Ref. Ares(2024)3178639 - 30/04/2024

UPPER
Unleashing the Potential of Public Transport in Europe

U-SIM

D3.2 U-SIM: simulation-based tools to evaluate the short and medium-large term impact of the urban mobility measures

WP3 Supporting tools and solutions to plan and develop user-centric and PT oriented infrastructure

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101095904

UPPER contributes to achieving the aims of the CIVITAS Initiative and the goals of the EU Mission: Climate Neutral and Smart Cities

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Deliverable details

Project number	Project acronym	Project title
101095904	UPPER	Unleashing the potential of public transport in Europe

Title	WP	Version
D3.2 U-SIM: simulation-based tools to evaluate the short and medium-large term impact of the urban mobility measures	3	1.0

Contractual delivery date	Actual delivery date	Delivery type*
30/04/2024	30/04/2024	R

*Delivery type: **R**: Document, report;
DEM: Demonstrator, pilot, prototype;
DEC: Websites, patent fillings, videos, etc;
OTHER;
ETHICS: Ethics requirement;
ORDP: Open Research Data Pilot.

Charlotte Fléchon	PTV
Daniele Tiddi	SIS
Francesco Gabbuti	SIS

Document history

Version	Date	Person	Action	Status*	Dissemination level**
V0.1	From 27.02.2024 to 08.04.2024	Charlotte Fléchon (PTV) Daniele Tiddi (SIS) Francesco Gabbuti (SIS)	Contents and draft	Draft	CO

V0.2	08.04.2024	Charlotte Fléchon (PTV)	Cleaning up of the document for review	Draft	CO
V0.3	22.04.2024	Mattia Pretti (SIS), Marco Surace (RSM), Charlotte Fléchon (PTV)	Review and corrections	Draft	CO
V0.4	25.04.2024	Mircea Steriu (UITP)	Review of the document	Draft	CO
V0.5	26.04.2024	Charlotte Fléchon (PTV), Daniele Tiddi (SIS)	Corrections and addition of 2.6 development timeline	Draft	CO
V1.0	30.04.2023	Charlotte Fléchon (PTV)	Final version to be submitted	Submitted	PU

*Status: Draft, Final, Approved, Submitted (to European Commission).

Dissemination Level: **PU: Public;
CO: Confidential, only for members of the consortium (including the Commission Services);
EU-RES: Classified Information - restraint UE;
EU-CON: Classified Information - confidential UE;
EU-SEC: Classified Information - secret UE

Contents

Abstract

The UPPER project envisions a transformative future for public transportation in European cities. Its primary objective is to position public transportation as the cornerstone of urban mobility systems. To achieve this ambitious vision, UPPER is set to implement and evaluate around 80 measures that aim to discourage private vehicle usage ("pushing") and enhance public transport ("pulling"), emphasizing inclusivity and Mobility as a Right (MaaR). To support the implementation of these measures, the UPPER project is developing a "Support toolkit" comprising of seven innovative technology-driven solutions. The project's success depends on understanding the technical, operational, and governance requirements and regulatory constraints to be met by both the nearly 80 measures and the UPPER support toolkit. This deliverable introduces 2 of the tools of the toolkit: the simulation tools U-SIM.plan and U-SIM.live.

This document presents an overview on the purposes, requirements, and functionalities of the U-SIM tools: U-SIM.plan and U-SIM.live.

Keywords

Public Transport, mobility management, simulation, modelling, real-time, planning, operation

Introduction

U-SIM is part of the UPPER toolkit provided to support the cities and regions of the consortium to implement their measures. In order to address modelling of both offline strategic planning and real-time decision support, U-SIM is split into two pieces of software: U-SIM.plan and U-SIM.live.

U-SIM.plan is an already existing offline desktop application for strategic planning macroscopic modelling tool also known under the commercial name PTV Visum. U-SIM.plan is a comprehensive, flexible software system for transportation planning, travel demand modelling and network data management. Designed for multimodal analysis, U-SIM.plan integrates all relevant modes of transportation (trains, metros, trams, buses, pedestrians, bicyclists, cars and trucks) into one consistent network model. It makes it the standard for macroscopic simulations and macroscopic modelling of transport networks and transport demand, public transport planning, and for the development of transport strategies and solutions, providing insights for long-term strategic planning but also short-term operational use. As part of Work Package 2, we have gathered the necessary requirements for U-SIM.plan and compared them with the already existing functionalities of the commercial software. The comparison shows that no additional developments are required. Consequently, there are no plans for further development within the scope of this project; instead, the focus will be on the application of the existing software. Therefore, the relevant section in this document is concise and includes references to existing documents for further information.

On the other hand, U-SIM.live is a tool that is being developed as part of the project. U-SIM.live is a real-time simulation-based decision support platform for public transport operators and agencies. It uses live data and curated data about public transport (PT) provided by the UPPER U-TWIN tool: schedule modifications, service disruptions, live PT vehicle positions, and passenger counts on board, at stations/stops and boarding/alighting. With these, it provides continuous data analytics, generates alerts, and supports the operational decisions, by allowing to simulate on-the-fly alternative mitigation strategies, and quantify the resulting effects of each of these. The functionalities defined for this tool rely on the requirements collected at the beginning of the project and reported in deliverable D2.4 and on one-to-one discussions with the cities and regions involved in the project. The tool is currently under development and the first version is planned to be released in April 2025 to the partners of the project.

This document gives an overview of the U-SIM.plan and U-SIM.live tools.

1. U-SIM.plan

1.1. About U-SIM.plan

1.1.1. Overview

Visum is an offline desktop application that is mostly used for strategic planning. It determines the impacts of existing or planned transport supply which can encompass both the private transport road network and the public transport network (including timetables) on demand.

Fields of application for planning tasks in Public Transport (PT)

- Planning and analysis of line networks
- Design and analysis of timetables
- Estimation of driver and vehicle requirements

- Cost-benefit analyses

Display (graphic/tabular) of PT-specific indicators (sold tickets, number of passengers boarding/alighting, number of students per zone or stop)

- Evaluation and display of passenger numbers and other indicators per transport system, link, stop, line, and operator
- Creation of presentation graphics to illustrate different planning variants
- Calculation and forecast of territory and operator-specific expenditure and revenue indicators
- Operational indicators for line costing calculation
- Generation of subnetworks with corresponding partial demand matrices

a) Fields of application for planning tasks in Private Traffic (PrT)

- Simulation of transport planning measures or construction measures to forecast resulting traffic volumes and their impacts
- Prognosis of the impacts of road tolls
- Intersection capacity analyses
- A separate analysis of different PrT transport systems (car, HGV, bicycle)
- Comparison of a demand matrix with current counted data
- Determination of noise and/or pollution emissions
- Generation of subnetworks with corresponding partial demand matrices

b) Possible applications for planning tasks with new forms of mobility or combinations

- Assessing the sustainability and efficiency of mobility services
- Determination of the fleet size
- Estimation of the expenses for relocating vehicles
- Cost-benefit analyses
- Studies on the extended accessibility of conventional public transport
- Estimation of the modal shift due to the introduction of new forms of mobility

1.1.2. Intended audience

U-SIM.plan is used by a variety of mobility industry stakeholders. These can be, but not limited to, the strategic planners of public transport services, operators, authorities, decision-makers, investors, and procurement officers.

1.1.3. Technical Readiness Level (TRL) Explanation

U-SIM.plan is a software already widely used, therefore with TRL9.

1.2. System Requirements

1.2.1. Hardware Requirements

The hardware requirements are summarized in Table 1.

Table 1 Hardware requirements to install and use U-SIM.plan (PTV Visum)

	Minimum	Recommended for standard installation
Processor	X64 processor with support for SSE4.2, e.g.: • Intel Core i5 / Core i7 • AMD FX	Recent multi-core processor, e.g.: • Intel Core i7-12700K, i9-12900K, i9-12900KS • Intel Xeon W-1370, W-1370P, W-1390P • AMD Ryzen 9 5900X, Ryzen 9 5950X or better[1]
Memory	4 GB	16-32 GB or more[2]
Disk space (software)	2 GB free disk space per product for compact installation	5 GB free disk space per product for full installation
Monitor	Screen resolution 1280x800 or 1366x768 pixels	Full HD (1920x1080 pixels) or higher resolutions, multiple screens are supported
Graphics Card	For 3D Graphics OpenGL® 3.0 or DirectX 11 support is recommended e.g. Geforce Rtx 4070	
USB / Network	• In case the license is provided in relation with a hardware dongle a full USB port is required for operation. • In case a network license is provided, access to a license server in the local network or the internet is required for operation.	
Disk space (project data)	Sufficient storage capacity for project data handling, ideally on SSD	

1.2.2. Software Requirements

U-SIM.plan runs only on windows:

- Microsoft Windows 10, latest release
- Microsoft Windows 11, latest release
- Microsoft Windows 2012 Server R2, latest Service Pack
- Microsoft Windows 2016 Server, latest Service Pack
- Microsoft Windows 2019 Server, latest Service Pack
- Microsoft Windows 2022 Server, latest release

The software can usually be run on most other versions of the Microsoft Windows operating system as long as they are currently supported by Microsoft. Restrictions may apply to older LTSB/LTSC or Education editions of Microsoft Windows.

1.3. Getting started

1.3.1. Access/Authentication

U-SIM.plan can be downloaded under its commercial name PTV Visum from the PTV download server https://cgi.ptvgroup.com/visionSetups/en/. For more information on how to install the software, the installation manual can be downloaded from the PTV download server as well. Inside this document help for getting started with the software is also given.

Furthermore, a valid license is required, licenses inquiries can be made through the PTV Group Website https://www.ptvgroup.com/en/contact.

1.3.2. User Interface Overview

The first screen to be seen when starting the software is the start page (see Figure 1). It gives an easy access to a wide range of services including the PTV Visum online help and the first steps tutorial which can also be followed on YouTube.

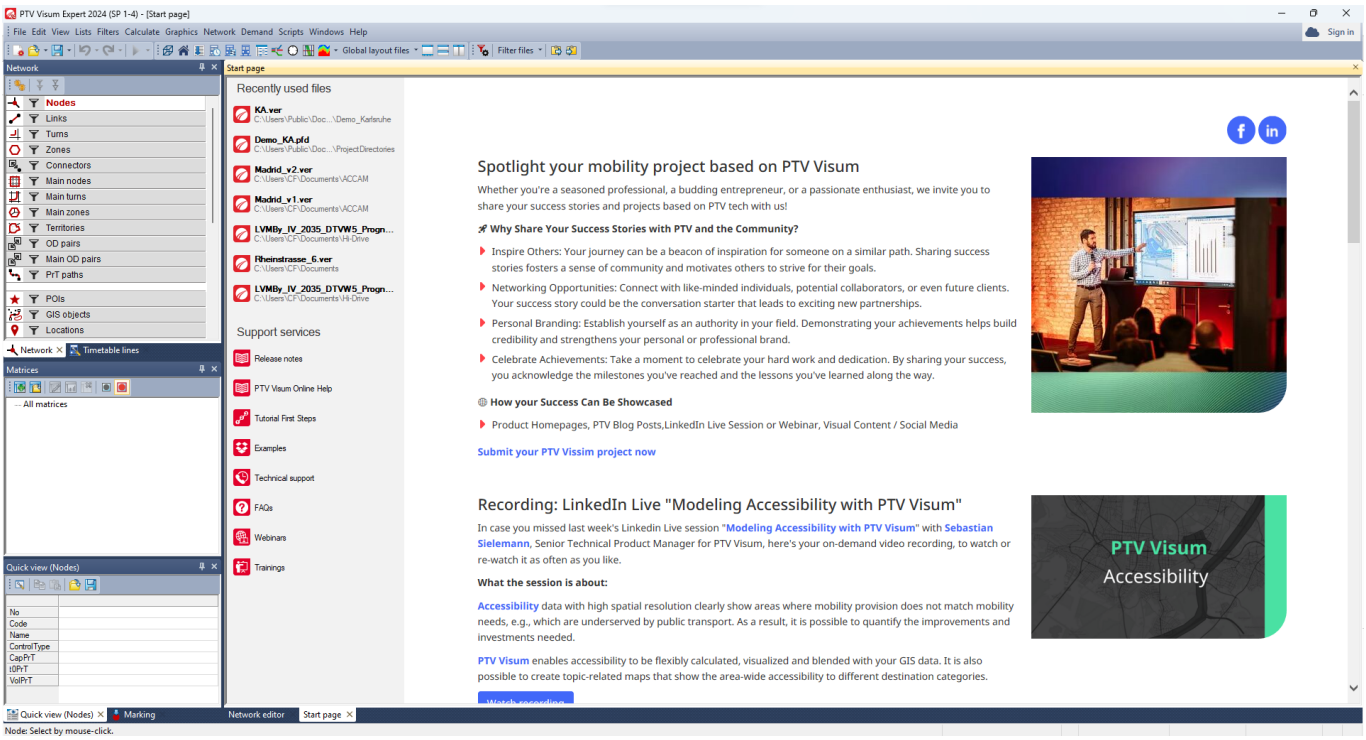


Figure 1 Start page of U-SIM.plan with links to first steps tutorial, release notes, VISUM help, support, etc.

By clicking on the tab “Network editor” at the bottom links of the window, one opens the Network editor view as shown on Figure 2.

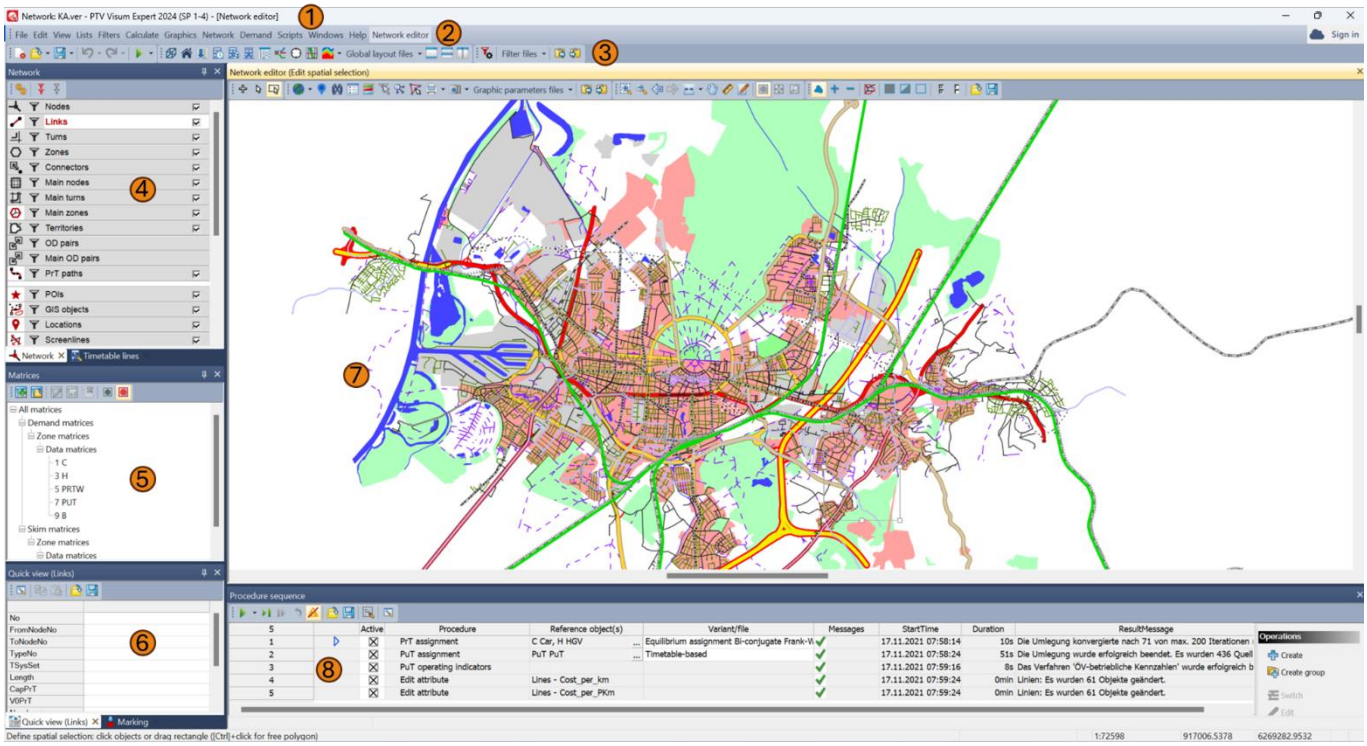


Figure 2 Network editor view. The numbering is explained in the text

(1) Title bar. The name and version number of the program are displayed as well as the name of the opened file and in brackets in the of the currently active window.

(2) Menu bar. The menus give access to the program functions. The menus provided on the menu bar refer to the currently active window and the commands provided in the Edit menu refer to the currently selected object type.

(3) Toolbars. The toolbars also give access to the program functions. The toolbars displayed refer to the window that is currently active.

(4) Network window. Here one can select a processing mode and an object type. Furthermore, one can enable or disable the graphical display of network object types or graphics object types and set filter per network object type. Additional functions can be accessed via the shortcut menu. Additionally, one can access the network objects relating to the currently highlighted network objects.

(5) Matrices window. Here on can view all the matrices contained in the model and edit them.

(6) Quick view window. Here the attribute values are displayed for the currently highlighted network object. In the Quick view window, one can edit the attribute values of the highlighted network objects.

(7) Network editor window. This window shows the network that is currently open. Here one can adjust the display and edit the network graphically. Using the scroll bars, one can move the currently displayed network section horizontally or vertically.

(8) The procedure sequence window. Here one can define calculations such as demand calculations or assignments and execute them in sequence.

Each window can be displayed full screen when needed and many other windows are available like for example timetable (graphical), timetable (tabular), transfers display of regular services, etc.

1.4. Functionalities of U-SIM.plan

U-SIM.plan is a very broad and versatile software enabling the modelling of a large variety of measures:

- Multimodal transport modelling:

plan transportation in a city or a region, get information on the mode split, analyse all travel processes in detail, and find the best solutions for present and future mobility challenges. It is possible to develop a master transportation system plan for the entire region, even when there is little data available.

- Public transport planning software: Optimize operations and user experience:

provides key figures on user experience (travel times, frequency, walking times, fares), as well as operational aspects and costs (operating times, performance kilometres, empty runs, vehicle requirements, depot use). Evaluates network and timetable variants and operating concepts. By combining strategic transport demand models with operational assessment tools, decisions can always be well-informed.

- Public transport planning software: Plan fleets, infrastructure, and electrification:

For the best long-term fleet procurement and maintenance, U-SIM.plan provides tools for travel demand forecasting, fleet planning, and operational concepts. Fleets with different types of vehicles can be allocated according to flexible criteria, including demand. It considers depot capacities, turning times, empty runs, and other factors. By comparing different scenarios, one can derive the optimal options for fleet procurement and operating costs. The transport planning software also considers electric vehicles - their unique energy consumption, charging processes, and charging infrastructure. Different operating concepts, such as overnight and opportunity charging, can be compared.

- Plan and integrate new modes of mobility:

supports transport planners and engineers to design, analyse, and integrate new modes of mobility. The transport planning software models cars, bikes, walking, and ride-sharing schemes, as well as their integration with all the variants of public transport. It is also possible to study the effects of autonomous and connected vehicles.

- Assess air and noise pollution from transport:

includes procedures for calculations of emissions and noise from transport, so you can assess these impacts without additional software. When used early in the planning process, it can help to detect unwanted effects of transport measures, such as increases in total emissions due to detours.

- Analyse toll systems, low emissions zones, and access restrictions:

models toll systems and access restrictions, such as low emissions zones (LEZs) or bans on trips for through-traffic. For area-wide restrictions like LEZs, the software considers resulting detours in routing and KPIs. Toll systems are studied as distance-based, area-wide, or tariffs between network access points. A special assignment procedure provides realistic representation of user preferences between toll costs and travel times. As a result, one can evaluate how tolls would affect users' route lengths, travel times and costs, and the expected revenues for operators.

- Manage and set up development scenarios:

with its integrated scenario management, U-SIM.plan enables effective preparation and evaluation of many scenarios. You can create and manage modifications to the model: infrastructure developments, new transit lines, population forecasts, and zoning policies. Scenarios can then be composed and evaluated in batch computations. Define and extract key KPIs according to planning goals and compare them to make the best plan for the community. Compare individual scenario variants, down to the smallest detail. When networks or inputs change, the scenario manager highlights the results which may no longer be valid.

- Activity-based demand modelling (ABM):

U-SIM.plan supports Activity-Based Demand Models (ABM), which model mobility decisions of individuals instead of groups of people. As a result, daily activity and travel schedules are created with information on start times, time spans, locations, and mode. One can easily integrate and manage ABM demand data; store surveyed or synthesized households, persons, tours, and trips; and connect them to the database. Trips can be assigned to static assignment paths for analysis. U-SIM.plan can also be used to import, manage, and analyse third-party highway and transit simulation model results.

- Create and maintain transportation model:

developing and maintaining transportation models means using data from many providers and sources. U-SIM.plan offers a variety of interfaces to import such data and to integrate it into an existing model. In addition to generic formats for tabular and GIS data, there are specialized interfaces for public transport data, demand matrices, and signal controls. One can build and maintain multimodal networks with powerful tools for data integration, matching of public transport lines to road network, merging of redundant or neighbouring objects, timetable simplification, and more.

- Transparency and extensibility:

good documentation of transportation models enables their long-term use by multiple diverse users. U-SIM.plan supports this need with a “self-describing” data model, graphical user interface, scripting API, and procedure/parameter files. All attributes are described by tooltips in the user interface. Calculation methods are displayed in a graphical user interface – so programming and scripting knowledge are only needed in advanced applications. Most visualizations can be adapted to suit the needs of the actual model users.

- Visualization and flexible graphics:

transport models have more impact through meaningful maps, diagrams, and 3D presentations. Even non-experts will easily understand the results and conclusions. Of course, any outputs can also be printed. U-SIM.plan offers a variety of interactive graphic tools for analysing and editing data – all flexible and adoptable to your needs. Special tools for public transport include graphical timetable, schematic line network plan, and graphical block editor. The windows can be arranged on several screens, and it is possible to switch between configurations. A synchronization mechanism ensures that different representations are focused on the same selected objects.

As explained above, the functionalities above refer to the requirements for the U-SIM.plan tool identified in the UPPER project through the use of the VOLERE methodology, whereby the PTV Visum: software was identified as complying the identified requirements, the full user manual of the Visum software is available here: https://cgi.ptvgroup.com/vision-help/VISUM_2024_ENG/Content/TitelCopyright/Index.htm

2. U-SIM.live

2.1. About U-SIM.live

2.1.1. Overview

U-SIM.live is conceived to improve the operational efficiency of Public Transport (PT) operators by providing a dedicated simulation tool. This tool aids in monitoring real-time ridership data and supports decision-making processes of the operators in the Operation Control Centre (OCC), by offering predictive analytics and predictive scenario evaluation.

U-SIM.live is delivered as a Software as a Service (SaaS), i.e. a cloud-operated software, offered to the users via a slick web user interface, tailored on the usual tasks performed by the OCC operators during their daily (and extraordinary) routine. It is connected to widely adopted standard data for PT operations (GTFS files), and on user-proprietary data for what concerns the PT demand. U-SIM.live uses the internal name of PTV Transit Flows (see Figure 3).

2.1.2. Purpose of the Tool

U-SIM.live provides PT operators with a comprehensive simulation platform. It accurately tracks PT vehicle live and forecasted position along their trip, and connects this with other real-time operational data, like network events and ridership live counts, facilitating informed decision-making. The tool simulations enable operators to foresee potential issues and devise effective mitigation/adaptation strategies. Additionally, the scenario simulation in real-time allows for the exploration of various operational outcomes, ensuring preparedness for diverse situations. Simulations of ridership allow measuring several performance indicators, for the monitoring, or in the simulation mitigation interventions: queues, congestion in station and on board of vehicles, critical transfers, waiting times and total passenger volumes and trip times.

In this sense, U-SIM.live wants to overcome the usual PT operation approach, which is limited to a focus on the position of vehicles on the network, putting the users at the centre of the analysis. In that regard, the tool allows PT Agencies and Operators to operate a PT which is not focused on generating most trips possible, but really serving the needs of the users, estimating these based on real observed data. So far, this approach has been limited to the planning phase, missing the deployment to the daily operations: U-SIM.live intends to address this gap.

2.1.3. Intended audience

Users of the tool are the PT OCC operators, who monitor the service operations, and who provide support to the drivers and the different stakeholders to mitigate the impacts of external disturbances to the scheduled service.

2.1.4. Technical Readiness Level (TRL) Explanation

The TRL for the tool prior to the start of the project was TRL 3: in fact, a research prototype is available, exploiting mocked data, on a relevant part, but not fully comprehensive of the application range.

In UPPER, the tool aims to reach TRL 7+, bringing the methodology into a scalable environment, working with real data, and real problems and users. New use cases have been added during the initial design phase of the project, in meetings with OCC operators.

System Requirements

2.1.5. Hardware Requirements

As a SaaS, U-SIM.live will be accessible via an internet browser. In terms of hardware requirements, the performance of the network connection will directly affect the final user experience.

The software will run in a proprietary cloud environment. It is beyond the scope of this document to provide the requirements of the cloud architecture on which U-SIM.live will run.

2.1.6. Software Requirements

Any Chromium-based browser will be able to display U-SIM.live web pages. Some examples are:

- Google Chrome
- Microsoft Edge
- Opera
- Brave
- Vivaldi

Internet Explorer is an example of unsupported browser.

To implement machine-to-machine protocols the architectural software solution available is via REST API.

2.2. User Roles and Permissions

2.2.1. Explanation of different user roles

User Admin

The user admin is the first user created in the system and the system owner. It is intended to be a human user. The Admin is responsible for configuring the tool to meet the needs of all other users, which will normally use it. The user persona of the Admin is not a standard PT operator, but rather more an IT operator.

User Operator

Operators are the most common users of the system, spending a significant amount of their time during daily operations using it. They are intended to be human users.

Client data provider (user)

Data provider clients are sources of input to the system. They are intended to be machine users. They are usually data providers of the tool owner, or other U-tools.

Client consumer (user)

Consumer clients are consumers of the output of the system. These are intended to be machine users. These are usually data receivers of the tool owner, or other U-tools.

2.2.2. Access permissions associated with each role

User Admin

- Manage permissions
- Set the keys element for a machine-to-machine (M2M) communication protocol for instant and daily values or towards infomobility systems (e.g.: API Keys)
- Activate manually the PT network update procedure
- Manage and specify data sources

User Operator

- Monitor the PT network in terms of:
    - Real-time position of public transport vehicles
    - Real-time congestion of PT passengers on the PT network
    - Real-time values of defined key performance indicators (KPIs)
    - Forecast estimated time of arrival (ETA) of PT vehicles at the remaining PT stops of their journey
    - Forecast PT passenger volume and congestion on the PT network
    - Forecast values of defined KPIs
- Define realistic scenarios based on probable events simulated on the PT network
- Evaluate the result of simulated scenarios on the PT network
- Read report about real-time, forecasted, and simulated PT network traffic to take operational decisions
- Set KPIs over the network measurement
- Define critical values of KPI that will trigger graphical user interface (GUI) alerts and internal communications (e.g.: automatic mail)
- Insert real (not simulated) events that change temporarily or permanently the PT network
- See the difference between the service as planned (GTFS data) and the service as realised (GTFS-RT data). GTFS stands for General Transit Feed Specification and defines a common format for public transportation schedules and associated geographic information.
- Interact with suggested scenarios raised by alerts
- See a real-time representation of the PT network

- See on the real-time representation of the PT network raw data from some of the data sources, with possibly missing known reference from other datasets

Client data provider (user)

- data provisioning user. The data will be uploaded either via the user interface (operators during continuous usage) or via configuration (admin)
- can use API to write data in M2M protocols
    - PT events
    - passenger volume measurements

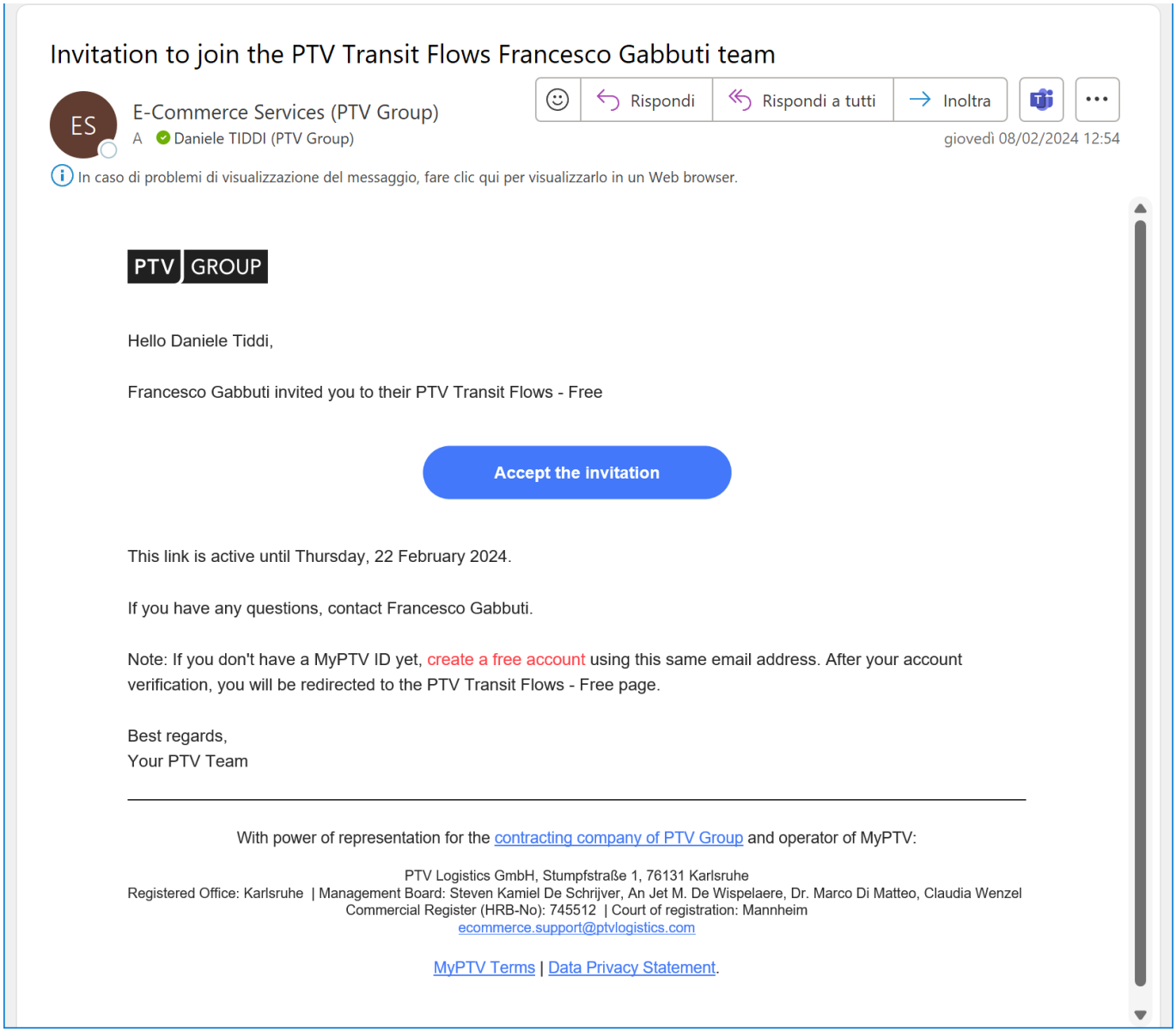
Client consumer (user)

- read only user
- can use application programming interface (API) for reading data in M2M protocols
    - vehicle ETA
    - passenger volume measurements
    - Real-time and forecasted values of desired key performance indicators

2.3. Getting started

2.3.1. Access/Authentication

User access is granted via a SaaS web portal, where the user can create their own account, upon first access. From then on, when accessing the portal, it will be possible to access an instance of U-SIM.live, configured by the tool development team according to their business context. Users will be invited to the platform with an intended role, or it will be possible to be invited to join an existing instance as shown in the example in Figure 3.



Invitation to join the PTV Transit Flows Francesco Gabbuti team

ES E-Commerce Services (PTV Group)
A Daniele TIDDI (PTV Group)

Rispondi | Rispondi a tutti | Inoltra

giovedì 08/02/2024 12:54

In caso di problemi di visualizzazione del messaggio, fare clic qui per visualizzarlo in un Web browser.

PTV GROUP

Hello Daniele Tiddi,

Francesco Gabbuti invited you to their PTV Transit Flows - Free

Accept the invitation

This link is active until Thursday, 22 February 2024.

If you have any questions, contact Francesco Gabbuti.

Note: If you don't have a MyPTV ID yet, create a free account using this same email address. After your account verification, you will be redirected to the PTV Transit Flows - Free page.

Best regards,
Your PTV Team

With power of representation for the contracting company of PTV Group and operator of MyPTV:

PTV Logistics GmbH, Stumpfstraße 1, 76131 Karlsruhe
Registered Office: Karlsruhe | Management Board: Steven Kamiel De Schrijver, An Jet M. De Wispelaere, Dr. Marco Di Matteo, Claudia Wenzel
Commercial Register (HRB-No): 745512 | Court of registration: Mannheim
ecommerce.support@ptvlogistics.com

MyPTV Terms | Data Privacy Statement.

Figure 3 Example of an invitation e-mail to join an existing tool instance.

In the login page as shown in Figure 4, the user will enter their e-mail and password to get access to U-SIM.live.

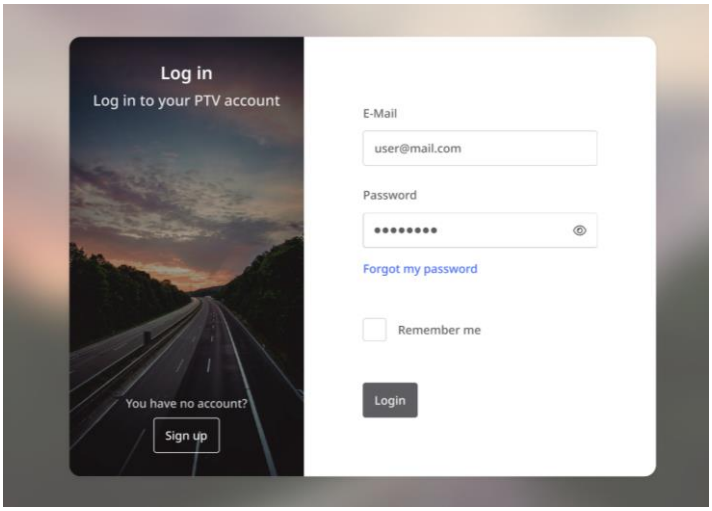


Figure 4 Login page.

2.3.2. User Interface Overview

The user interface is a landing web page, with some usages, and two main applications.

One – the Configurator app – where the Admin can configure the settings of the tool instance, including data settings, allowed users, and their roles as shown in Figure 5.

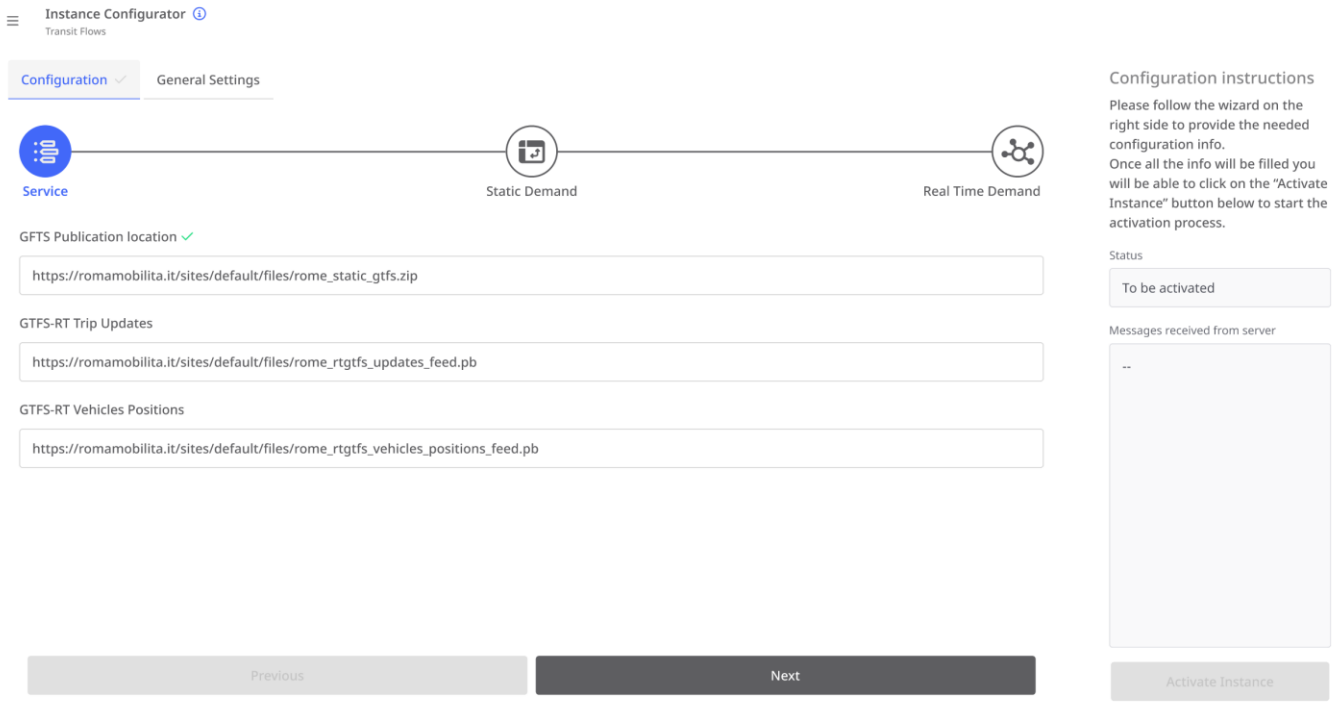


Figure 5 Tool configurator, accessible to the Admin users.

Another one – the Evaluations app – where the Operators can enter a user-friendly environment that supports their daily work of taking decisions, when desired (ideally, in the context of UPPER, after identifying a service criticality in

U-TWIN[1]). Here, the tool supports the operator by preparing the issues to be resolved, in order of estimated criticality. Each issue can be addressed by examining the sub-sequences (in terms of indicators) on the PT network of the possible solutions compatible with the problem being addressed. The tool supports the operator by guiding the decision-making process, by automating most of the manual steps as much as possible as shown in Figure 6.

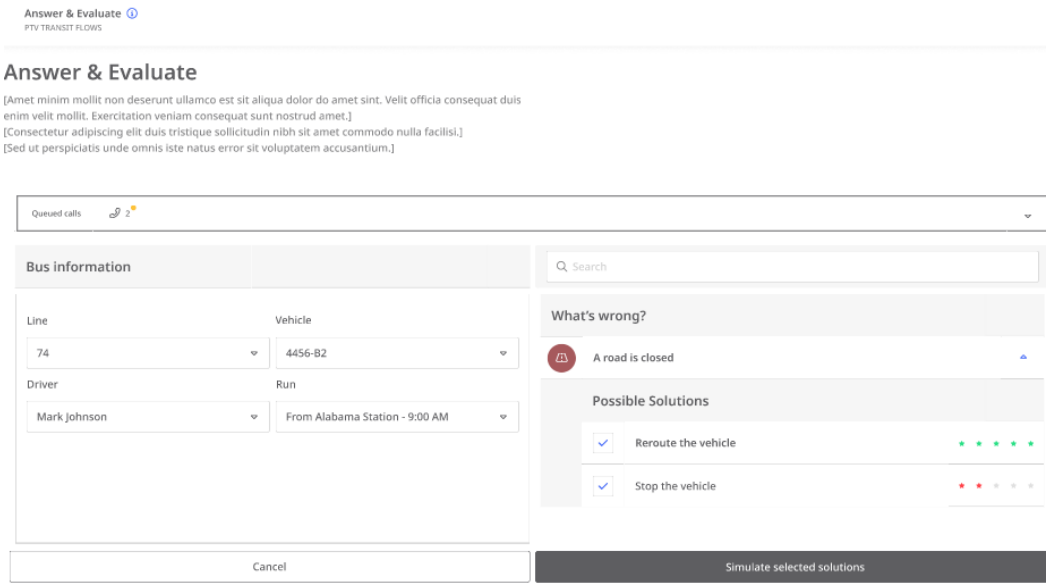


Figure 6 Main environment GUI, accessible to the Operator users.

2.4. Functionalities of U-SIM.live

U-SIM.live simulates PT fleet and demand, to estimate the current and forecast the future situation of the PT network, in terms of vehicle positions, delays, estimated time of arrivals, and demand volumes in different parts of the network. To do this, it periodically ingests the latest PT data and periodically provides an updated estimate and forecast of the expected situation. Additionally, it can simulate on-demand custom situations, intended to be operator mitigation actions of live disruptions or more in general criticalities.

2.4.1. Core Features

2.4.1.1. Editing of PT service data sources

In the Configurator app it is possible to specify the service information, for what concerns the publication location of the static schedule (in GTFS format), and the live information on real-time service modifications (in GTFS-RT – feed type Trip Updates format), and live vehicle positions (in GTFS-RT – feed type Vehicle Positions format). The data is intended to be provided in the form of publicly accessible URLs: after insertion, the data is downloaded and preliminarily validated, providing feedback to the user on the correct configuration. The service information of the Instance Configurator is shown in Figure 7.

[1] For more information on the UPPER tool U-TWIN, see deliverable D3.1.

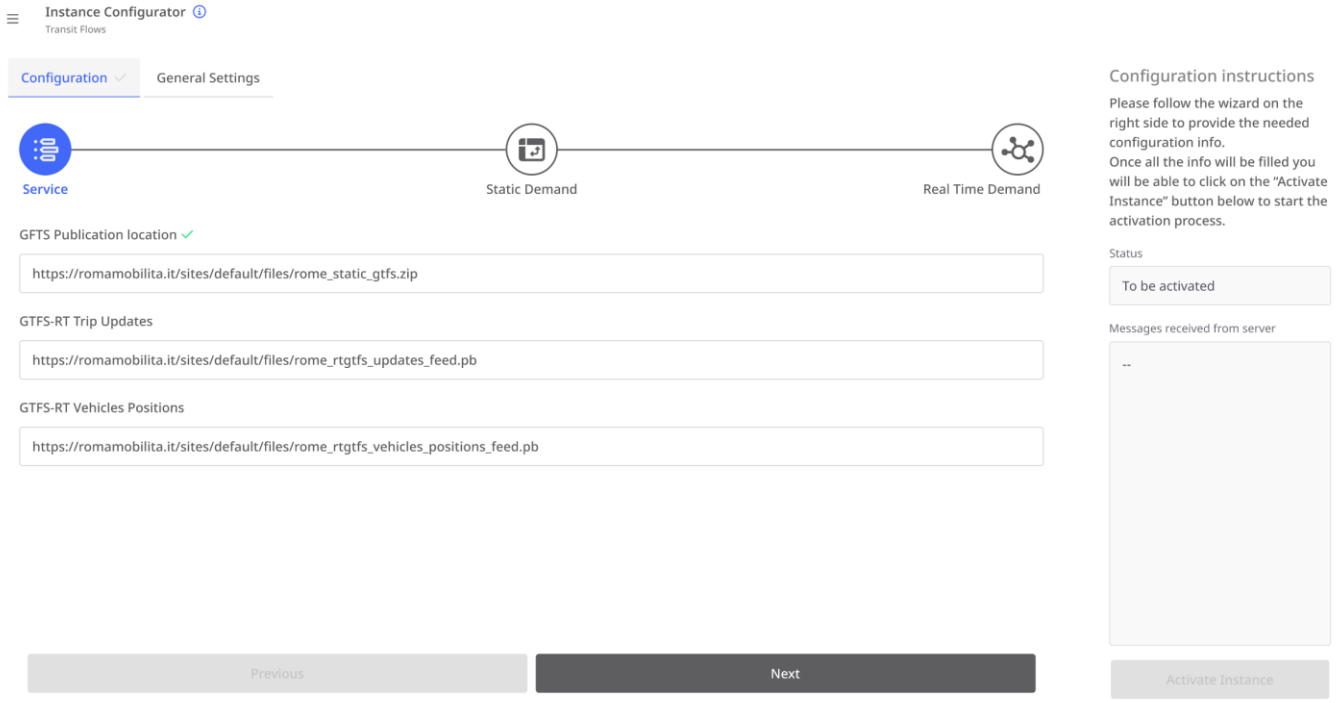


Figure 7 The service information user interface of the Instance Configurator app (to be updated in the next submission of the deliverable)

2.4.1.2. Editing of PT demand data sources

In the Configurator app it is also possible to specify the typical demand information, for what concerns the zones to which the demand information refers (in PTV Visum format), and the demand volume matrices (in PTV Visum format), including their distribution (and repetition) over time. The data is provided in the form of an upload of a PTV Visum version file: once uploaded, the data is preliminarily validated by the tool, providing feedback to the user about the correct configuration.

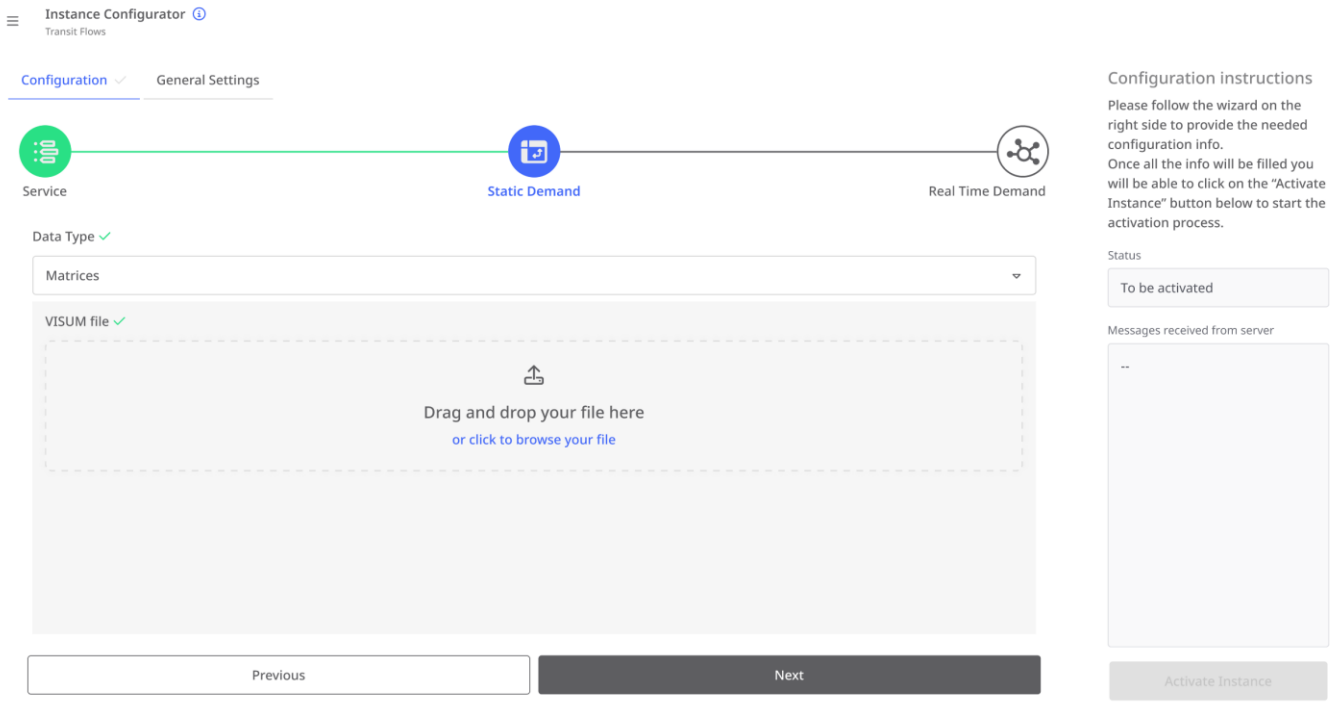


Figure 8 The static demand user interface of the Instance Configurator app.

2.4.1.3. Continuous update of vehicle position, delay and ETAs

This feature is provided by the backend components of U-SIM.live, and is, therefore, in the context of the project, only available via U-TWIN, in the integration between the two tools. The processed data is part of the input of the simulations in 2.4.1.4 and 2.4.1.5 below.

2.4.1.4. Continuous update of passenger volumes on board of PT vehicles, waiting at stations and stops, transferring between lines, congestion on board, boarding success rate, average user waiting times

This feature is provided by the backend components of U-SIM.live, and for this reason it is only made available via U-TWIN in the context of the project, in the integration between the two tools. The processed data is part of the input of the simulations at 2.4.1.5 below.

2.4.1.5. Simulation of operator real-time interventions on the service

As shown in Figure 9, the operator can insert few details about a route and optionally trip (left), access a quick list of possible situations (incidents, or criticalities), and for each of them, a quick-to-use list of possible mitigation actions (right). These are automatically selected by the tool, amongst the ones compatible with the issue and the line (for example, the deviation of circulating PT vehicles on the allowed alternative routes of a line, when in presence of an obstacle along the route). The coupling of the lines and situations and solutions is part of the tool configuration, as it depends on the user's processes, habits and conventions.

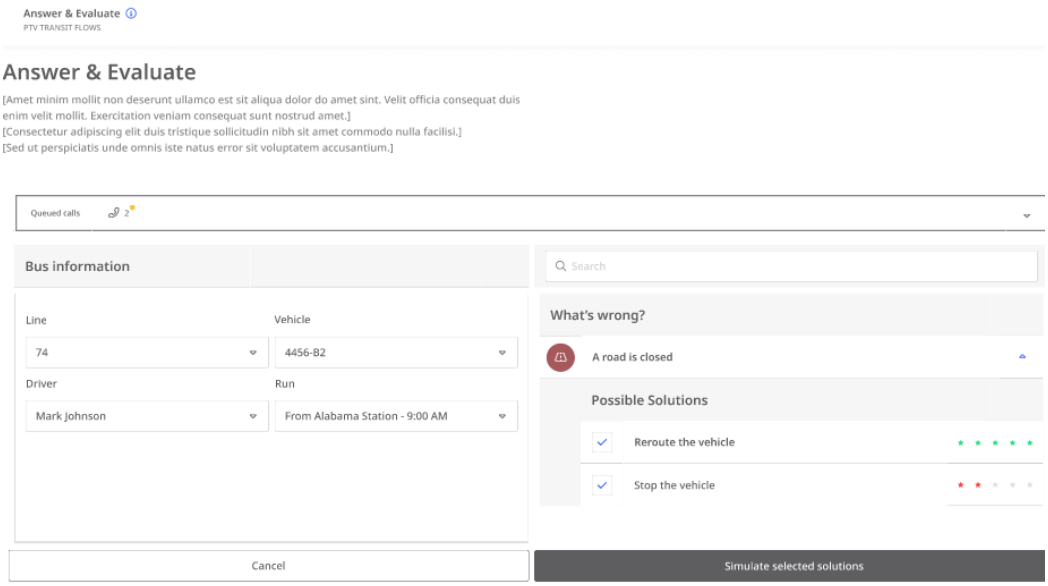


Figure 9 User interface of the simulation of operator real-time interventions on the service.

2.4.1.6. Inspection and comparison of PT indicators for scenario simulations

The operator can view different PT indicators for each of the alternative simulations and compare between the different simulations. For example: total vehicle delays, vehicle kilometres operated, total congestion on board of vehicles and at stations/stops.

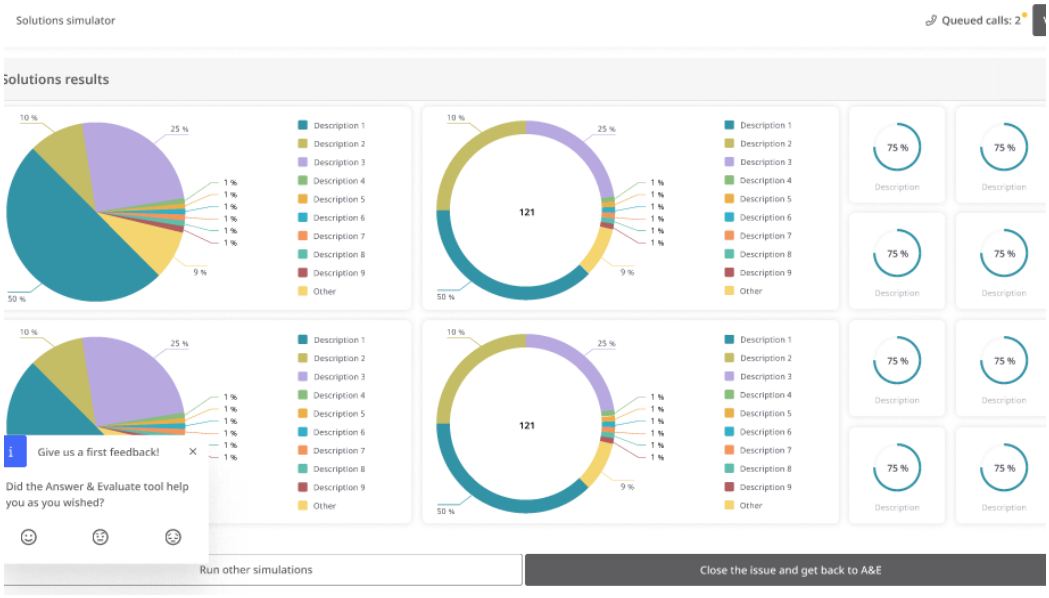


Figure 10 Indicators for scenario simulations.

2.4.2. Advanced Features

2.4.2.1. Editing of PT live demand data sources

As shown in Figure 11, in the Configurator app it is possible to specify the live demand information, for what concerns the publication location of the live data (in proprietary API format, or csv), namely:

- passenger counts on board of vehicles,
- passenger counts boarding and alighting a vehicle at a stop,
- passenger counts at station entrances and exits, or single turnstiles,
- passenger counts waiting at a stop or platform.

The data is intended to be provided in the form of publicly accessible URLs: after insertion, the data is downloaded and preliminarily validated, providing feedback to the user on the correct configuration.

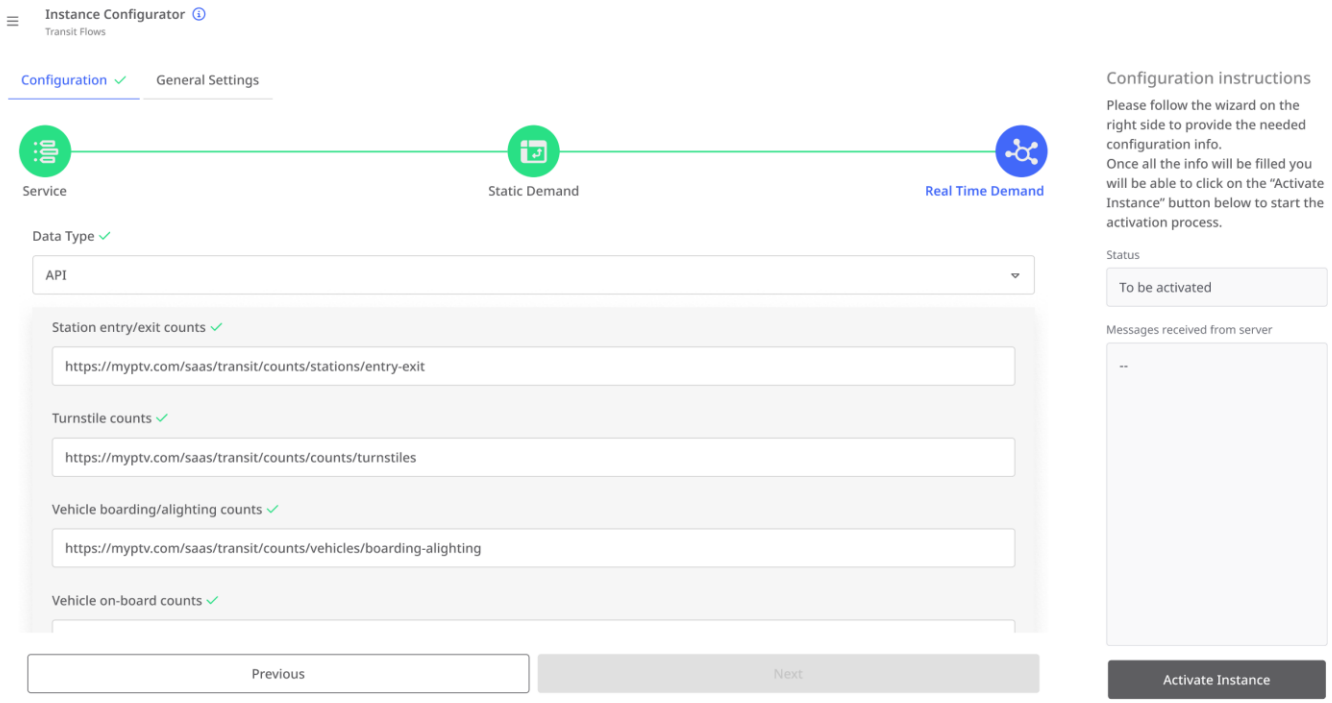


Figure 11 Real Time Demand user interface of the configuration app.

Given that during the first phase of the project none of the partner sites using U-SIM.live have declared the availability of such type of data, this feature has been postponed and will only be activated if such data becomes available in one of the UPPER sites using the tool.

2.4.2.2. Insertion of preset situations to be analysed

To ease the operator analysis work, and in line with the integration of U-SIM.live with U-TWIN, it is possible to insert in U-SIM.live preset situations to be inspected as shown in Figure 12. For example, it is possible to add items to a queue of punctual PT service issues, which already include the input information described in 2.4.1.5. This way, the

operator can access the analysis, which already contains the required input information, by clicking on one of the items in the queue.

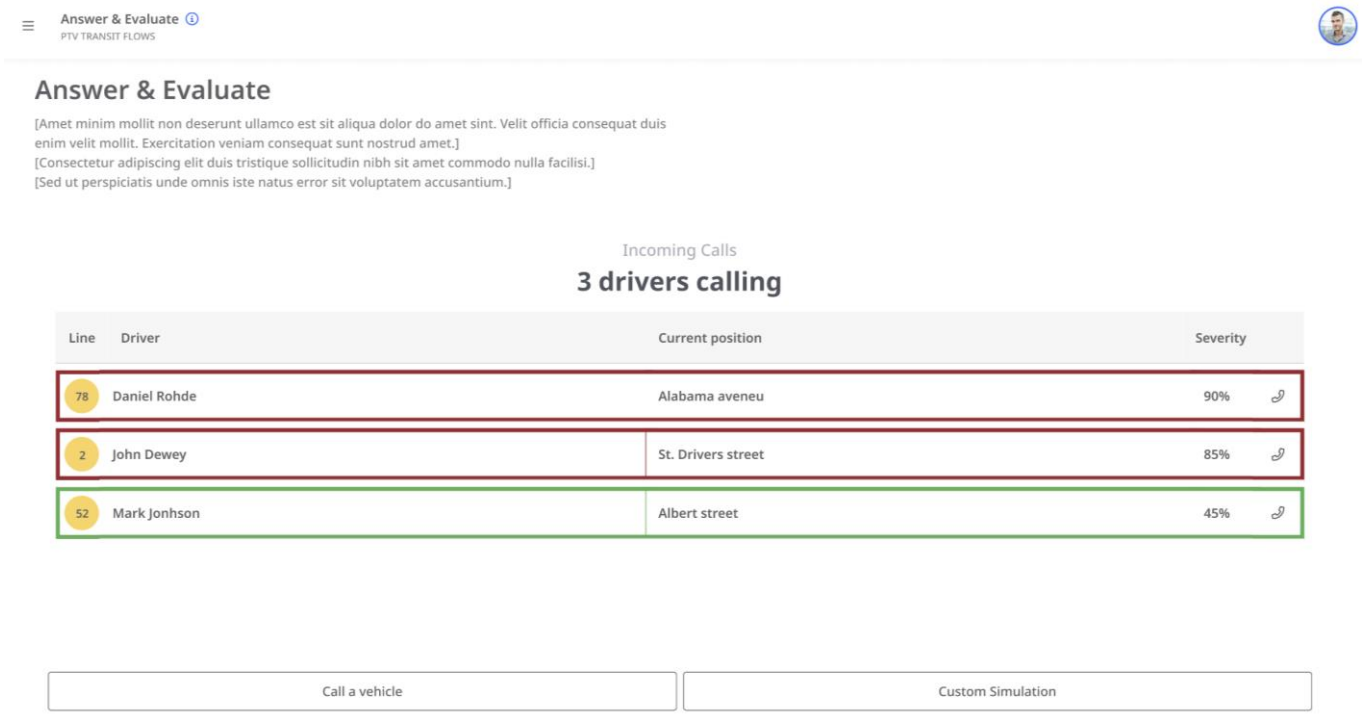


Figure 12 Operator view of the queue of inserted anomalies.

This type of integration between U-SIM.live and U-TWIN is at a conceptual stage and will be deferred until the two tools are technically integrated.

2.5. Data Requirements

- Input schedule must be in GTFS format.
- Input of PT demand data must be in Visum (U-SIM.plan) format, and the file must contain at least demand matrices and zone shapes.
- The zones must at least partially overlap the PT stops.
- The demand matrices must cover continuously a desired service time range (e.g., next 365 days).
- Input service modifications in real-time must be in GTFS-RT format.
- Input real-time vehicle positions must be in GTFS-RT format.

2.6. Development timeline

The development of U-SIM.live is planned as the following:

	2023												2024												2025			
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28
Tool ideation																												
Requirements identification																												
1st development phase and release of a functional version																												
Development of core functionalities																												
Bilateral meetings with cities to prioritize developments																												
2nd development phase and release of 1st version																												
Development of remaining functionalities																												
Testing and validation by horizontal partners																												
Fine-tuning of the tool																												
Deployment in the cities																												

Figure 13 Gantt of the development of U-SIM.live (current month is M16)

From ideation to deployment, the development of this tool goes through several phases:

- **"Tool Ideation"** (M1-M4): In the early stages, attention was centred on sharpening the definition of the tool and delineating its key features. This process included an in-depth examination of measures proposed by cities and pinpointing functionalities that are essential for supporting cities in the implementation of these measures. This work led to the development of a product card. This document provided a concise overview of the tool, a list of its main functionalities, insights into who could benefit from it, and an analysis of the measures that could utilize the tool's features. This product card became an important asset for cities and transportation operators, helping them to better understand the tool's possible impact and advantages.
- **"Requirements Identification"** (M4-M10): The process of collecting requirements for the tool was a collaborative effort that took place in work package 2, involving the tool's developers, creators of other tools within the project (to address any tool interactions), and end users such as cities, transport operators, and transport authorities. To precisely define these requirements, a sequence of workshops was held, succeeded by applying the Volere methodology. This approach includes the iterative validation and revision of various requirements by all participating stakeholders. The result was a consensus on a comprehensive list of requirements—technical, legal, and operational. These findings are documented in Deliverable D2.4, which records the outcomes of this phase.
- **"1st Development Phase and Release of a functional version"** (M10-M21): During this phase, the core interface and functionalities of the tool are developed. Concurrently, bilateral discussions with city representatives and traffic control operators are conducted to determine essential features and to prioritize them according to the specific requirements of their measures. This is the current stage of development.
- **"2nd Development Phase and Release of 1st Version"** (M22-M28): During this phase, the development of the tool's remaining functionalities will be finalized. Alongside this, the tool will undergo extensive testing and validation to gather essential feedback on its usability. Moreover, the developers will improve existing features by addressing any bugs or issues found following the initial release and by integrating the feedback received.
- **"Deployment of the Tool in the Cities"** (M26-M28): Starting in month 26, the tool will be gradually deployed across cities, following a comprehensive strategy encompassing training and support that will then be continued in WP6.