

# D3.1 U-TWIN: Integrated mobility solution for urban and peri-urban digital twins

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



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## Abstract

This deliverable will present the design of services, functionalities, and specifications of the U-TWIN tool. It aims to serve as a comprehensive user manual, providing detailed visual descriptions of the work undertaken in the development of U-TWIN and each of its functionalities. The development of this tool directly addresses the needs and concerns expressed by the end-users during the initial stage of the project. Based on the identified needs, which primarily revolve around the need for support in implementing measures to unleash the potential of public transport, each requirement has been translated into functionalities within U-TWIN.

Functionalities closely related to any of the 80 measures outlined in the UPPER project have been given priority. The purpose of this user manual is to guide project partners who will utilize the tool throughout the project's duration on how to use it, access its various functionalities, and conduct analyses. This deliverable accompanies the initial version of the tool, with the final version scheduled for delivery in April 2025. Therefore, some functionalities are still in the development phase, and detailed information on their usage may not be available within this first version of the deliverable.

## Keywords

U-TWIN, Digital Twin, Urban Digital Twin, toolkit.

# 1. About U-TWIN

## 1.1. Overview

U-TWIN is a tool rooted in the innovative concept of Urban Digital Twins (UDT), designed to support cities and Public Transport entities in comprehensively managing urban mobility effectively. It offers an integrated and modular real-time representation of urban mobility assets, providing insights and into their current operational status.

By harnessing the power of UDT, U-TWIN facilitates a holistic real-time visualization and monitoring of PT systems, enabling stakeholders to gain actionable insights into their performance. It goes beyond observation by actively informing about anomalous situations such as excessive occupancy levels, delays compared to schedules, or poor air quality. Additionally, U-TWIN offers forecasted information including travel times, estimated arrival times or occupancy rates.

The tool empowers end-users, including mobility authorities and PT operators, to implement corrective measures promptly and efficiently when necessary, enhancing the overall effectiveness of urban transportation management. Through its advanced capabilities, U-TWIN supports proactive decision-making by providing a deeper understanding of the intricate relationship between PT operations, traffic dynamics, incidents, and other urban variables.

In summary, U-TWIN leverages the UDT framework to deliver real-time insights into urban mobility operations, thereby optimizing public transportation management and fostering proactive responses to dynamic urban mobility challenges.

## 1.2. Purpose of the Tool

U-TWIN becomes a key supporting tool for various purposes, including real-time monitoring of public transport (PT) operations, identification of abnormal situations, and initiation of corrective actions when necessary. U-TWIN serves as a vital tool in supporting relevant stakeholders to make informed decisions regarding urban mobility management.

Furthermore, U-TWIN acts as an integrator and standardizer of diverse data sources, enabling it to function as a comprehensive data lake. This capability allows U-TWIN to provide valuable data feeds to additional systems such as simulators (U-SIM) and other applications that require real-time information, such as Mobility as a Service (MaaS) platforms. As a result, U-TWIN extends its utility beyond real-time monitoring and decision-making, becoming an essential component in the ecosystem of urban mobility management and optimization.

The U-TWIN platform offers the digital twin of PT and mobility assets of the city, in an open and interoperable way, becoming a building block for the city/urban digital twins and providing an architecture with enough flexibility to be integrated into current systems and prepared by design to be interoperable and scalable for potential extensions.

The U-TWIN tool has been developed using open-source technologies based on JavaScript, such as:

- **MeteorJS:** A JavaScript platform for high-performance web application development.
- **MongoDB:** A highly scalable and flexible document database, with an advanced querying and indexing model.
- **React:** A high-performance JavaScript library that allows the development of interactive and reactive web applications using reusable components that automatically manage GUI updates when data changes.
- **Material UI:** A user interface component library for React based on Google's popular Material Design.
- **DeckGL:** A WebGL-based framework for exploratory visual analysis of large datasets, designed to reflect the reactive programming paradigm, whether using VanillaJS or ReactJS.

- **Mapbox:** A mapping and geolocation development platform designed to create customized and enriched mapping experiences, offering the possibility to create custom map styles

### 1.3. Intended audience

The primary end users of the U-TWIN tool **are city authorities, Public Transport Operators (PTOs), and Public Transport Authorities (PTAs)**. U-TWIN serves as a valuable support system for these stakeholders, enabling them to make informed decisions based on up-to-date information regarding PT operations, traffic conditions, user demand, and other relevant urban factors. By providing a comprehensive view of PT activities and their interrelations with urban dynamics, U-TWIN facilitates proactive management of urban mobility.

## 2. System Requirements

This section compiles the system requirements that the end-user needs to take into account to be able to utilize U-TWIN. Requirements at hardware, operating system and browser level have been established as the tool will be distributed as a cloud deployed application accessible with an internet browser.

### 2.1. Hardware Requirements

#### 2.1.1. Processor (CPU)

- Minimum: Dual-core CPU (e.g., Intel Core i3 or equivalent)
- Recommended: Quad-core CPU or better (e.g., Intel Core i5 or equivalent)

#### 2.1.2. Memory (RAM)

- Minimum: 4 GB RAM
- Recommended: 8 GB RAM or more

#### 2.1.3. Graphics Card (GPU)

- Minimum: Integrated GPU (e.g., Intel HD Graphics)
- Recommended: Dedicated GPU with at least 2GB VRAM (e.g NVIDIA GeForce GTX 1050 or equivalent)

### 2.2. Supported operating systems and browsers

#### 2.2.1. Operating System



- Minimum: Windows 10, macOS 10.15 (Catalina), or Linux (Ubuntu 18.04 or equivalent)
- Recommended: Latest stable version of the respective operating system

### 2.2.2. Browser

- Minimum: Latest version of Google Chrome, Mozilla Firefox or Microsoft

### 2.2.3. Network connectivity

- Minimum: Stable internet connection (at least 10 Mbps download speed)
- Recommended: High-speed internet connection (at least 25 Mbps download speed)

## 3. User Roles and Permissions

The U-TWIN tool features a comprehensive user management system, which includes three main user roles:

- **U-TWIN Administrator:** Managed by ETRA I+D, this role guarantees complete oversight by granting access to all datasets stored within the system. The U-TWIN Administrator is responsible for deploying the tool in the city, customizing it to the specific location, and linking relevant data sources. Additionally, they have the authority to create new user accounts and assign corresponding roles and permissions.
- **Site Administrator:** Users with the "Site Administrator" role can access the U-TWIN tool tailored for their city and leverage all functionalities described in section 6). Moreover, users with this role will also have access to the "Administration tool" (see section 4). This administration tool will allow them to have some autonomy in uploading files or linking data sources.
- **Site Visualizer:** Users with the "Site Visualizer" role can access the U-TWIN tool configured for their city and utilize all features detailed in section 6.

Regarding permissions, the U-TWIN administrator (ETRA I+D) retains the ability to customize permissions for "Site Administrators" and "Site Visualizers," filtering data based on specific criteria. This flexibility allows for tailored access, such as restricting data from particular agencies or excluding information sourced from third-party services like TomTom or Here. Such a customizable framework ensures that each user interacts solely with data pertinent to their responsibilities, bolstering data security, privacy, and enhancing user engagement within the U-TWIN platform.

## 4. Administration tool

Along with the U-TWIN tool, an administration tool is actively being developed to allow a site administrator role to setup connections with external data sources and manage the data to be imported in the system. This administrator tool will be offered separately from the U-TWIN tool.

In the current stage of the development, the administration tool is planned to allow to manage GTFS sources, both static and real time ones, coming from a private URL of the public transport organization or coming from a public database like [the mobility database](#).

With this administration tool, the public transport operator or authority will be able to manage completely autonomously the import of data sources, both GTFS static and real-time. In April 2025, this tool will be finished and completely described in detail in the corresponding deliverable, see Section 8. Development timeline.

The Administration tool will offer a range of functionalities, including the ability to define geographical zones. This feature empowers cities or public transport operators to integrate information from pre-existing zones in other applications or services into the U-TWIN tool.

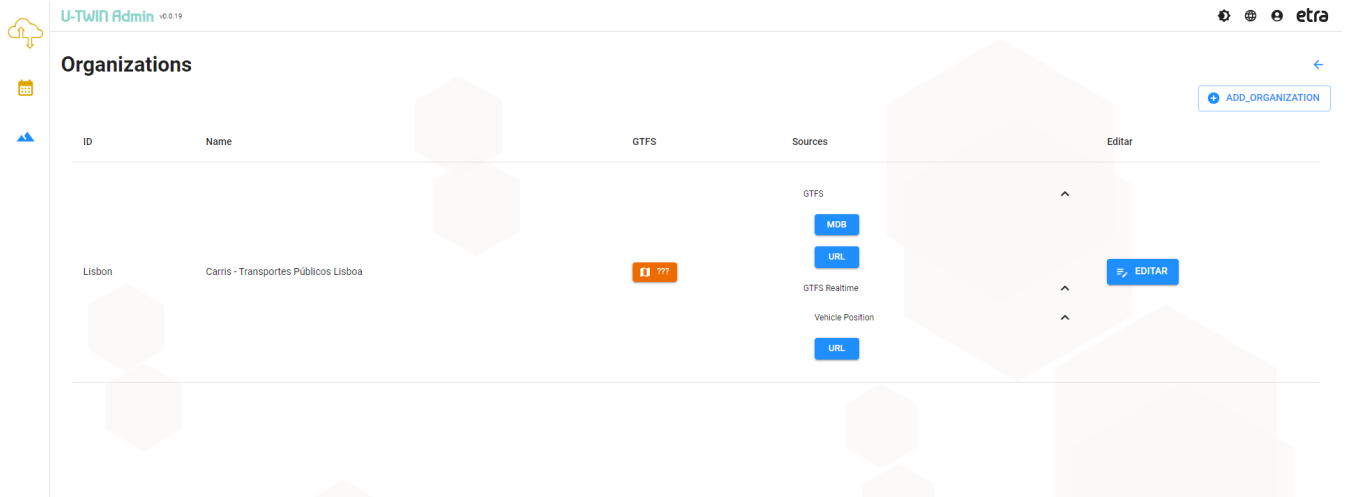


Figure 1 - Work In Progress: Administration tool

As depicted in the image below, users will have the option to upload a new GeoJSON or Shapefile (SHP) file, or alternatively, copy and paste geometry and properties directly into a modal window. The newly added data will be seamlessly integrated into the system and displayed alongside the list of layers within the U-TWIN tool.

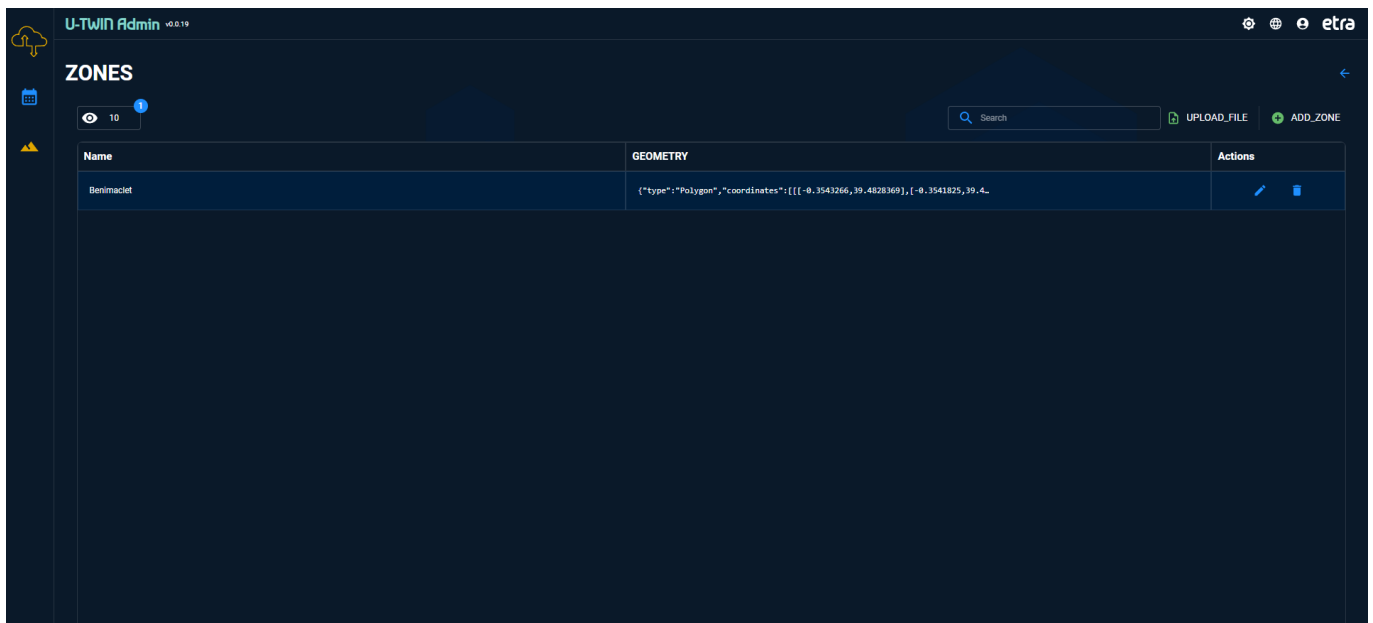


Figure 2 - Work In Progress: Administration tool

## 5. Getting started

All the screenshots shown below are centred on the city of Valencia, as the city indicated its intention to use the tool.

### 5.1. Access/Authentication

The access to the application is provided by a user/password pair of credentials.

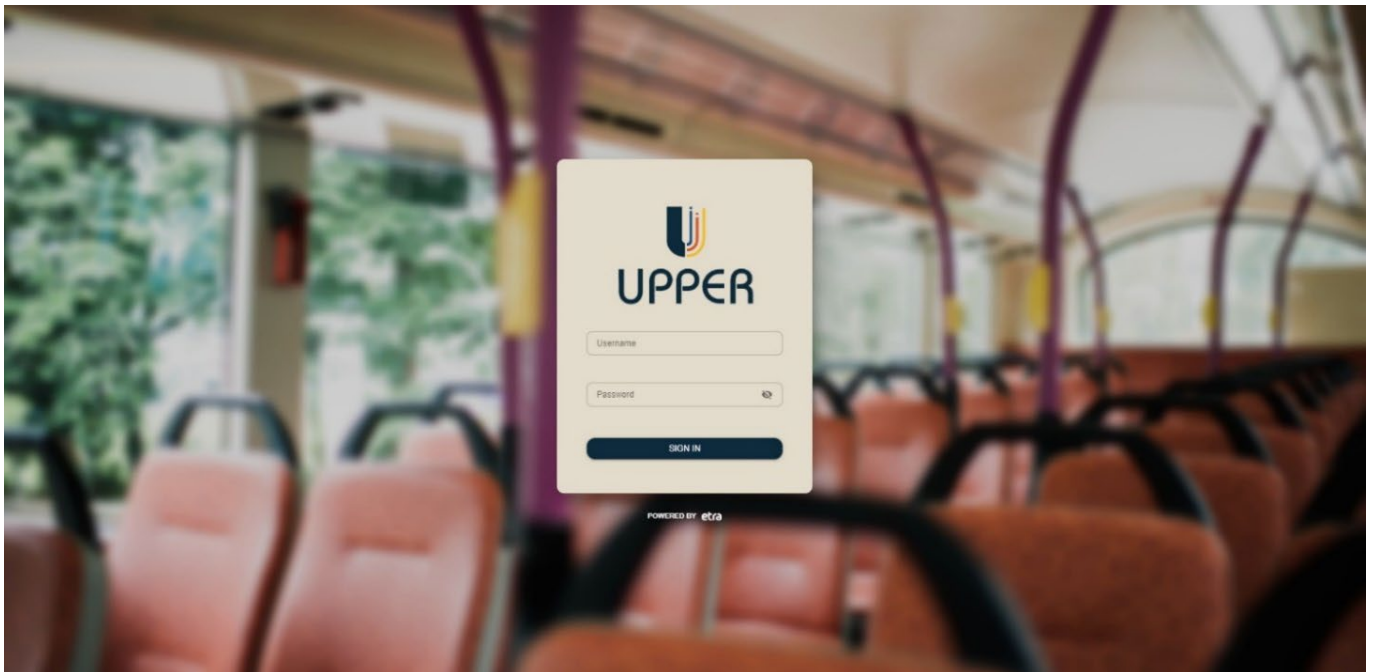


Figure 3 - U-TWIN Login interface

The interface provides a simple method to authenticate and access the app using a username and password.

### 5.2. User Interface Overview

The main view of the U-TWIN app, depicted below, serves as the central hub for accessing the multiple features and functionalities designed to support public transport management tasks.

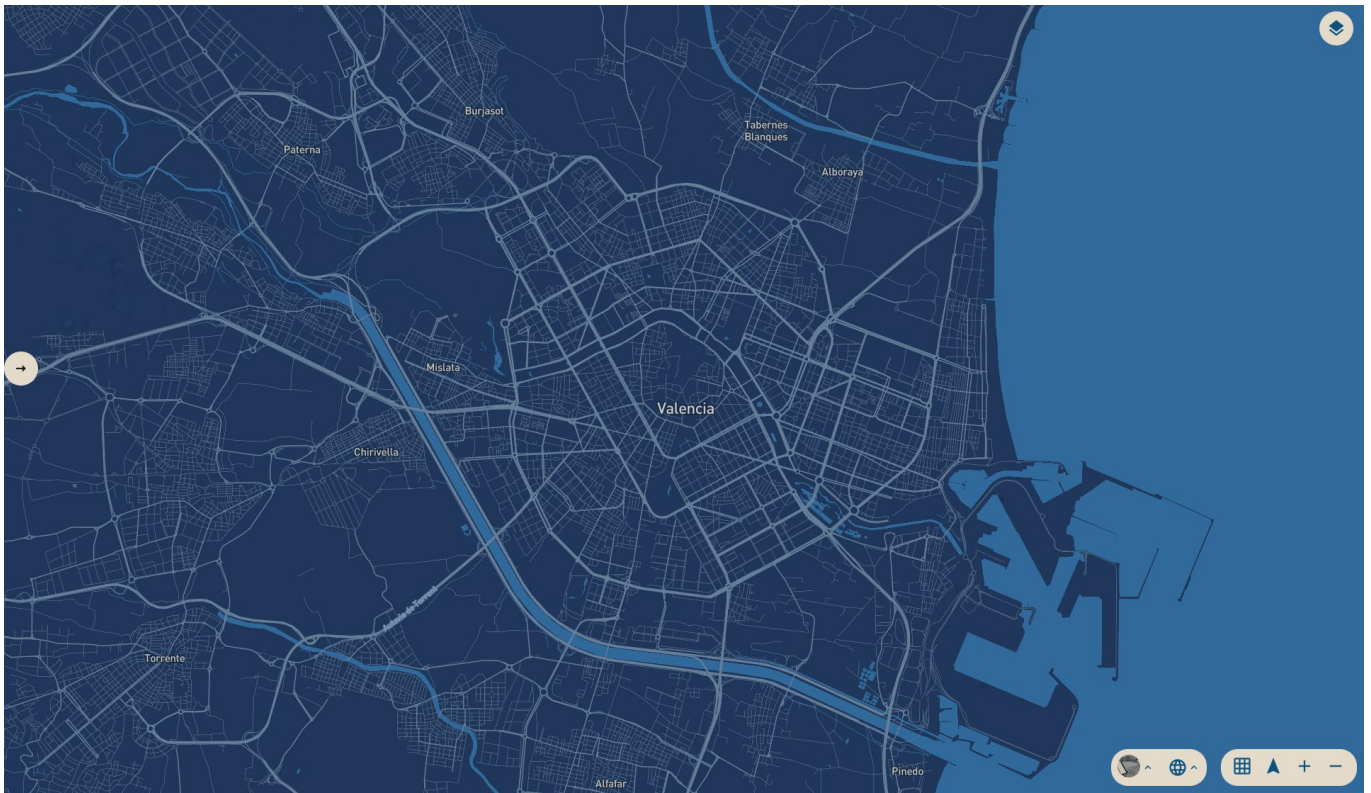


Figure 4 – Main U-TWIN view



Figure 5 – Bottom menu actions

The bottom actions offer users the ability to fine-tune various aspects of the application, enhancing usability and personalization. They serve as a convenient access point for tailoring the U-TWIN experience to individual preferences. Moving from right to left, users will encounter the following functionalities:

1. **Map Style:** Allows to change the map style.
2. **Language:** Enables users to switch to another language for the interface. Currently, only Spanish and English are supported.
3. **Bearing:** This icon rotates the map to indicate the bearing (rotation relative to the Earth's north axis). Clicking it recentres the view.
4. **Pitch:** Indicates if the view is pitched relative to the zenithal view. Clicking it recentres the map to the zenithal view.
5. **Add Zoom:** Increases the zoom level of the map.
6. **Minus Zoom:** Decreases the zoom level of the map.

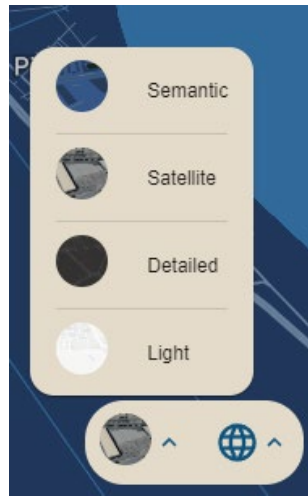


Figure 6 - Map style details

At the top of the application, initially, there is initially only a single action button.



Figure 7 - Layers action button

Clicking this button will reveal a sidebar containing a section where users can enable or disable the various layers.

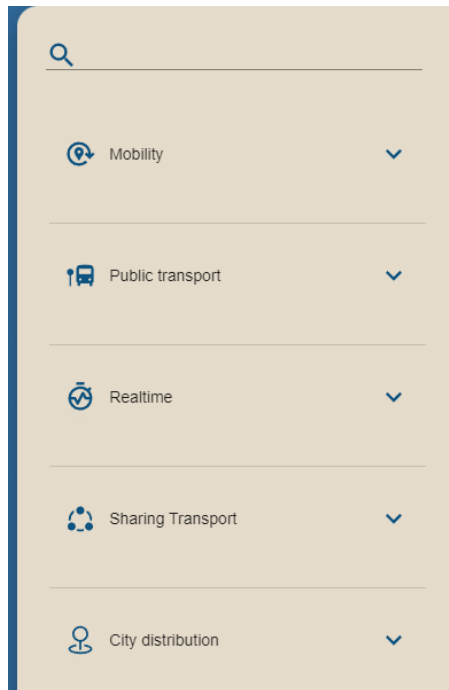


Figure 8 - Layers sidebar

Within this sidebar, users can discover various categories of layers supported by the application, along with a search input for further exploration. Clicking on any category will expand it, revealing the associated layers within that specific category.

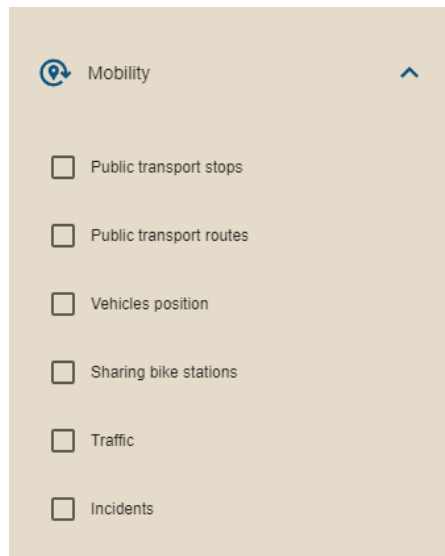


Figure 9 – Layers

Each layer can be individually enabled and will appear on the map accordingly.

The list of categories and their respective layers is as follows (please note that certain layers may belong to multiple categories):

- Category **Mobility**
  - Public transport stops
  - Public transport routes
  - Vehicles position
  - Sharing bike stations (*Note 1*)
  - Traffic
  - Incidents
- Category **Public transports**
  - Public transport stops
  - Public transport routes
  - Vehicles position
- Category **Realtime**
  - Vehicles position
  - Sharing bike stations (*Note 1*)
  - Traffic
  - Incidents
- Category **Sharing transport**
  - Sharing bike stations (*Note 1*)

- Category **City distribution** (Note 2)
  - Roads
  - Services
  - Accessibility index
  - Zones

*Note 1: So far, information related to the bike sharing system has been fully integrated into the tool. However, the U-TWIN tool is ready to seamlessly integrate data coming from other micromobility services (car sharing, sharing scooters, free floating bikes and so on). For example, U-TWIN allows representing on the map the location of sharing scooters, if the operator or the city can provide access to it.*

*Note 2: The tool is prepared to display information contained in GeoJSON or similar format, this includes (if provided) traffic lights.*

Once a layer is chosen, the corresponding data will be displayed on the map, enabling users to hover over each element for additional information.

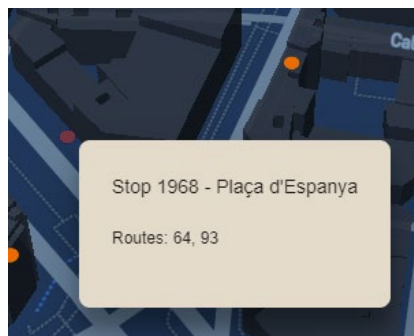


Figure 10 - Hover details over stop

Additionally, users can click on elements to access more detailed information within the sidebar.

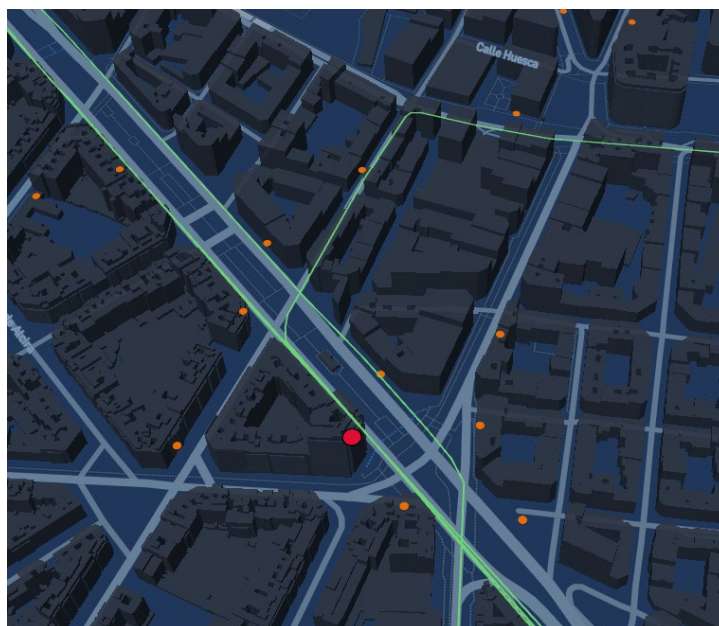


Figure 11 - Selected stop and routes

Upon clicking an element, the map will highlight its associated elements. For instance, clicking on a bus stop will highlight the routes connected to that stop.

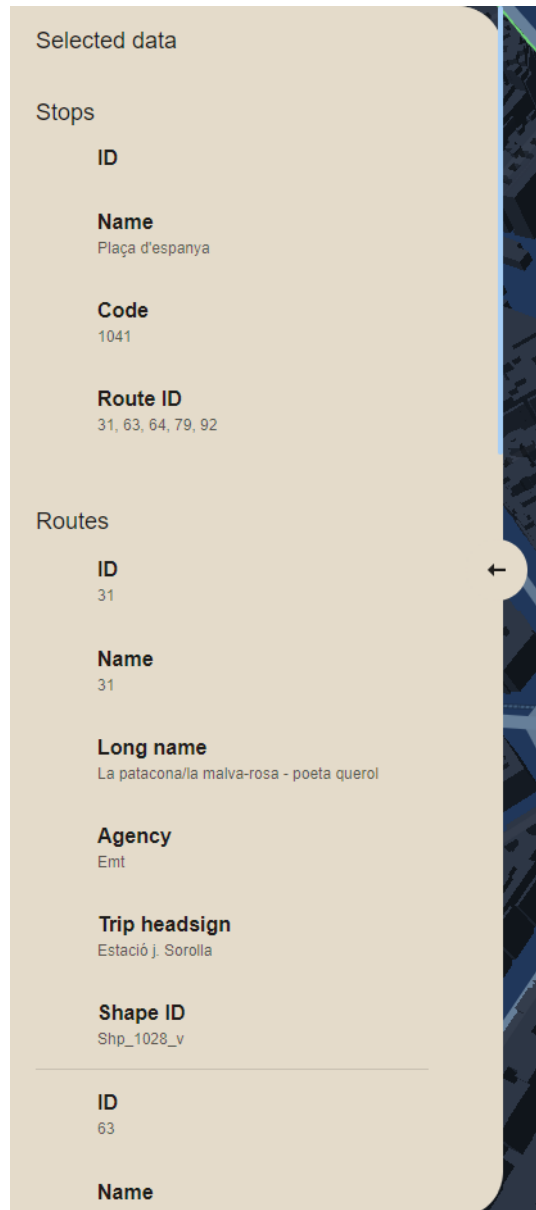


Figure 12 - Sidebar with details

In addition to the default buttons in the interface, the activation of certain layers will incorporate additional icons and buttons to facilitate user interaction with the displayed information. The functionality of each of these buttons will be detailed in section 6 below.



Figure 13 - Additional buttons

These buttons appear in the top right corner of the applications near to the layer action button.

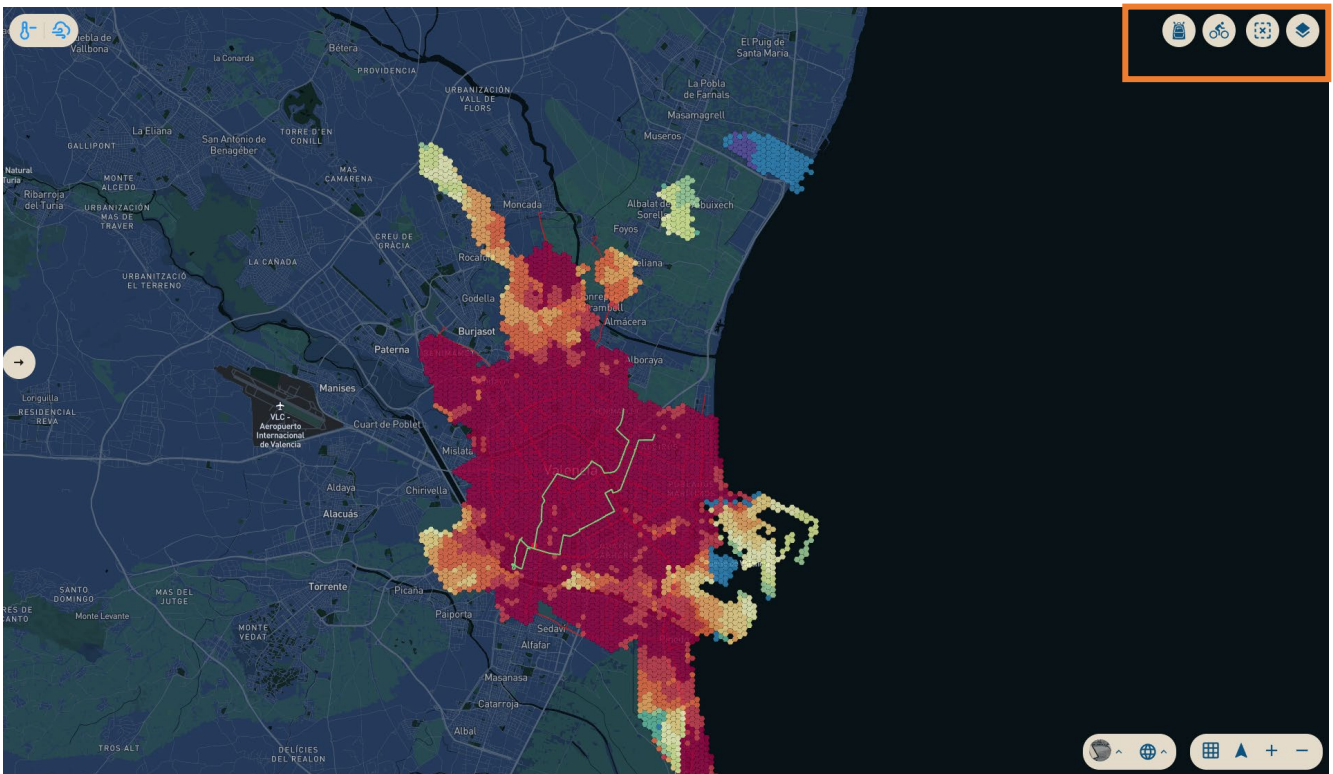


Figure 14 - Base map with additional icons

## 6. Functionalities of U-TWIN

The following section delves into the various functionalities of the U-TWIN tool, categorizing them into two main groups: **core functionalities**, which focus on real-time monitoring and control of public transport and the overall state of mobility in the city, including related incidents and alerts (*Note 3*); and **advanced functionalities**, which rely on U-TWIN's interaction with third-party systems, whether they are other UPPER tools like U-SIM or other applications.

*Note 3: The integration of real-time data related to pedestrian flows is not directly addressed in this manual. However, provided that the city facilitates this type of data, it would be possible to display on the map alerts or incidents related to congested areas.*

### 6.1. Core Features

#### 6.1.1. Integration and display of base-maps and geographical information

##### 6.1.1.1. Display of base-maps

The base map serves as the primary interface for presenting a wide array of available information, offering a visual representation of data essential for comprehensive analysis and decision-making within the U-TWIN platform. Its versatility allows users to overlay diverse datasets and navigate through spatial relationships with ease.

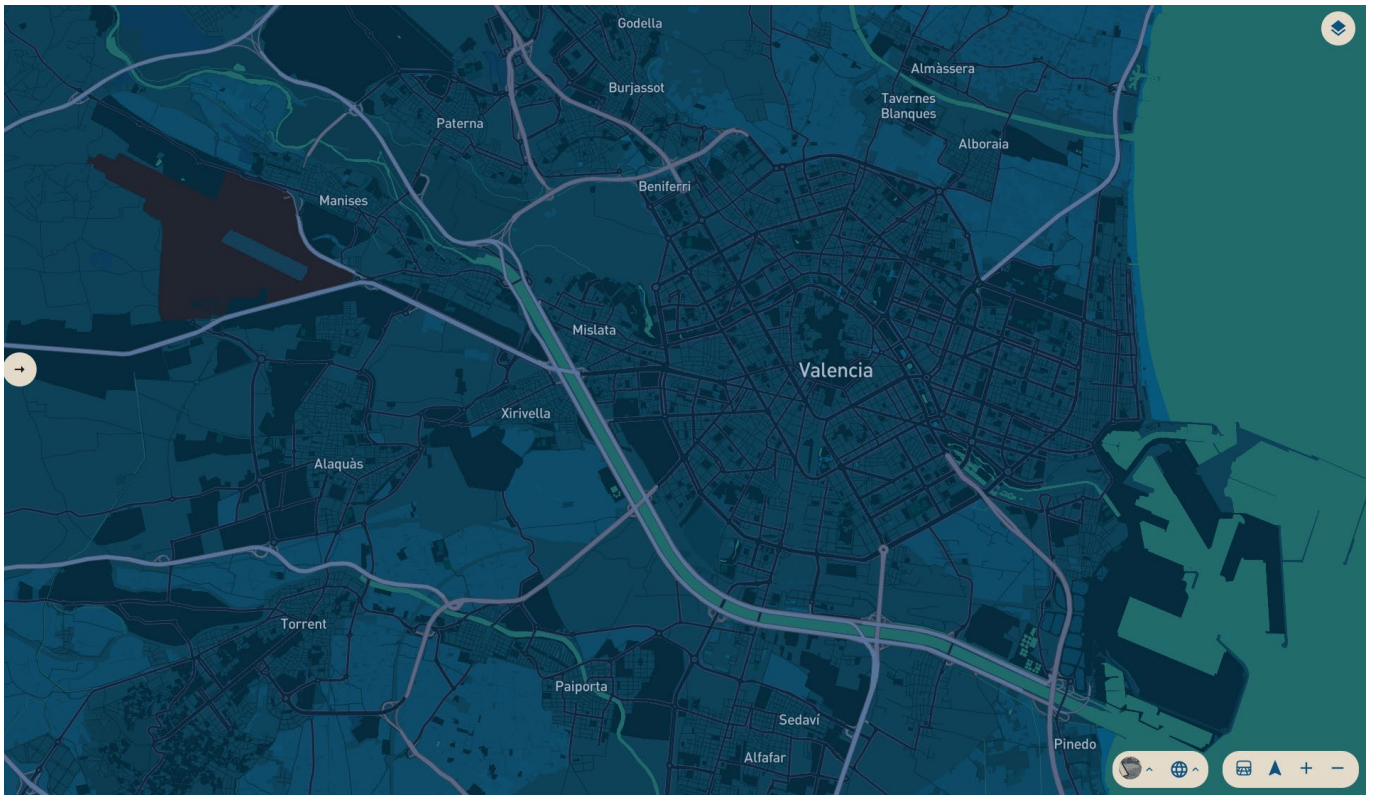


Figure 15 - Base map

The app offers multiple actions buttons to control how the map is visualized, allowing to increase or reduce the zoom, or centre the bearing and pitch of the view.



Figure 16 - Map controls

There's also the possibility to change the map style dynamically using one of the action buttons.

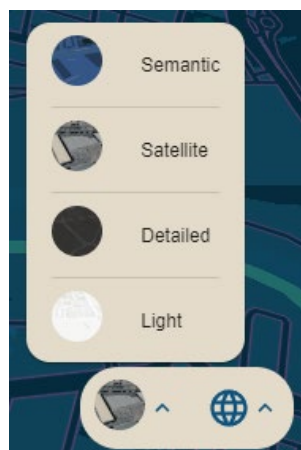


Figure 17 - Map style selector

Clicking on any of the styles will instantly modify the colour scheme of the base map.



Figure 18 - Base map light

The subsequent subsections outline the geographical information that is available for display on the city's base map.

#### 6.1.1.2. Display of roads and sections

U-TWIN enables users to overlay road data onto the base map, showcasing the distribution and details of roads throughout the city. This feature provides valuable spatial information essential for urban planning, transportation analysis, and infrastructure management.



Figure 19 - Road information

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "City distribution" category, and then enable the checkbox for "Roads".

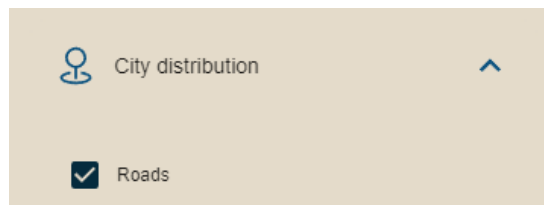


Figure 20 - Enabling roads layer

To present this information, the user needs to provide data in the GeoJSON standard format, which should include at least the geometric details represented as LineString or MultiLineString. Additionally, any data within the properties field of the GeoJSON will be incorporated into the information displayed in the tooltip. This information can also be sourced from OpenStreetMap if necessary. The tooltip will display the available info. If it includes the number of lanes per direction, then that will be shown, if the only information is the total number of lanes that's what will be shown, and if there's no info available at all, no details will be displayed. Additionally, information related to the availability or not of a dedicated bus lane (or BRT) will be shown in the tooltip, if the information is available.

The image below illustrates an example of the information found within the road tooltip, featuring details such as the road name, maximum speed limit, and number of lanes associated with the road.

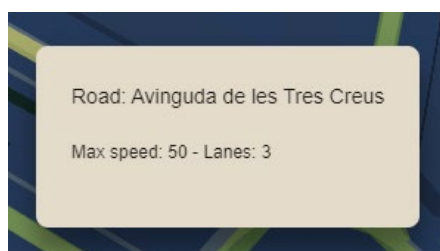


Figure 21 - Road tooltip

### 6.1.1.3. Display of zones

The tool enables users to visualize zones-specific information and their distribution across the cityscape. This feature enhances the understanding of local dynamics and supports targeted interventions tailored to specific communities.

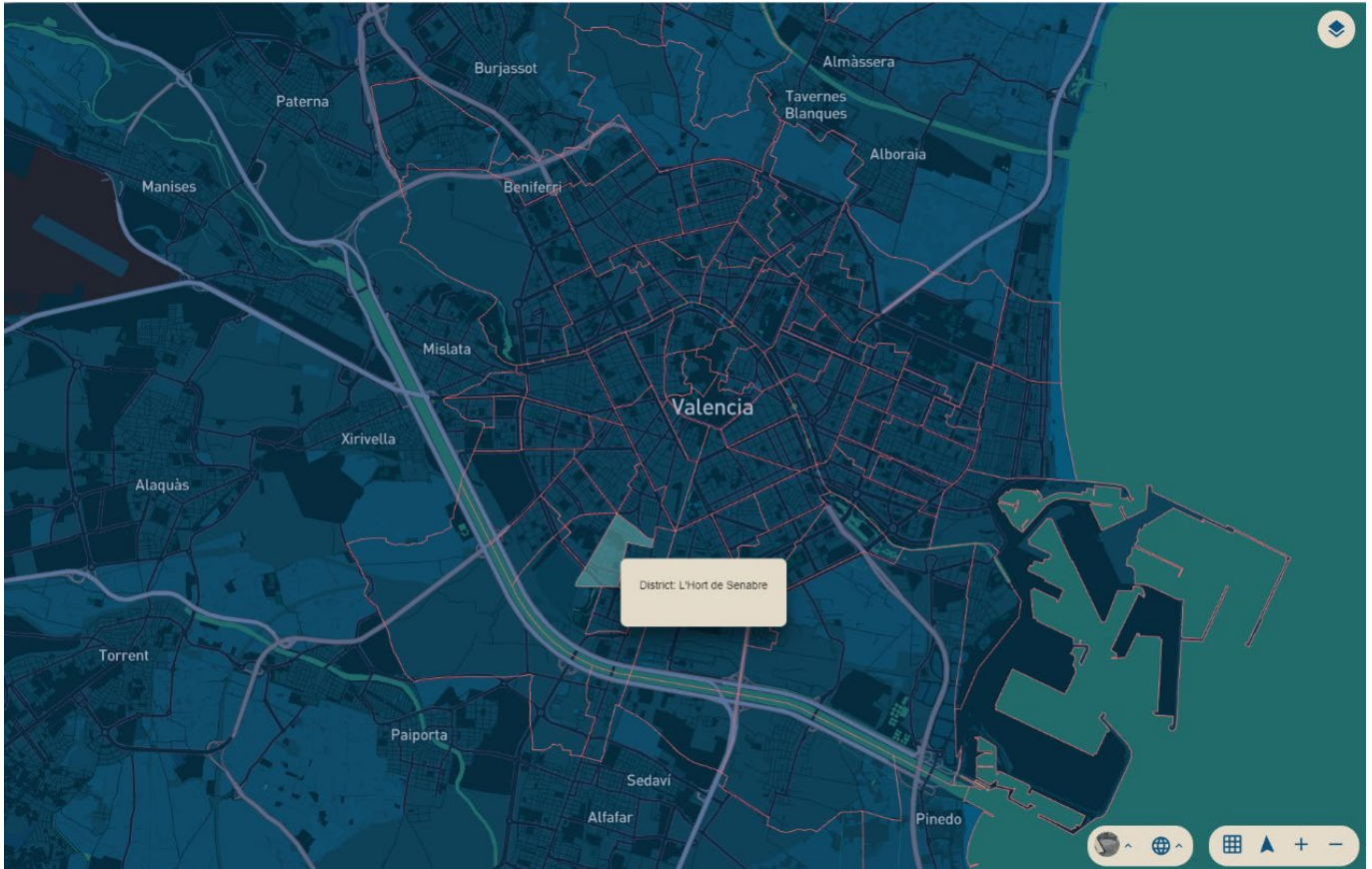


Figure 22 - Zones layer view

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "City distribution" category, and then enable the checkbox for "Zones".

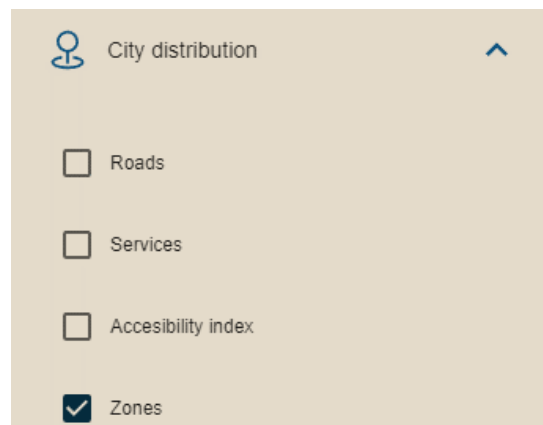


Figure 23 - Enabling zones layer

To present this information, the user must provide data in the GeoJSON standard format, including geometry information represented in Polygon format. Additionally, a field name should be included either at the root of the document or within the properties field. Alternatively, this information can be sourced from OpenStreetMap as well.

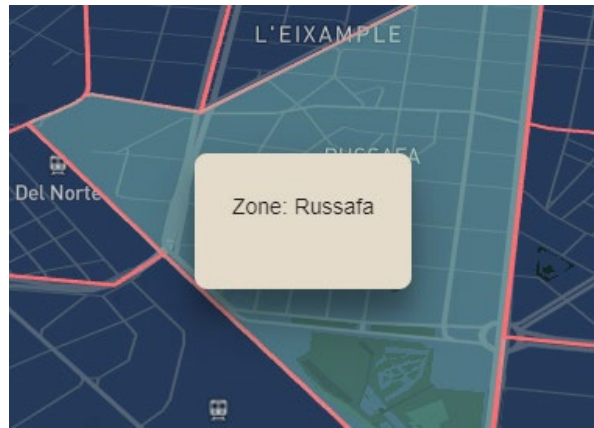


Figure 24 - Zone tooltip

The tooltip displayed upon hovering over the zone reveals the name associated with that particular zone.

#### 6.1.1.4. Display of services

U-TWIN incorporates a dynamic services layer, providing detailed information across various service categories and their geographical distribution on the map. Presently, the available service categories encompass essential amenities such as:

- School
- Hospital
- Clinic
- Shopping
- University
- Industrial

This feature enables users to gain insights into the spatial distribution of key services within the city and their potential impact on public transport operation and traffic levels. For instance, users can observe traffic congestion around schools during entry and dismissal times, allowing for proactive traffic management strategies.

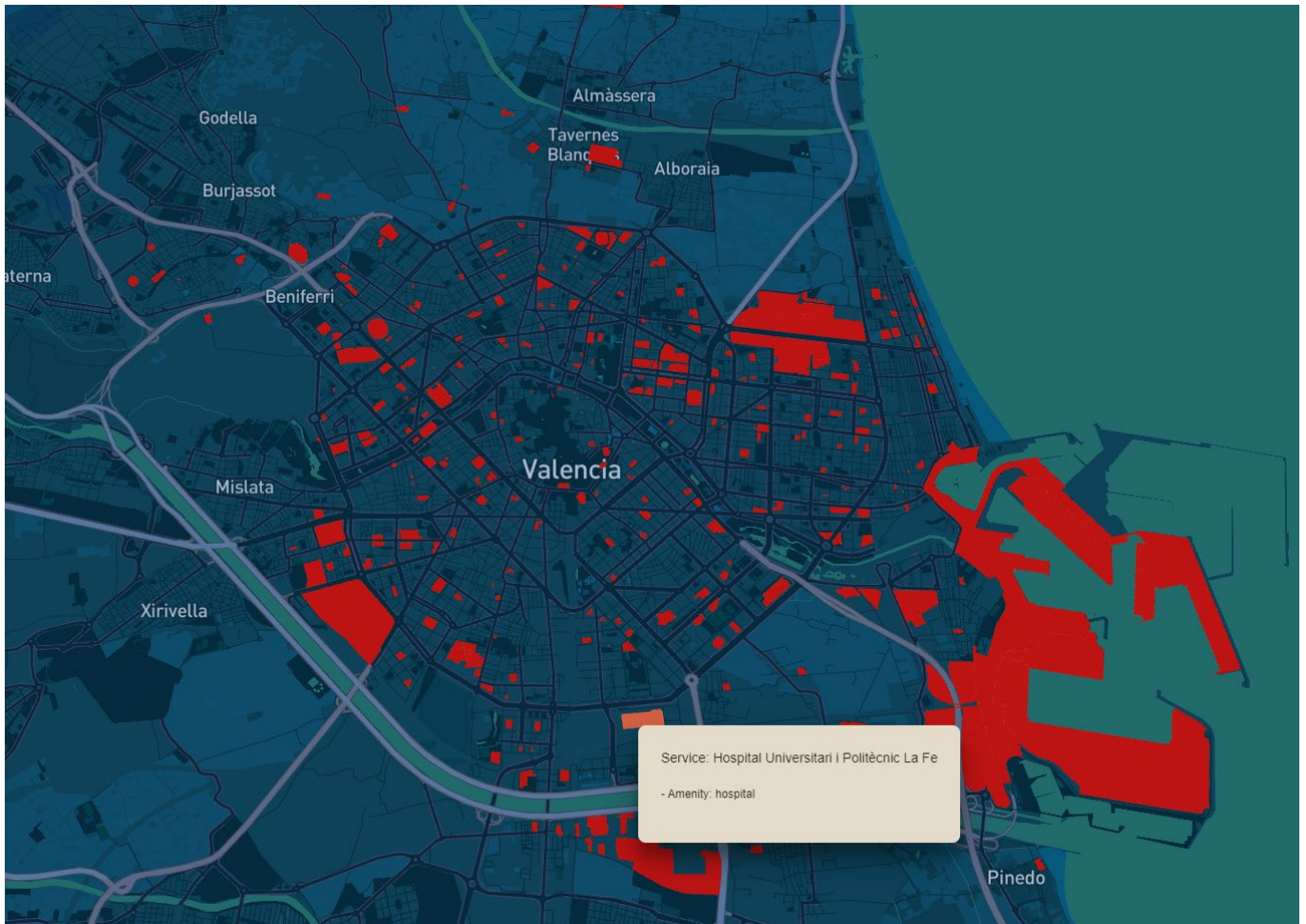


Figure 25 - Services on the map

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "City distribution" category, and then enable the checkbox for "Services".

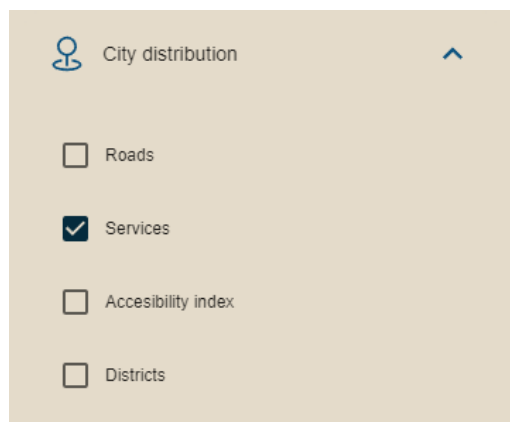


Figure 26 - Enabling services layer

To showcase this information, the user needs to supply data in the GeoJSON standard format, which must include geometry information presented in Polygon format. Furthermore, a property object should encompass the service

type within an amenity field, along with a designated name. Additionally, this data can also be sourced from OpenStreetMap if required.

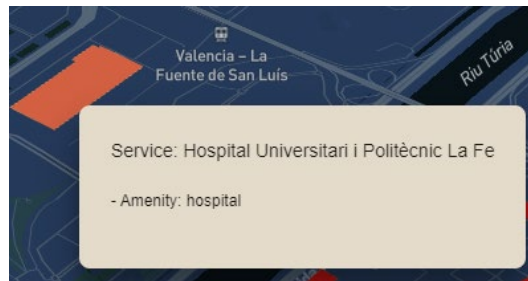


Figure 27 - Services tooltip

When hovering the mouse over a service, a tooltip will appear, showcasing both the service's name and its corresponding amenity type.

#### 6.1.1.5. Display of weather conditions

The tool includes a minimal weather indicator. This feature, represented by a dual-icon button, provides users with immediate visual information on current temperature conditions (cold, warm, hot) with icon and colour, and basic weather states (e.g., cloudy, sunny, raining). This feature is designed to enhance user experience by offering a minimal contextual information at a glance.

The weather information is displayed on the top left border of the tool, ensuring easy visibility and quick access for users.



Figure 28 - Base map with weather conditions

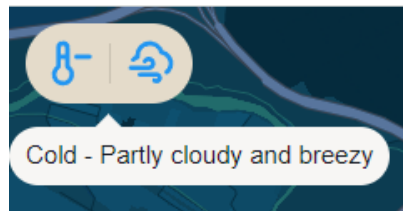


Figure 29 - Weather conditions

The data to be displayed is gathered every 15 minutes from [weatherbit.io](https://www.weatherbit.io) source. This information is displayed at city level.

## 6.1.2. Integration and display of mobility assets static information

A primary focus of the tool is to provide comprehensive public multimodal transport information. This section emphasizes functionalities related to the integration and display of static information concerning mobility assets, such as public transport stops and routes. Users can leverage this feature to gain insights into the layout and infrastructure of the transportation network.

### 6.1.2.1. PT stops

The tool offers the capability to visualize public transport stops directly on the base map. Furthermore, users can access detailed information for each stop, including the stop name, the stop code and the routes that serves.

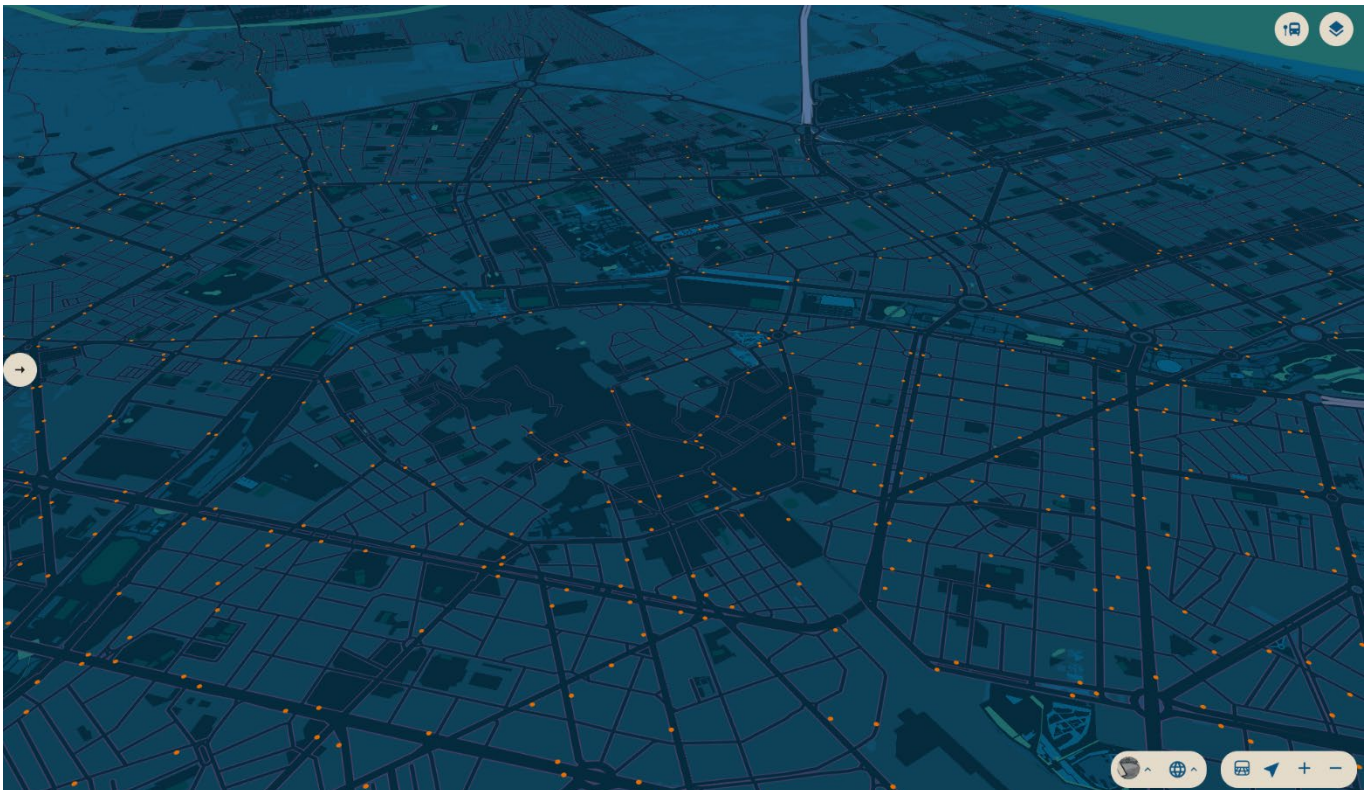


Figure 30 - Public Transport Stops on the map

The comprehensive details can be accessed either through the hover tooltip or from the information sidebar located on the left side of the screen, activated upon clicking on a stop.

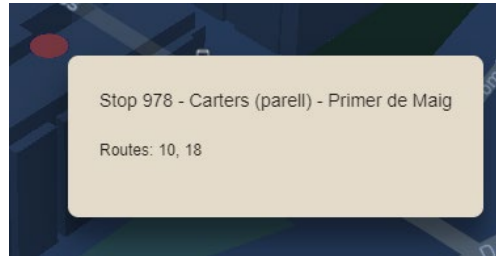


Figure 31 – Stop's hover tooltip

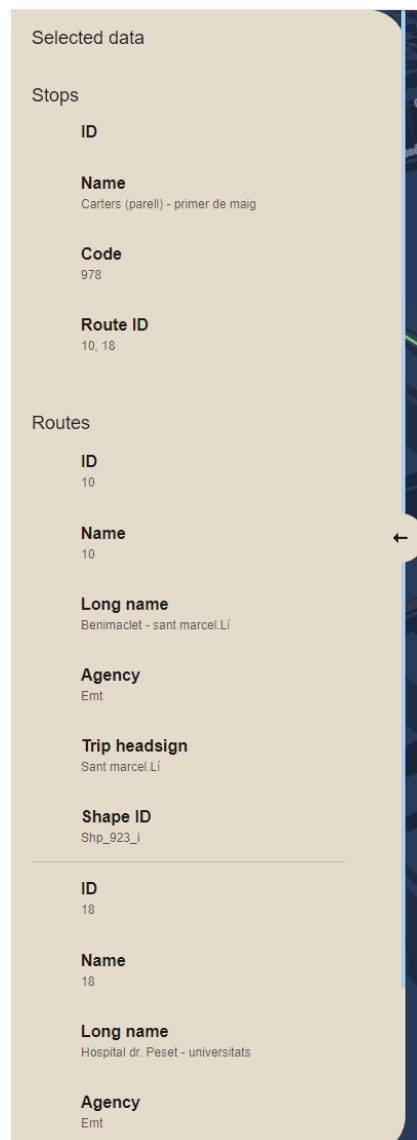


Figure 32 - Stop's information on the sidebar

Upon clicking a stop, the sidebar will not only reveal stop information but also display route information.

Additionally, a new button will emerge in the top-right section of the user interface, as detailed in section 5.2 of this document.



Figure 33 - Additional button

This supplementary button provides the functionality to deselect all previously selected stops and routes.

To enable the visualization of the PT stops, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Public transport stops".

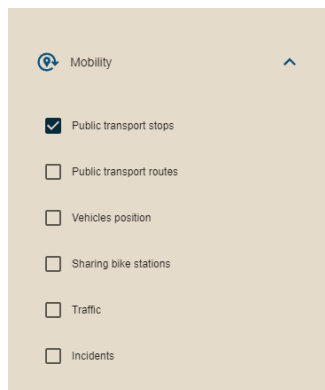


Figure 34 - Enabling public transports stops layer

It can also be enabled from the same menu in the "Public Transport" category.

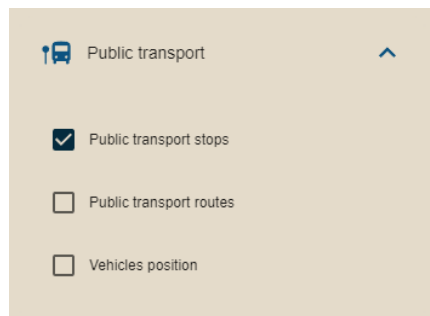


Figure 35 - Enabling public transports stops layer

The data source for this layer must be provided in [GTFS format](#) and imported into the application via the administrator tool.

#### 6.1.2.2. PT routes

Similar to the functionality for public transport stops, the tool also allows for the visualization of public transport routes. This feature enables users to overlay the routes of various public transportation modes onto the base map, providing a comprehensive view of the transport network.



Figure 36 - Public transport routes

Each route offers detailed information, including the route code, its name and the vehicle type, like bus or train.

The detailed information could be seen from the hover tooltip or from the info sidebar, placed on the left of the screen, once a stop is clicked.

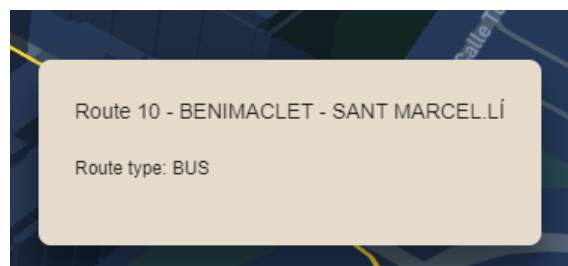


Figure 37 – Route's hover tooltip

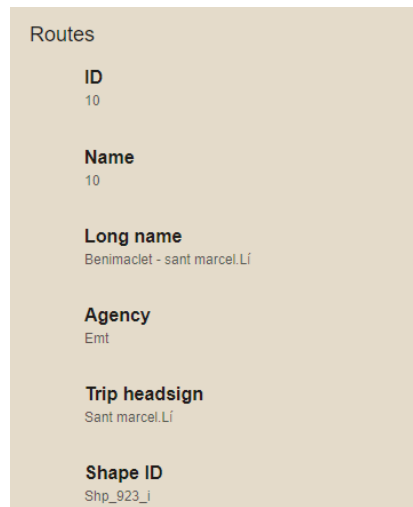


Figure 38 - Route's detail on the sidebar

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Public transport routes".

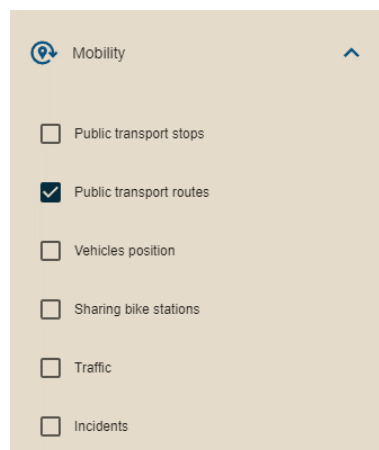


Figure 39 - Enabling public transports routes layer

It can also be enabled from the same menu in the "Public Transport" category.

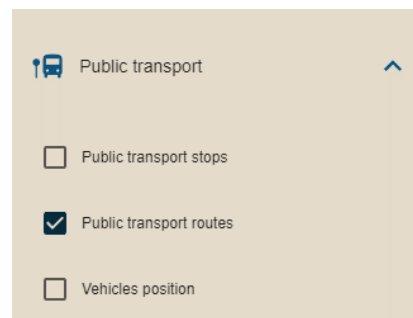


Figure 40 - Enabling public transports routes layer

The data source for this layer must be provided in [GTFS format](#) and imported into the application via the administrator tool.

### 6.1.2.3. Micromobility services

The tool enables the visualization of various micromobility services provided by the city, including bike-sharing stations, scooter stops, and more. It displays the location of each of these stations or stops, along with relevant associated information such as the company, the name of the station or stop and the capacity of the station.

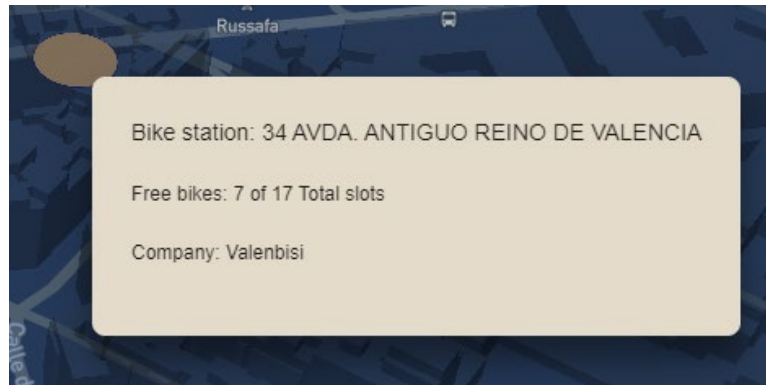


Figure 41 - Bike station's tooltip example

This information is displayed in a tooltip when the user hovers over the station.

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Sharing bike stations".

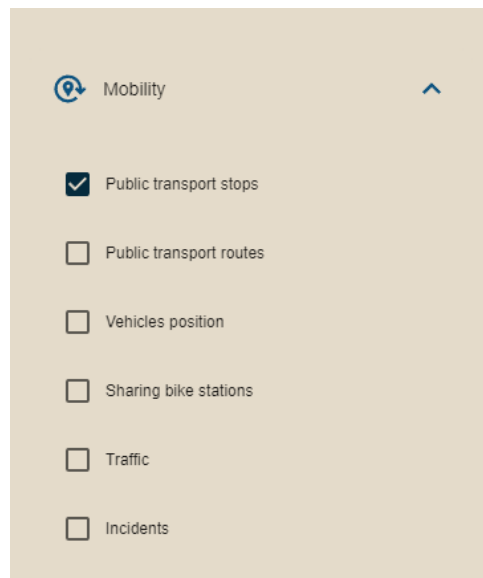


Figure 42 - Enabling sharing bike stations layer

This information could be also enabled through the "Realtime" and "Sharing transport" categories.

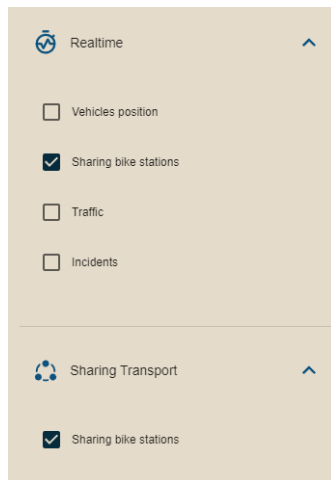


Figure 43 - Alternative enabling sharing bike stations layer

This information needs to be provided in GeoJSON format, containing at least the station's location geometry, total number of slots, and either the number of empty slots or available slots. Regular updates are necessary to ensure accurate representation in the tool. This data could be provided by the PTO/city council or could be sourced from open platforms, if available, such as [citybikes](#)

### 6.1.3. Real-time visualization and monitoring of traffic dynamics

U-TWIN excels in providing real-time insights into traffic conditions within the city. It seamlessly integrates with traffic information sources, whether sourced directly from city services or third-party providers such as TomTom. Through dynamic visualization on the map interface, users can monitor the current service level of city roads in real-time. This invaluable information empowers authorities and operators to make informed decisions regarding traffic management, route optimization, and emergency response strategies.

The visualization of traffic information on the map interface is intuitive and informative, with color-coded lines delineating different levels of congestion. From fluid traffic indicated by blue lines to severe congestion denoted by red lines (*Blue > Green > Orange > Red*), users can quickly assess the prevailing conditions and identify areas of concern. This granular level of detail provides a holistic understanding of real-time traffic conditions for urban planners, traffic management authorities, and transportation operators alike.

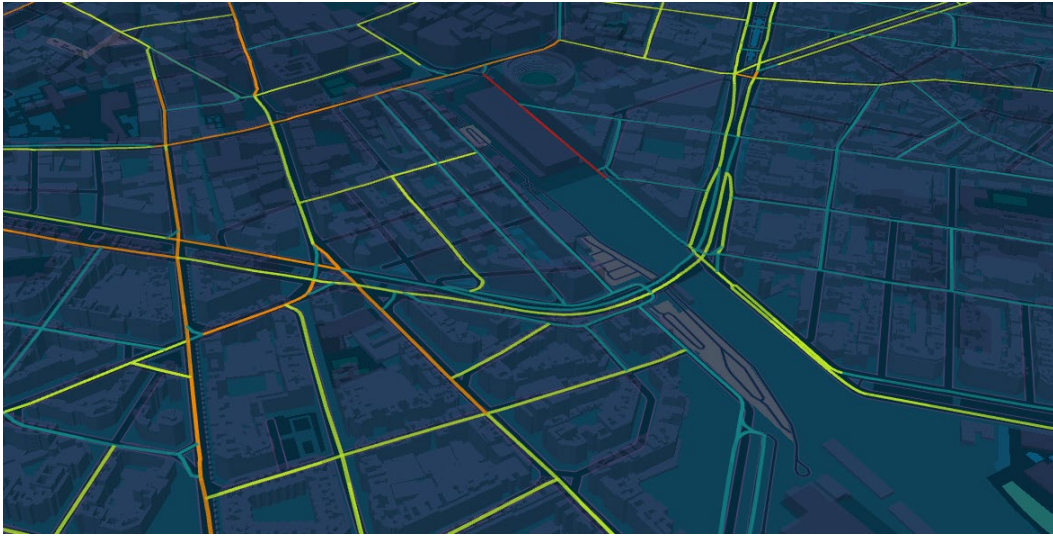


Figure 44 - Traffic service level

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Traffic".

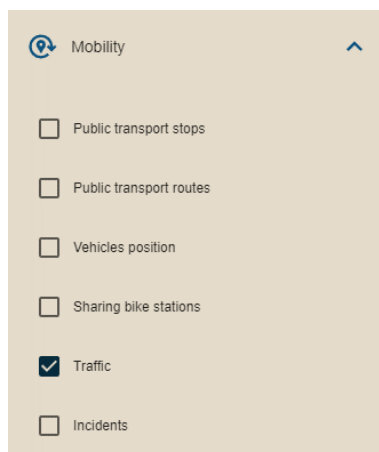


Figure 45 - Enabling Traffic layer

It can also be enabled from the same menu in the "Realtime" category.

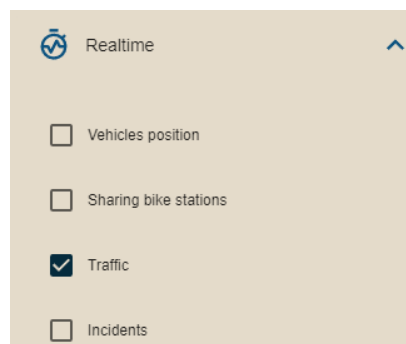


Figure 46 - Alternative enabling of traffic layer

Presently, this information is sourced from a third-party service (TomTom). However, in future iterations, it could potentially be supplemented by other sources such as additional third-party providers or integration with the city's traffic system.

#### 6.1.4. Real-time visualization and monitoring of PT operations

Aligned with its role as a digital twin, U-TWIN provides real-time information on public transport operations, encompassing dynamic data such as vehicle positioning and occupancy rates. The following subsections describe the tool's capacity to integrate and display live PT operational data, enabling users to actively monitor the status and performance of PT services in real-time and facilitating proactive decision-making and optimization of PT services.

##### 6.1.4.1. Vehicle positioning

This feature is dedicated to seamlessly integrating and presenting live data pertinent to public transport operations, enabling users to actively track the movement of PT vehicles in real-time. U-TWIN excels in providing real-time information on ongoing vehicle trips, offering insights into their current positions and any updates occurring during the journey, such as delays or deviations from the scheduled route.

By leveraging this functionality, stakeholders can maintain a comprehensive understanding of PT operations, facilitating proactive decision-making to optimize service delivery and improve passenger experiences. Additionally, the tool's capability to display real-time vehicle positioning enhances operational efficiency and enables timely responses to incidents or disruptions within the public transport network.

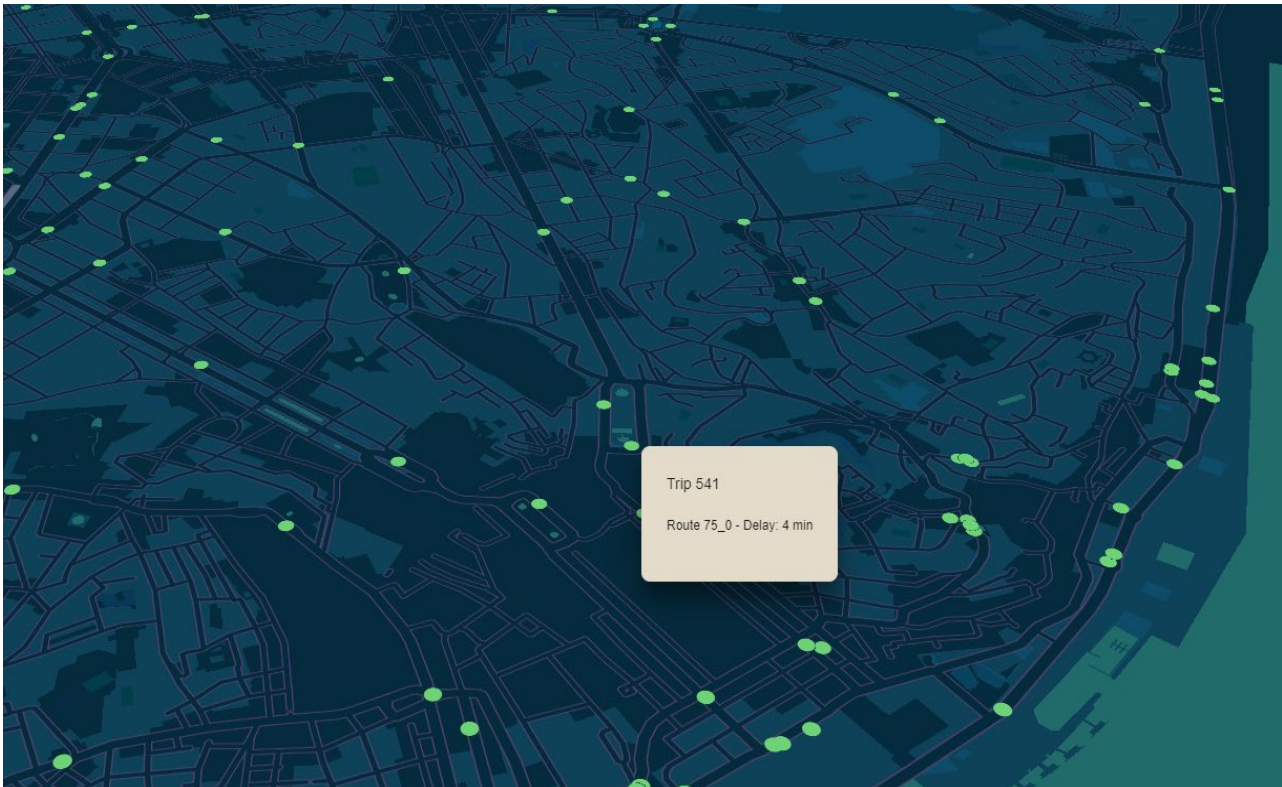


Figure 47 - Real time vehicle position

Upon hovering over each vehicle, a tooltip will display the available information sourced from the GTFS-RT file of the vehicle update feed.

In upcoming iterations of the tool, a color-coded system and distinct shapes will be implemented to highlight delays and differentiate between vehicle types, provided such information is available.

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Vehicle position".

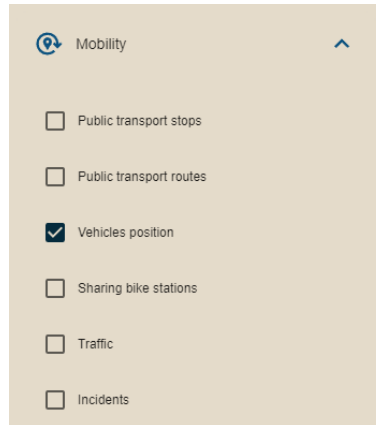


Figure 48 - Enabling vehicle position layer

It can also be enabled from the same menu in the "Realtime" and the "Public transport" categories. Both categories are activated automatically if any of them is activated.

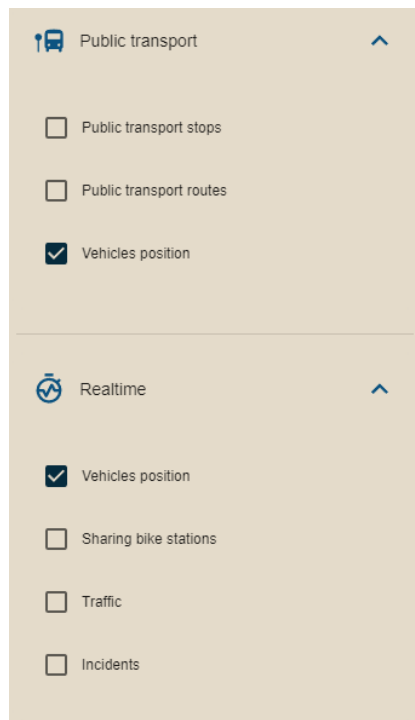


Figure 49 - Alternate enable of vehicle position layer

To activate this functionality, the Public Transport Agency (PTA) or Public Transport Operator (PTO) must supply the Real-Time (RT) feed. In this first version, U-TWIN is compatible only with the GTFS-RT vehicle position feed. The next version (April 2025) will introduce support for additional formats, including the GTFS-RT trip update feed and SIRI real-time data formats. This expansion will enhance compatibility and broaden the tool's capacity to integrate real-time data from diverse sources, ensuring comprehensive monitoring and analysis of public transport operations.

#### 6.1.4.2. Vehicle occupancy rate

This functionality seamlessly integrates and presents real-time data relevant to public transport operations, allowing users to actively monitor the occupancy levels of PT vehicles. It serves as a valuable functionality for identifying instances (transport mode, route, vehicle and time) of high occupancy, which may impact passenger experience. By providing insights into vehicle occupancy in real-time, this feature enables transport operators to devise mitigation strategies to address instances of excessive occupancy, particularly at recurring times. This proactive approach aims to enhance passenger satisfaction and optimize the overall public transport experience. This functionality is still under development process and will be available in the next version of the tool (April 2025).

#### 6.1.5. Real-time monitoring of micromobility services assets

U-TWIN offers micromobility services functionality, allowing users to access relevant information such as the real-time location of the vehicles (in case of free-floating bikes, sharing scooters and so on) and real-time information related to the micromobility stations and their availability. With respect to the availability level at the micromobility stations, this feature enables users to view the current status of, for example, the bike-sharing stations, providing valuable insights into the availability of sharing bikes at each location. By incorporating this data, U-TWIN enhances its utility as a comprehensive urban mobility platform, empowering PTAs/PTOs/city councils to make informed decisions and promote sustainable modes of travel.

These stations will be represented in a different colour based on the availability of the micromobility vehicles:

- Dark green if the availability (number of free vehicles divided by the total number of slots) is equal to or bigger than 90%.
- Lime green between 75% to 89%.
- Yellow between 50% and 74%.
- Orange between 25% and 49% .
- Red for between 0% and 24%.

This information will be updated at least every 5 minutes, but it will be adapted to the update frequency of the origin source.

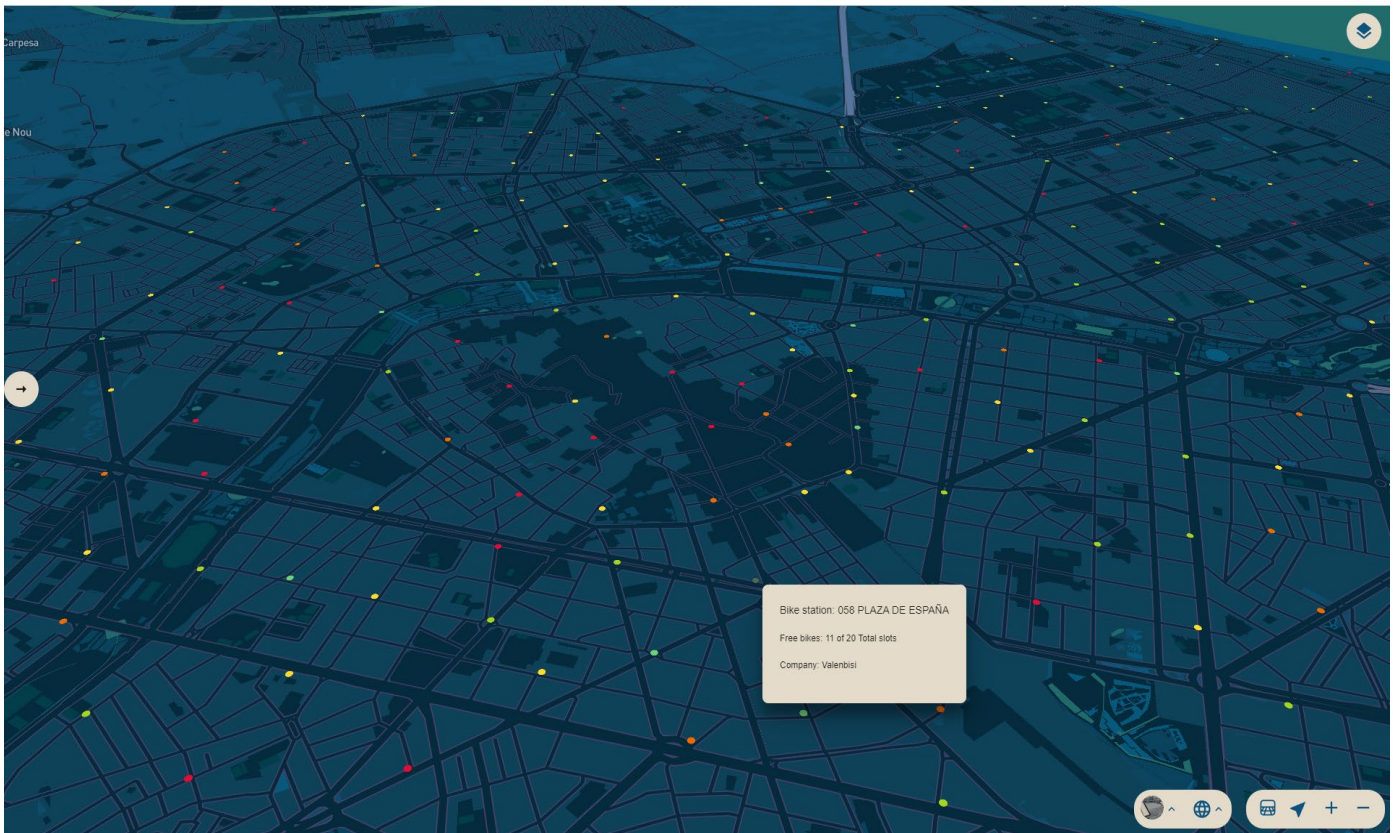


Figure 50 - Bike sharing stations

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Sharing bike stations".

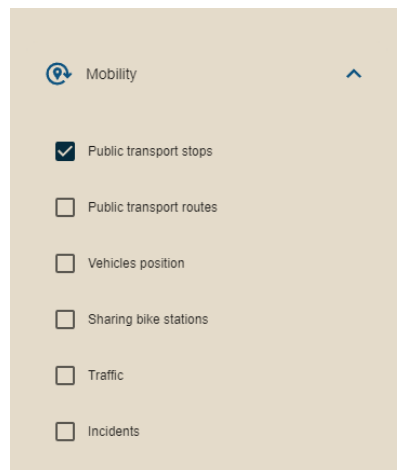


Figure 51 - Enabling sharing bike stations layer

It can also be enabled from the same menu in the "Realtime" and "Sharing transport" categories.

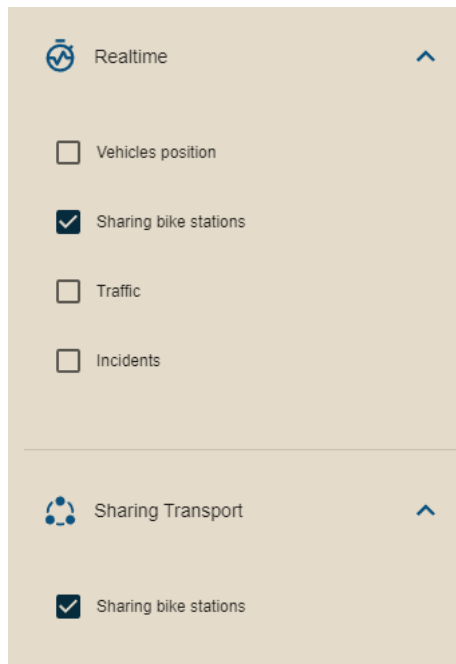


Figure 52 - Alternative enabling sharing bike stations layer

The information should be presented in GeoJSON format, containing essential details such as the station's location geometry and metrics including total slots, as well as either empty slots or available slots. Regular updates are essential to ensure accurate representation within the tool. This data could be provided by the PTO/city council or could be sourced from open platforms, if available, such as [citybikes](#).

### 6.1.1. Display of incidents and alerts related to PT operation

This functionality allows users to visualize and track incidents and alerts relevant to public transport (PT) operations. Users can readily monitor real-time updates on incidents such as delays, accidents, or service disruptions, ensuring timely responses and effective management of PT services. By providing comprehensive insights into potential disruptions, this feature enhances operational efficiency of the public transport network.

This functionality is still under development and will be available in the next version of the tool (April 2025).

### 6.1.2. Display of incidents and alerts alien to PT operation

This functionality enables the tool to showcase alerts and incidents that may impact public transport operations. Users can visualize a variety of incidents, including closed roads, traffic jams, or road works, through intuitive icons displayed on the map interface. By providing real-time updates on external factors affecting transportation, this feature enhances situational awareness and supports proactive decision-making for optimizing public transport services.



Figure 53 - Incidents and alerts

Presently, there are 10 distinct icons designed to represent various alerts and incidents, alongside four different colours denoting severity levels.

The teal colour indicates low severity, yellow denotes medium severity, orange signifies high severity, and red represents extreme incidents.

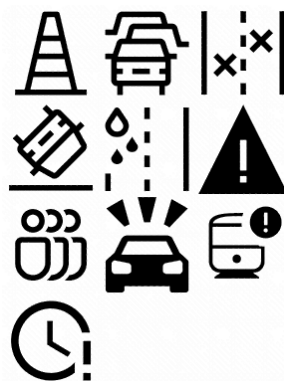


Figure 54 - Available incidents and alerts icons

In the current version of the U-TWIN tool, the available icons include those listed above. Enumerating them from left to right and from top to bottom: road works, traffic jams, closed roads, vehicle accidents, slippery roads, default incident, long queue (at public transport stops), slow traffic, public transport accidents, and delays.

These icons represent various types of incidents that may occur and can be positioned as points or along lines on the map. When a user hovers over an icon, a tooltip containing additional information is presented.

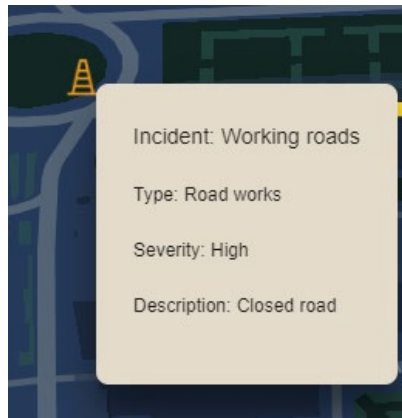


Figure 55 - Incident tooltip

If available, the incident will include an associated title, type, severity, and a corresponding description.

To enable the visualization of this information, the user must click on the "Layers action button", navigate to the "Mobility" category, and then enable the checkbox for "Incidents".

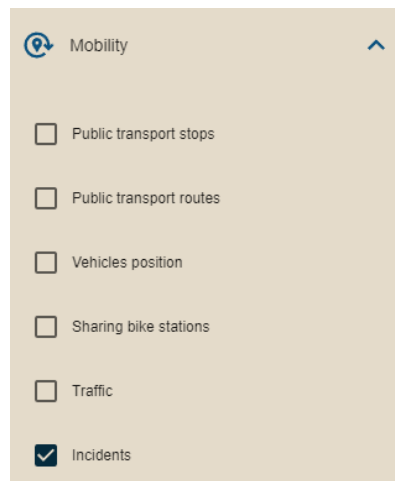


Figure 56 - Enabling Incidents layer

It can also be enabled from the "Realtime" category

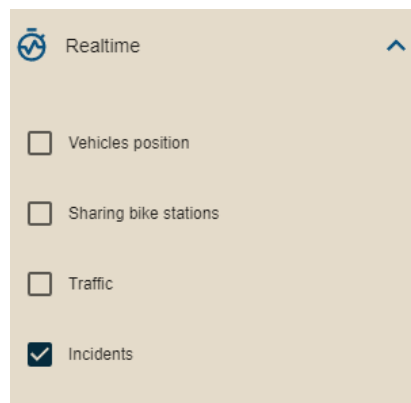


Figure 57 - Alternative enabled incidents

This information should be available in GeoJSON format, containing at least the location geometry, severity level, and incident type. Alternatively, it can be sourced from a third-party provider such as TomTom.

## 6.2. Advanced Features

### 6.2.1. Data lake for supplementary systems and applications

U-TWIN serves as a versatile data lake for integrating with supplementary systems and applications. It will expose an accessible endpoint for retrieving up-to-date data based on snapshots. This functionality enhances interoperability and facilitates the seamless integration of U-TWIN with external systems, empowering stakeholders to leverage its rich dataset for diverse urban management applications.

The data that could be recovered is the following (note that until the next version of the tool the complete list will not be definitive):

- Public transport stops
- Public transport routes
- Latest updated data from RT
- Bike sharing and other micromobility service status
- Alerts and incidents
- Latest retrieved weather conditions

This data snapshots will be available to be gathered from an **API Rest** by a third-party service or application. A secure authentication method will also be developed to protect the tool data to be exposed.

This functionality is still under development and will be available in the next version of the tool (April 2025).

### 6.2.2. On-demand simulation of corrective strategies

U-TWIN will establish connectivity with U-SIM.live, enabling end users to simulate corrective strategies in response to incidents or alerts. While the simulation will be fully executed within U-SIM.live, a dedicated button for direct access to the service will be implemented in U-TWIN in the next iteration. This integration enhances the functionality of U-TWIN by providing users with a seamless pathway to simulate and evaluate strategies for mitigating disruptions and optimizing operations in real-time.

This functionality is still under development and will be available in the next version of the tool (April 2025).

### 6.2.3. Arrival time predictions

In a future version of the tool (scheduled for April 2025), U-TWIN will have the capability to predict arrival times at the next stop and forecast demand using historical data. These predictions will be generated using various computer algorithms, with accuracy improving over time as the tool is deployed and utilized. Additionally, accuracy enhancements will be made based on factors such as weather conditions and calendar data.

## 7. Data Management

### 7.1. Importing Data

U-TWIN will allow the user to import GTFS files from a zip file or an URL endpoint, thanks to an administration tool (see section 4). This same administration tool will provide the capability to define real-time data as feeds URL in GTFS-RT vehicle position, GTFS-RT trip update, or SIRI format. For any data not in GTFS or GTFS-RT format, a method for importing it will be developed for the subsequent version of the tool, due in April 2025.

The data formats required for enabling each one of the functionalities are detailed under the corresponding section.

Furthermore, this administration tool will enable users to establish an automatic update schedule for GTFS files retrieved from URLs, rather than files directly.

### 7.2. Exporting Data

The exporting data functionality will leverage the API exposed in section 6.2.1 of this document.

U-TWIN will serve as a data lake for various services and applications, providing an endpoint for data retrieval based on snapshots. This feature enables users to export data seamlessly from U-TWIN, facilitating interoperability and data utilization across multiple platforms and applications.

The data that could be recovered is the following (note that until the next version of the tool the complete list will not be definitive):

- Public transport stops
- Public transport routes
- Latest updated data from RT
- Micromobility service status
- Alerts and incidents
- Latest retrieved weather conditions

All this data could be retrieved from the API Rest that will be developed for the next iteration of the tool (April 2025).

### 7.3. Actions log

To enhance monitoring capabilities and facilitate debugging across all deployment environments, every action executed within the tool, whether on the client-side or server-side, will be meticulously logged. These logs will be categorized according to the type of action performed, such as map style adjustments or GTFS data updates, facilitating efficient tracking and comprehensive analysis.

### 7.4. Data updating

Along with the U-TWIN tool, an administration application (see section 4) will be offered to manage the update of static and real-time files, such as GTFS and GTFS-RT, automatically and manually.



## 7.5. Data requirements

U-TWIN will be compatible with GTFS formats for static data, and GTFS-RT or SIRI for real time data.

For any other data, such as bike station information or additional static data, it will be necessary to adapt it to meet the format requirements defined in this document, within each feature section. This ensures compatibility and consistency in data representation across the platform, enabling seamless integration and utilization of various data sources within the U-TWIN ecosystem.

## 8. Development timeline

The development of the U-TWIN tool is planned as 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 1st version										█	█	█	█	█	█	█	█												
Development of core functionalities										█	█	█	█	█	█	█													
Bilateral meetings with cities to prioritize developments													█	█	█	█	█												
2nd development phase and release of 2nd version																█	█	█	█	█	█	█	█	█	█	█	█	█	█
Development of remaining functionalities																█	█	█	█	█	█	█	█	█	█	█	█	█	█
Testing and validation by horizontal partners																			█	█	█	█	█	█	█	█	█	█	█
Fine-tuning of the tool																													
Deployment in the cities																													

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

- **“Tool Ideation”** (M1-M4): In the initial phase, the focus was on refining the tool's definition and outlining its essential functions. This involved a thorough analysis of proposed measures by cities and the identification of functionalities crucial for supporting cities in implementing these measures. The culmination of this ideation phase was the creation of a comprehensive product card. This document provided a clear and detailed description of the tool, a catalogue of core functionalities, insights into potential beneficiaries, and a mapping of measures that could leverage the tool's capabilities. This product card served as a key resource for cities and transport operators, facilitating a deeper understanding of the tool's potential impact and benefits.
- **“Requirements Identification”** (M4-M10): The requirements gathering process for the tool was carried out collaboratively, involving the tool developers themselves, developers of other tools within the project (in case of interaction between tools), as well as end users (cities, transport operators, and transport authorities). To define requirements in detail, a series of workshops were conducted, followed by the utilization of the Volere methodology, which entails iterative validation and revision of different requirements by all partners. The outcome of this process was a list of requirements (technical, legal, and operational) agreed upon by all parties involved. Deliverable D2.4 documents the results of this phase.
- **“1st Development Phase and Release of 1st Version”** (M10-M16): During this phase, the core interface and functionalities of the tool have been developed. Concurrently, bilateral meetings with city representatives have taken place to prioritize certain features based on the unique needs of their measures. By the time this deliverable is submitted, this phase will have been concluded.
- **“2nd Development Phase and Release of 2nd Version”** (M16-M24): During this phase, the remaining functionalities will be developed. Concurrently, the tool will undergo a rigorous testing and validation by designated project horizontal partners, who will offer valuable feedback on its usability. Furthermore, the tool



developers will refine existing features, addressing any identified bugs or issues from the initial release, and integrating feedback collected from both horizontal partners and end users.

- **“Deployment of the Tool in the Cities”** (M22-M28): Starting in month 22, the tool will be gradually deployed across cities, following a comprehensive strategy encompassing training and support. Fine-tuning efforts will persist until month 28, guided by user feedback, ensuring optimal functionality and user satisfaction.