will be run to assess the different functionalities added progressively on the TANGENT Dashboard. The aim is to carry out these tests on a regular basis, until the complete tool and all its functionalities are tested before the end of September 2024.

This is **STEP 1** of the testing of the TANGENT Dashboard. **This testing runs from April, 3rd to April, 29th**. After this date, the functionality will remain on the dashboard, but its testing will be considered as finished.

STEP 1 consists of testing: TANGENT Dashboard for the current state of the network monitoring, during daily commuting. Please try to answer this form from your experience during peak hours.

To answer this form, you need to access in parallel to the dashboard **XXX**, using the credentials you received by email from "**XXX**".

This form aims to assess 3 aspects of the dashboard:

1. **Usability and reliability**: Evaluate the user-friendliness and the clarity of the dashboard
2. **Accuracy**: Assess the correctness of the data, maps and elements displayed
3. **Compliance with initial requirements**: Review and update of the expectations listed at the beginning of 2023.

Thank you for your participation! Your feedback is extremely valuable for improving the TANGENT dashboard.

The TANGENT testing team.

Introduction questions

What is your full name? *

Votre réponse

What is your role in the city (job title / department / organization) *

Votre réponse

Dashboard Usability and Reliability

This section aims to assess the user-friendliness and the clarity of the dashboard and the functionality.

Use your credentials and access to the TANGENT Dashboard.

Before clicking anything, spend 10-15 seconds looking around the main page.

How do you evaluate the amount of information on the main page? *

	1	2	3	4	5	
Not enough information	○	○	○	○	○	Too much information

The displayed elements (maps, figures) are clear and relevant *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Let's start playing with the tool!

Click on the top right of a map and select "Expand" to make it bigger. You can move the mouse over the map, zoom in and zoom out, click on elements to get more information. Repeat for other maps as needed.

Is the information on live traffic and incidents (if available) easy to understand? *

	1	2	3	4	5	
Very difficult	○	○	○	○	○	Very easy

Is the information on live public transport easy to understand? *

	1	2	3	4	5	
Very difficult	○	○	○	○	○	Very easy

Any other comment regarding live data?

Votre réponse

Let's customize the dashboard!

If you do not have the access to customize the dashboard, you can skip this question. Otherwise, if you haven't yet, try using the customizer. If you need help, you can take a look at the tutorial video: https://www.youtube.com/watch?v=cybPjJvsNx4

The customization of dashboards is easy to do

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Any other comment regarding customization?

Votre réponse

Global feedback on the TANGENT Dashboard

Overall review of the usability & user-experience of the TANGENT Dashboard

I found the tool unnecessarily complex *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I found the tool easy to use *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I would imagine that most people would learn to use this tool very easily *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Any other comment / question on the user experience?

Votre réponse

Accuracy of the elements displayed

This section aims to assess the correctness of the data, maps and other elements available on the dashboard.

Look at the KPI figures displayed (usually on the top right of the dashboard). Do they seem coherent with the current situation in the area? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Totally

Does the traffic data displayed on the maps seem coherent with the current situation in the area? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Totally

Does the incident data displayed on the maps seem coherent with the current situation in the area? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Totally

Does the public tranport data displayed on the maps seem coherent with the current situation in the area? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Totally

Does the data displayed when elements are clicked on the maps seem coherent? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Totally

If you found difficulties in any of the previous elements, please describe them.

Votre réponse

Rennes requirements

Do you think the city data sources are well covered? *

1	2	3	4	5
○	○	○	○	○

As a mobility expert, you have listed your expectations for this functionality

Expectation 1: Visualise the current traffic and the congestion in the area defined

Have your initial expectation been met? *

- ○ Totally
- ○ Partially
- ○ No

Expectation 2: See the state of the public transport (buses in the area)

Have your initial expectation been met? *

- ○ Totally
- ○ Partially
- ○ No

Expectation 3: Notice the delay of the various services (buses, shuttles)

Have your initial expectation been met? *

- ◯ Totally
- ◯ Partially
- ◯ No

Expectation 4: Visualise the planned elements that disrupt the traffic (road works, blocked road, etc.)

Have your initial expectation been met? *

- ◯ Totally
- ◯ Partially
- ◯ No

Expectation 5: Display traffic and public transport statistics and choose the granularity

Have your initial expectation been met? *

- ◯ Totally
- ◯ Partially
- ◯ No

Have your initial expectations changed? *

- ◯ Yes
- ◯ No

If the previous answer is yes, what has changed? *

Votre réponse

Any other comment?

Votre réponse