UPPER
Unleashing the Potential of Public Transport in Europe

U-NEED

D4.1 U-NEED: A tool to optimise the PT offer in line with the user mobility patterns

WP4 Innovative solutions to increase the efficiency, reliability and attractiveness of PT

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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

This document aims to serve as a comprehensive user manual for the U-NEED tool, detailing its functionalities and specifications. Within this manual, visual descriptions of the development work undertaken for U-NEED and its individual features are presented. The tool's creation directly addresses the expressed needs and concerns of end-users during the project's initial stages. By translating these identified needs into specific functionalities, U-NEED aims to support the implementation of measures that unlock the potential of public transport.

Those functionalities closely aligned with the 80 measures to be demonstrated in the UPPER project have received prioritization. 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. While this deliverable accompanies the initial version of U-NEED, the final version is scheduled for delivery in April 2025. As a result, some functionalities are still under development, and detailed usage information may not be fully available in this initial release."

Keywords

U-NEED, Origin-Destiny matrix, mobility pattern, user demand, toolkit.

1. About U-NEED

1.1. Overview

U-NEED is a comprehensive Big Data analytics and visualization tool designed to address the complex needs of municipal authorities, public transportation operators (PTOs), and public transport authorities (PTAs) in managing and optimizing public transportation (PT) services. Its primary aim is to provide insights into transportation demand and urban mobility patterns, facilitating informed decision-making to tailor PT offer accordingly.

The tool seamlessly integrates Origin-Destination (OD) information from various transportation modes, offering a cohesive understanding of how people move throughout the city. Through advanced data processing capabilities, U-NEED generates a detailed 3D geographic representation of people flows, allowing stakeholders to visualize and analyse transportation patterns with precision.

U-NEED is designed for medium and long-term public transportation (PT) optimization and planning. It becomes a key support tool for various purposes, including the analysis of mobility patterns, the accessibility studies and the identification of inefficiencies in the PT offer. Its final goal is to enhance understanding of multimodal transportation demand and urban mobility patterns, empowering decision-makers to make data-driven choices for optimizing travel structures and adjusting PT offerings.

1.2. Purpose of the Tool

U-NEED can provide strong support in the identification of inefficiencies within PT offer, such as poorly covered geographic areas, excessive travel times, and insufficient capacity. By pinpointing these areas of concern, U-NEED enables authorities and operators to prioritize improvements and allocate resources effectively to enhance overall transportation efficiency.

Furthermore, U-NEED facilitates the optimization of PT capacity, schedules, frequencies, and routes based on user needs and passenger flows. By leveraging predictive analytics, the tool assists in forecasting demand and PT operations under various scenarios, empowering decision-makers to proactively address potential challenges and anomalies.

U-NEED serves as a valuable asset for both medium-term operational adjustments and long-term strategic planning. Its data-driven approach empowers stakeholders to make informed decisions regarding PT infrastructure investments, service enhancements, and policy interventions, ultimately contributing to the creation of more efficient, responsive, and sustainable urban transportation systems.

The U-NEED tool has been developed using Open-Source technologies based on JavaScript, such as:

- **MeteorJS:** A JavaScript platform for developing high-performance web applications.
- **MongoDB:** A highly scalable and flexible document database, as well as an advanced query and indexing model.
- **React:** A high-performance JavaScript library that enables the development of interactive and reactive web applications through reusable components that automatically manage the graphical interface update when data changes.
- **Material UI:** A library of user interface components for React based on Google's popular Material Design.
- **KeplerGL:** A library for visualizing geospatial data based on WebGL. It is designed to be highly interactive and scalable, allowing for the creation of custom high-quality geospatial visualizations and enabling the handling of large datasets, rendering maps quickly and smoothly. It can be easily integrated with React.

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

1.3. Intended audience

The primary end users of the U-NEED tool are city authorities, Public Transport Operators (PTOs), and Public Transport Authorities (PTAs). U-NEED will enable these stakeholders to: (i) better understand how people moves throughout the city; (ii) detect inefficiencies in the PT offer; (iii) and better define strategies to enhance and optimize the public transport network.

2. System Requirements

This section compiles the system requirements that the end-user needs to take into account to be able to utilize U-NEED. Requirements at hardware, operating system and browser level have been established.

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)

2.1.4. Network connectivity

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

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

2.3. Deployment requirements

The deployment of the U-NEED tool will involve individual cloud-based setups for each city. Each city will have its own personalized deployment configured to meet its specific needs and requirements, including the particular location of the city and the different data source connection, among others.

3.User Roles and Permissions

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

- **U-NEED Administrator:** Managed by ETRA I+D, this role guarantees complete oversight by granting access to all datasets stored within the system. The U-NEED 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-NEED 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-NEED tool configured for their city and utilize all features detailed in section 6.

Regarding permissions, the U-NEED 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-NEED platform.

4.Administration tool

A dedicated tool is currently being developed for user administration purposes. Users with “Site administrator” role will have access to it. This tool will be available in April 2025, and will allow the administrator roles to setup connections with external data sources and manage the data to be imported in the system.

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.

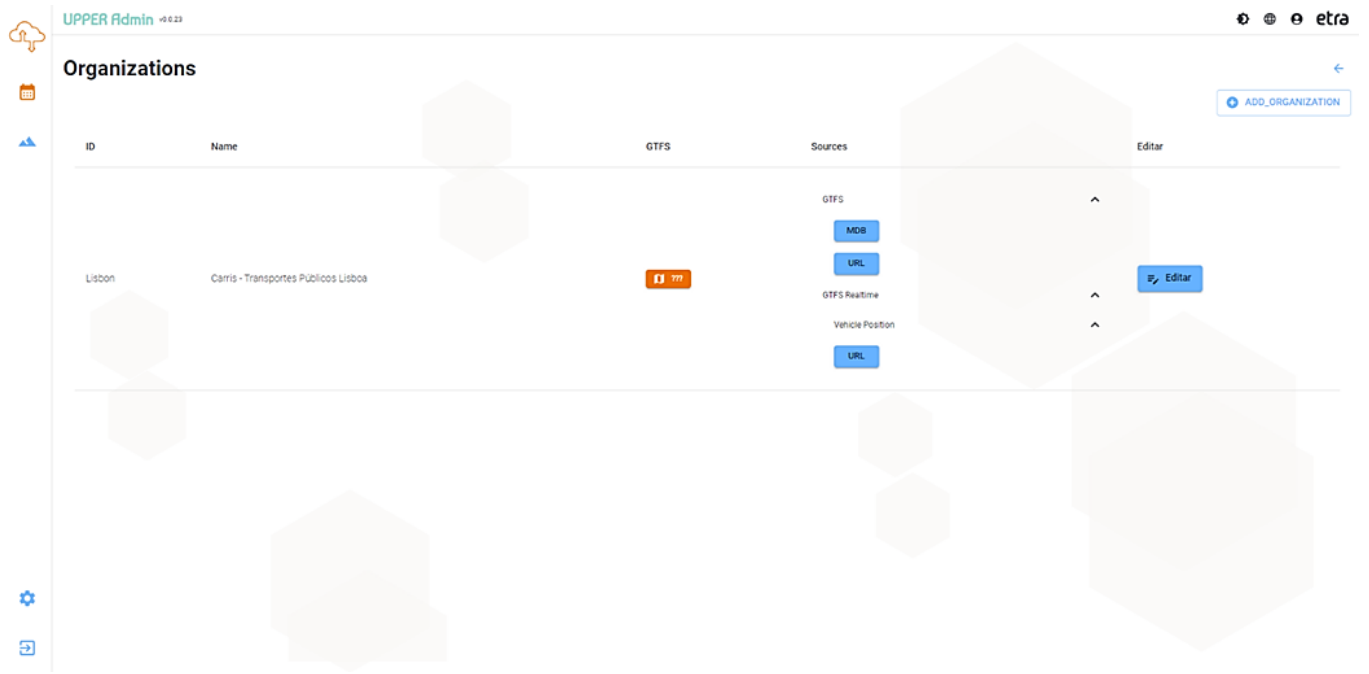


Figure 1 - Work in progress: Administration tool

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-NEED tool. For instance, importing Visum zones model could be of interest to the user, rather than relying solely on the default district distribution provided by the 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-NEED tool.

It is worth noting that the Administration tool includes a feature to convert coordinates from the UTM system to the latitude/longitude format while preserving the original geometry. This functionality was deemed essential during the development phase, particularly because a significant portion of data coming from the municipalities is provided in the UTM format. From a technical standpoint, UTM coordinates are planar and measured in meters, making them incompatible with the coordinate system used by standard web mapping tools, which rely on latitude and longitude.

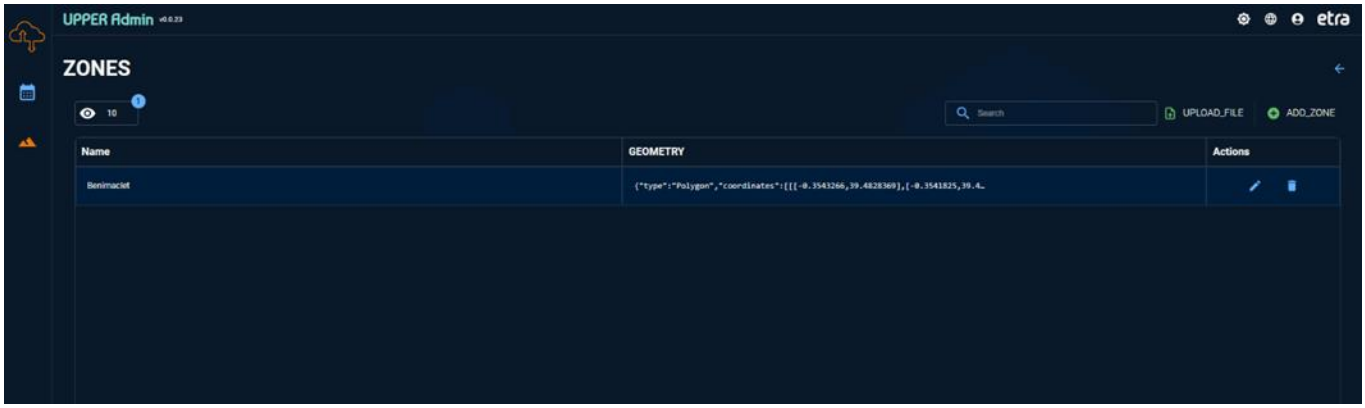


Figure 2 - Work in progress: Administration tool

5. Getting started

5.1. Access/Authentication

The administrator of the U-NEED tool (ETRA I+D) is able to create new users and assign the corresponding roles to them. It will not be possible to create a user in other ways. The access to the application is provided by a user/password credentials.

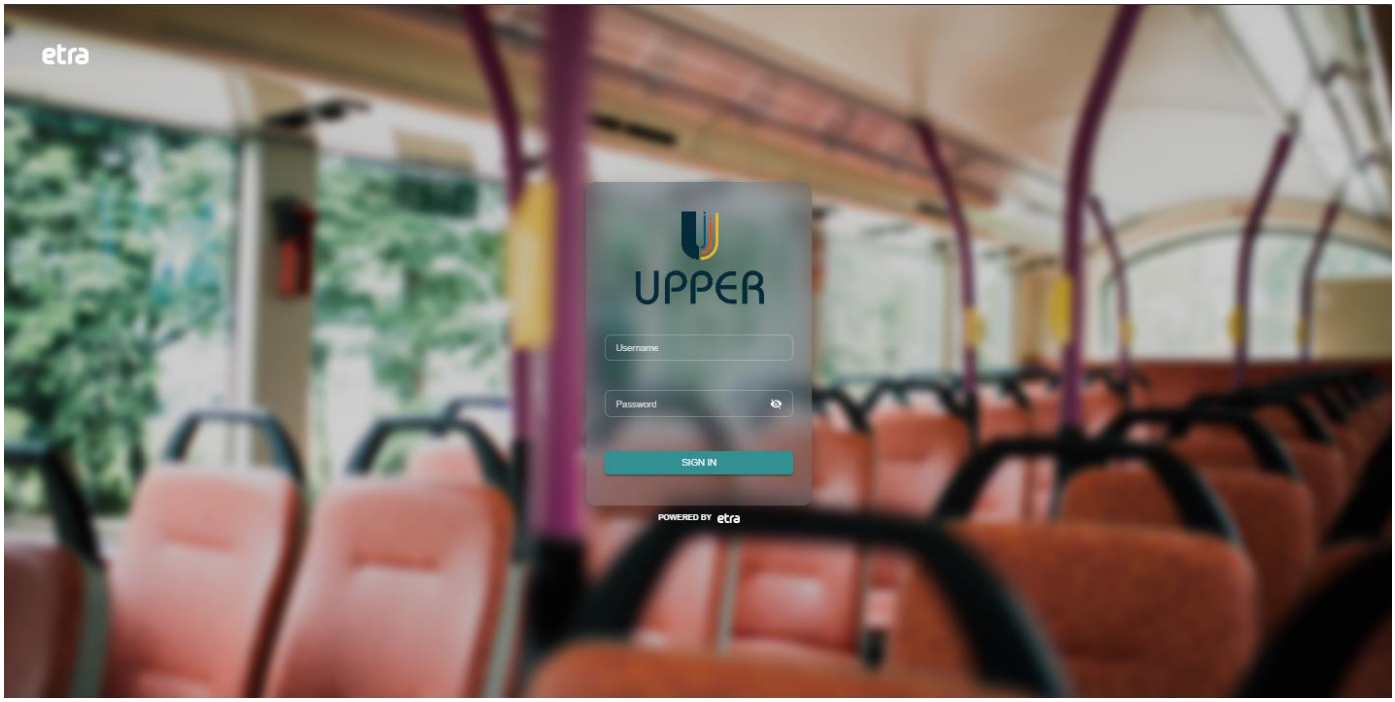


Figure 3 - U-NEED login view

5.2. User Interface Overview

Once the user is logged in, the tool displays the main view with a background map centred on the city that the user has in their settings and a toolbox on the left where the user can perform many different actions.

The main view of the U-NEED tool is showed below.

Figure 4 - U-NEED main view

The toolbox has been developed based on the KeplerGL library toolbox, adding new functionalities and changing the default colours by the dark theme of the UPPER's style guide. The use of this library is due to the high customization of its components and its high performance with sets of large amounts of spatial data. Following to this, the different actions that can be performed in the main view are going to be described.

5.2.1. Map settings

First of all, there are some icons on the right of the map which are intended to modify some map settings:

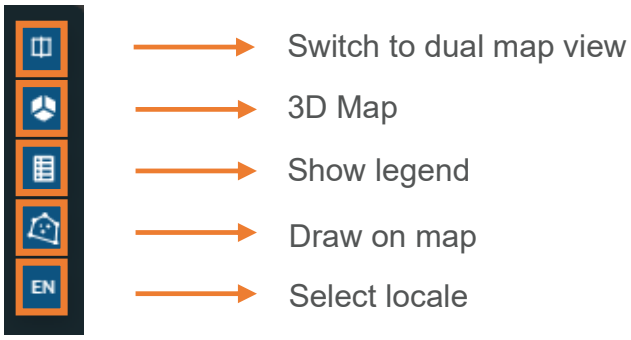


Figure 5 - Map settings

- Switch to dual map view: You can display a side-by-side comparison of the same map area with different layers with the Split Map functionality.

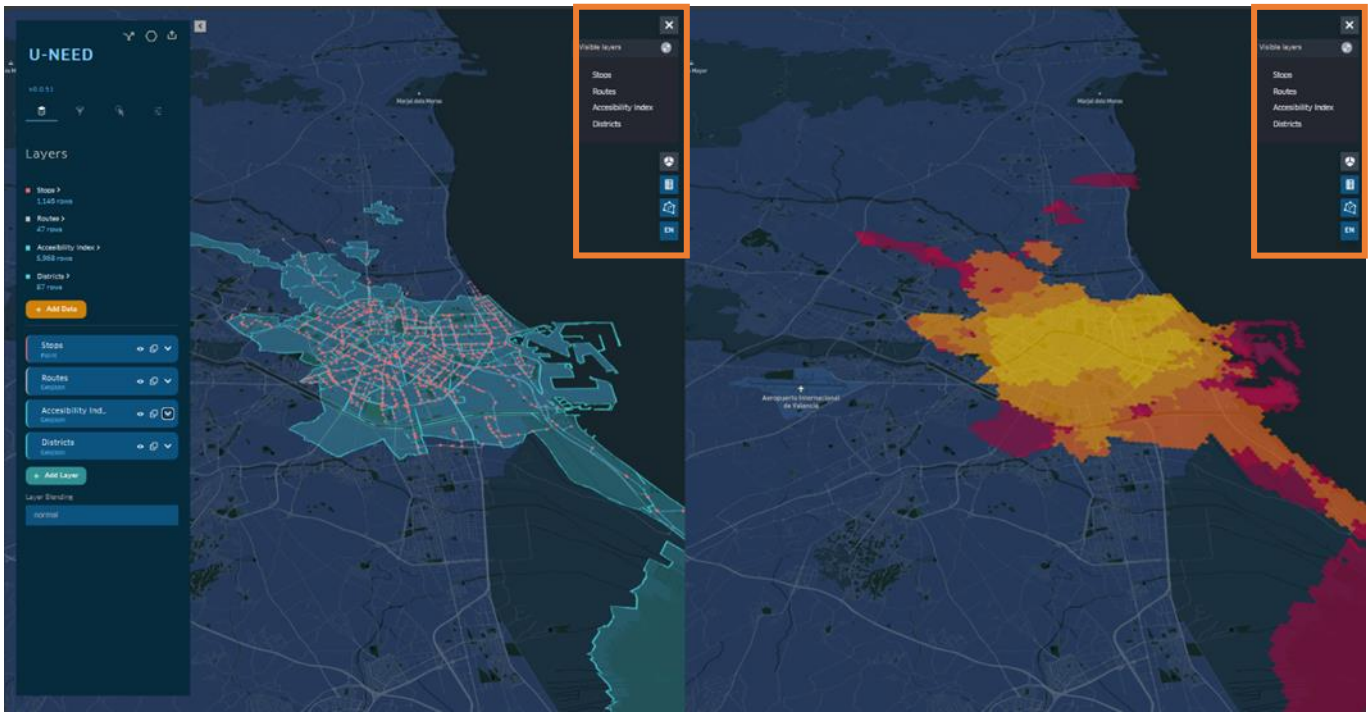


Figure 6 - Dual map view

- 3D Map / Disable 3D Map: View your map in 3D (or come back to the map in 2D).

Figure 7 – 3D Map view

- Display legend: Display the meaning of each colour displayed over the map.

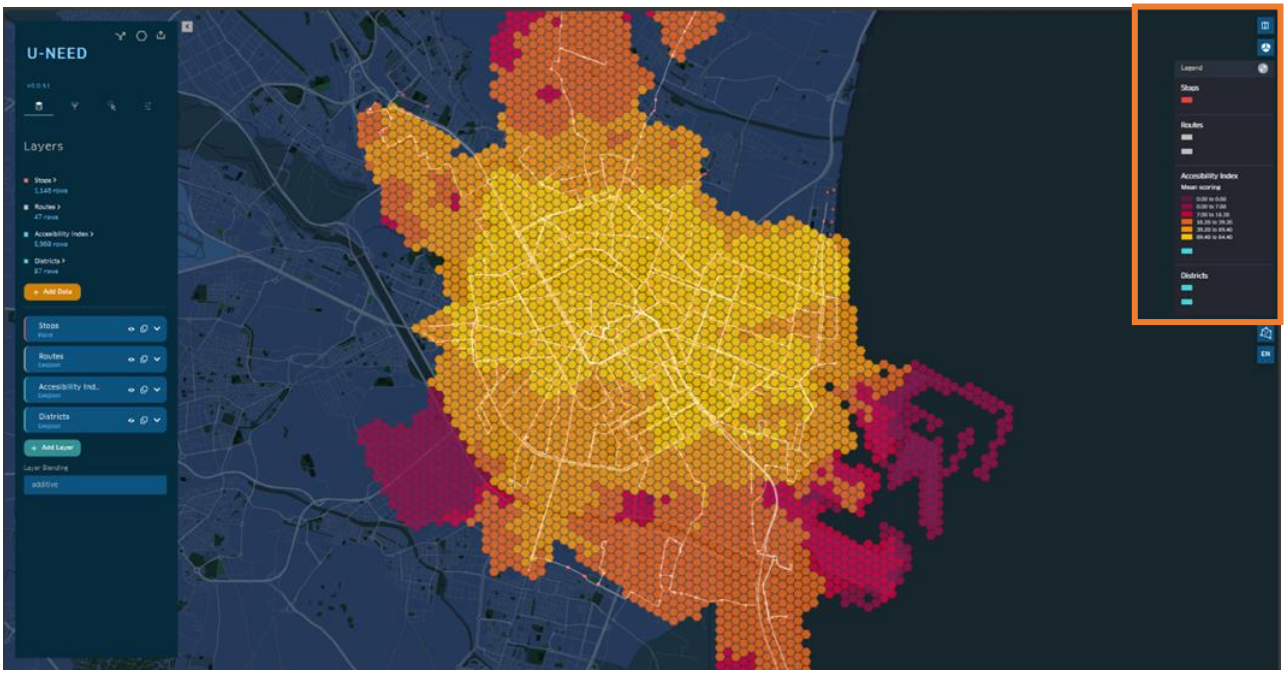


Figure 8 – Legend over the main view

Figure 9 – Legend detail

- Draw on map: When the user clicks on the “Draw on map” icon, a new set of icons is displayed.

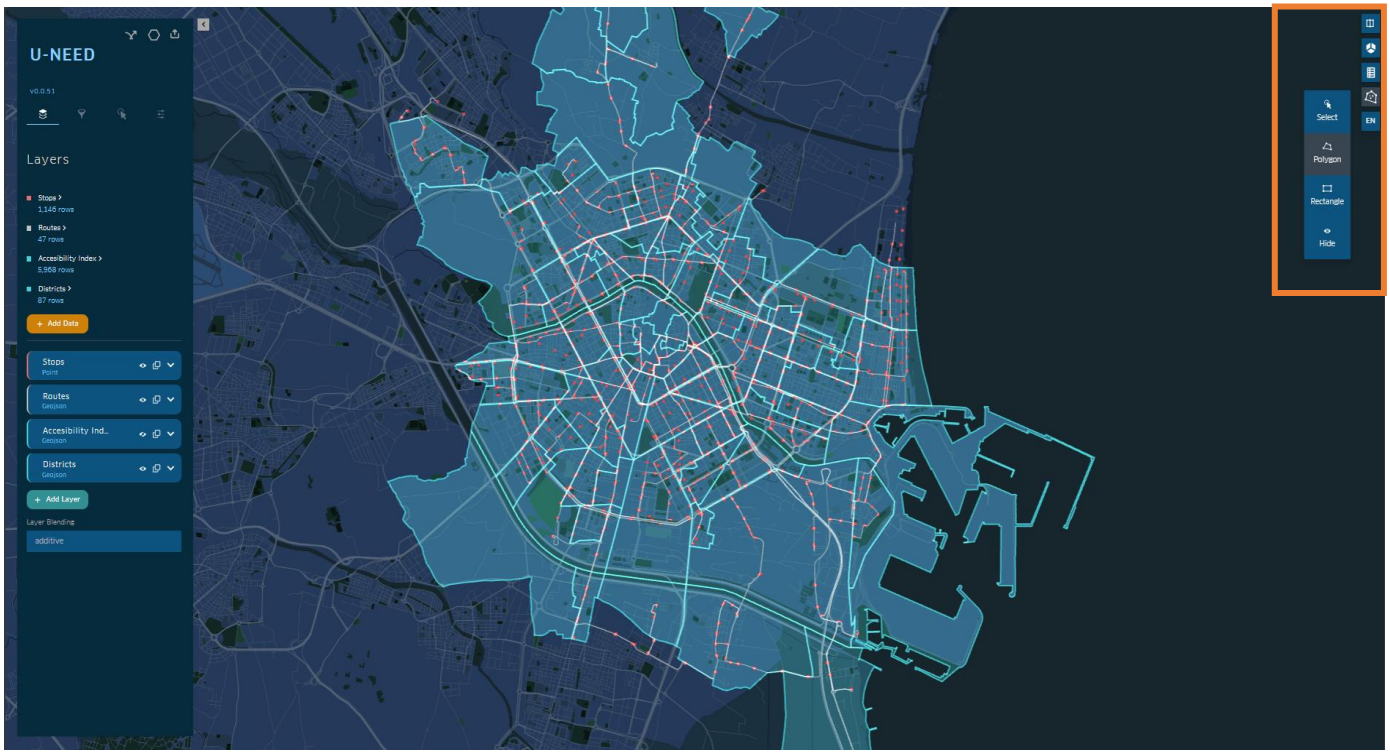


Figure 10 – Draw on map over the main view

Select: Select a drawn polygon

Polygon: Draw a multipoint polygon over the map

Rectanle: Draw a rectangle over the map

Hide: Hide the polygons drawn

Figure 11 – Draw on map detail

This functionality can be used to filter data depicted over the map, by clicking the right mouse button over the polygon drawn and selecting the corresponding layer in “Filter Layers”.

In the following example, the user has filtered data from the view, hiding all the points (bus stops) depicted outside the rectangle.

Figure 12 – Data filtered through “Draw on map” functionality

- Select locale: The user can select the language of the texts to be displayed.

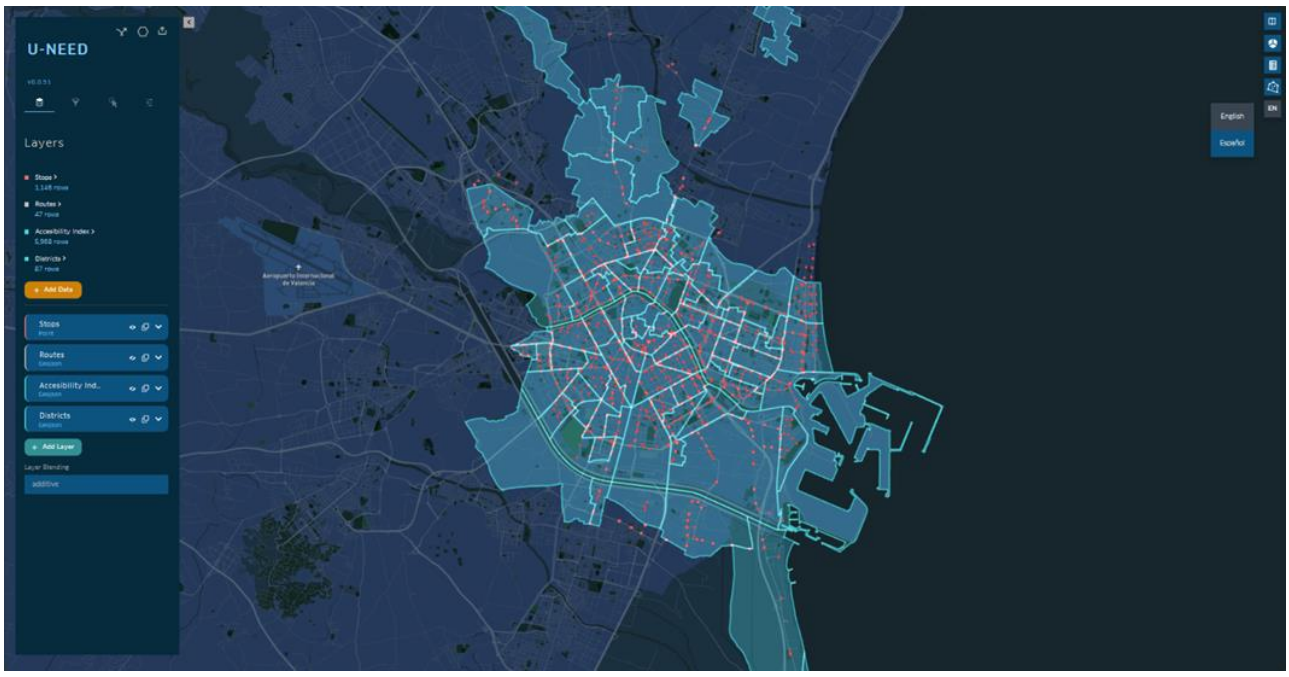


Figure 13 – Language selector

By default, the user can select English (EN) or Spanish (ES). If a user wants a new language, the tool can be configured to do so. However, the user needs to provide the translated texts in advance.

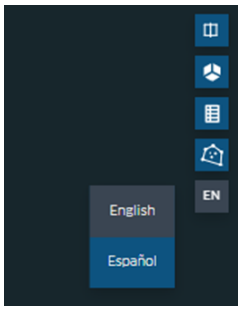


Figure 14 – Language selector detail

To facilitate translation when needed, ETRA I+D will provide key-value files (txt, csv or similar) with all the different keys used in the tool and the corresponding translation in English as value. It will be a task of the city to translate those English texts and return to ETRA I+D the new key-value file with their translation. From this point, the task of ETRA I+D will be to load the translation received and add a new button with the new language in the language selection area.

5.2.2. Toolbox

The U-NEED tool has a toolbox on the left of the screen where users can interact with data and visualizations. The different actions of the toolbox are described with more detail in the corresponding sections of this document. In this section, only the location of the different modules is going to be described.

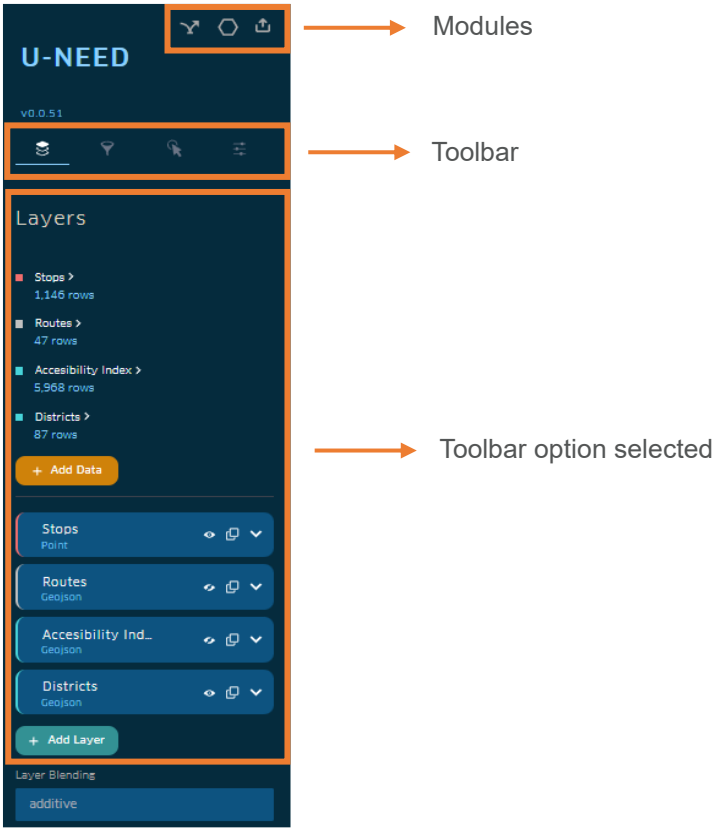


Figure 15 – Toolbox detail

5.2.2.1. Modules

In this section of the toolbox, direct accesses have been provided to each of the newly developed modules intended to address the different specific functionalities of U-NEED, and not provided by the KeplerGL library itself. In addition, some useful KeplerGL modules have been kept available in the toolbox to take advantage of their usage, such as: Export Image, Export Data and Export Map.

The new modules developed are:

- Import O/D data 

  If O/D information has been provided, the user will be able to use this module and filter the historical data stored based on different parameters such as date and time ranges, weather type, day of the week and type of day. Once the information is filtered, it will be displayed over the map.

- Accessibility index 

  This module uses geospatial algorithms such as a route planner to work out the index of accessibility of a city using three different transport modes: Walking, driving, and biking. In April 2025, the tool will be also able to show the Accessibility index of the Public Transport mode. The result is a tile of hexagons in varying colours that overlays the entire geometry of a city indicating the percentage of accessibility from every hexagon to various amenities (schools, universities, public transport stops, hospitals …).

- Share 

  This module is useful to export results in form of maps, images, tables, particular file formats and so on. The users will be able to compare and analyse different sets of historical data using the exported data, for example, comparing maps, comparing data, simulating new outputs based on historical data (using other tools such as U-SIM.plan) and many other analyses.

5.2.2.2. Toolbar

Figure 16 – Toolbar with option icons

The toolbar inherited from KeplerGL has four different options, which are: Layers, Filters, Interactions and Base Map. All of these options are here below described:

- Layers:

  Not only the user is able to visualize both, raw data loaded and also the created layers with their associated visual styles.

  New data can be loaded using the Add Data button and new layers can be created using the Add Layer button. In this case, the user must associate the data source to the new layer and optionally modify the visual style loaded by default.

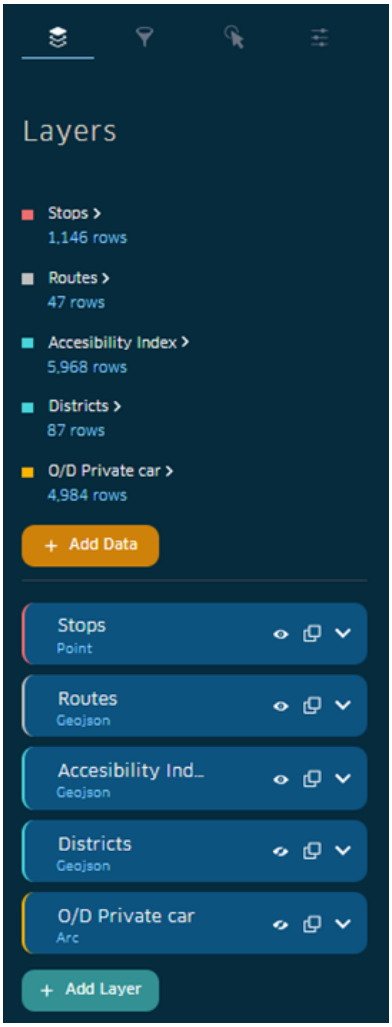


Figure 17 – Layer option detail

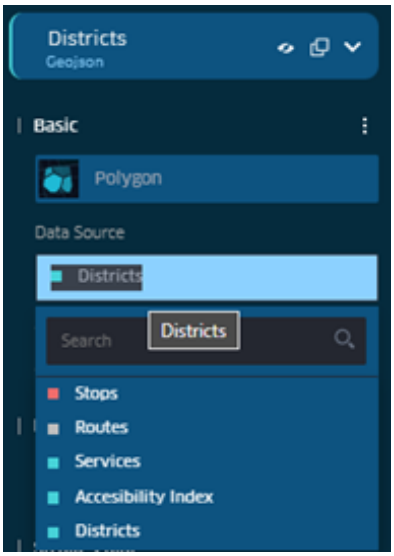


Figure 18 – Selecting the data source when creating a new layer

Figure 19 – Selecting the type of layer when creating a new one

Each layer can be customized, for example, editing the fill and outline colours, and the radius in case of a Point layer. Or, in case of a Polygon layer, the layer can be customized editing the fill and stroke colours, the stroke width and so on. All of these options can make more readable the map depicted.

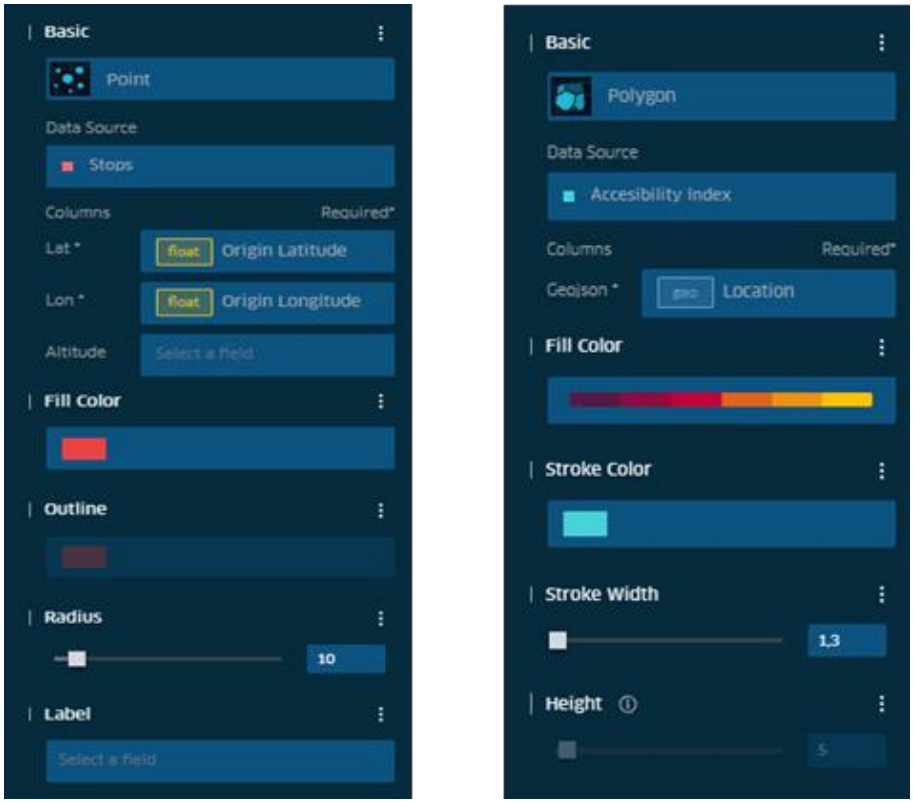


Figure 20 - Layer customization detail

- Filters:

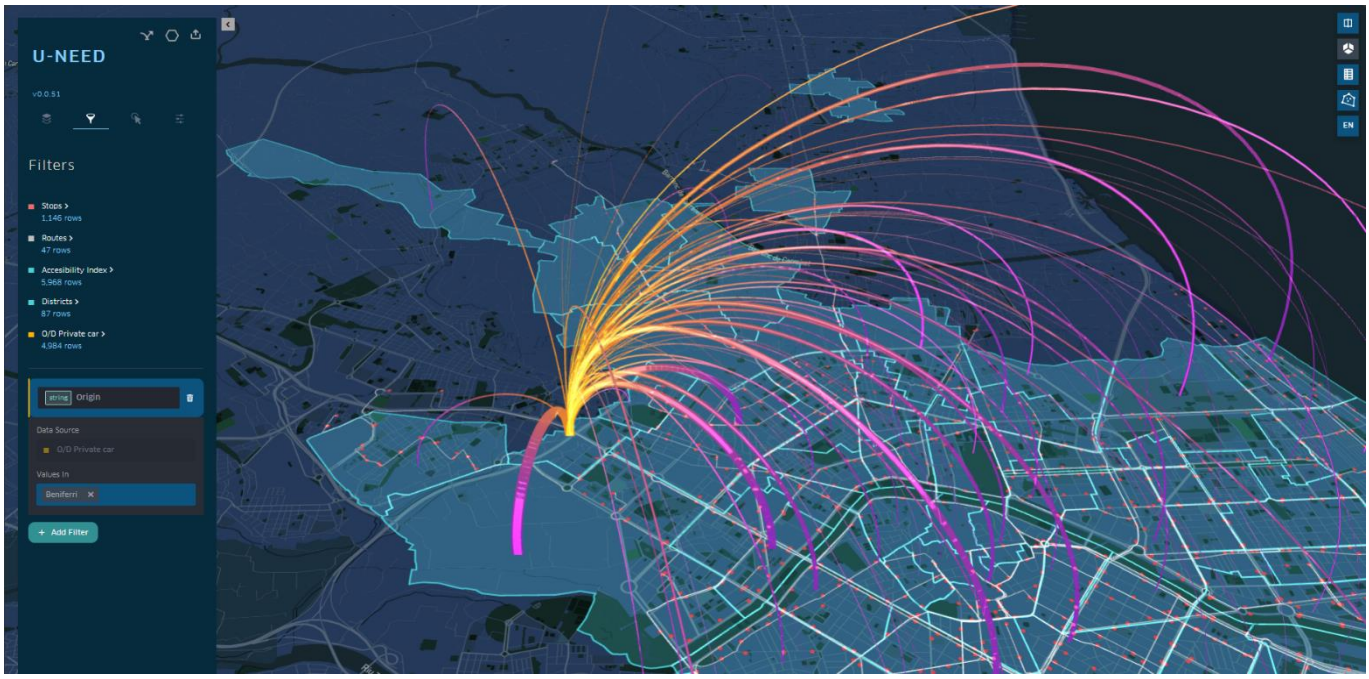


Figure 21 – O/D arcs filtered by origin

The user can easily create as many filters as they want to better visualize the information depicted. For example, when hundreds of O/D arcs are being depicted, a filter can be used to visualize only those that are relevant. On this example, the user has created a new filter in order to filter those arcs that have the same origin (depending on the data source, it can be same zone, PT stop or coordinates).

Figure 22 – Filter option detail

- Interactions:

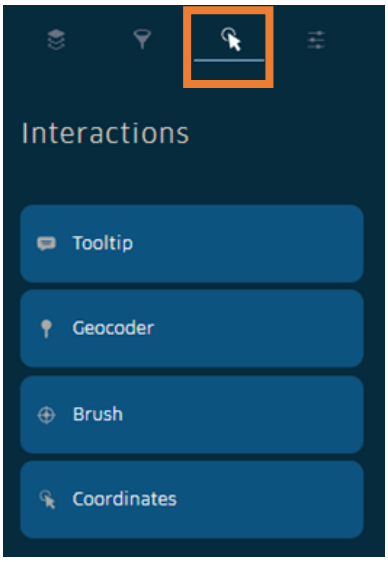


Figure 23 – Interactions option detail

The user can toggle customization options on the map, including: Tooltip, Geocoder, Brush and Coordinates.

- Tooltip: Displays metrics when hovering over a data point. The user can choose which fields are displayed in the tooltip configuration menu, adding or removing fields.

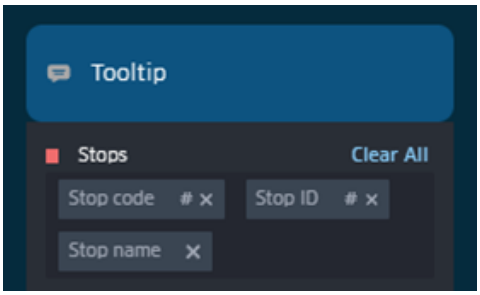


Figure 24 - Tooltip fields detail

Figure 25 – Tooltip example

- Geocoder: Displays a text box where the user can write an address or points of interest. The tool moves the view to the address selected in a list.

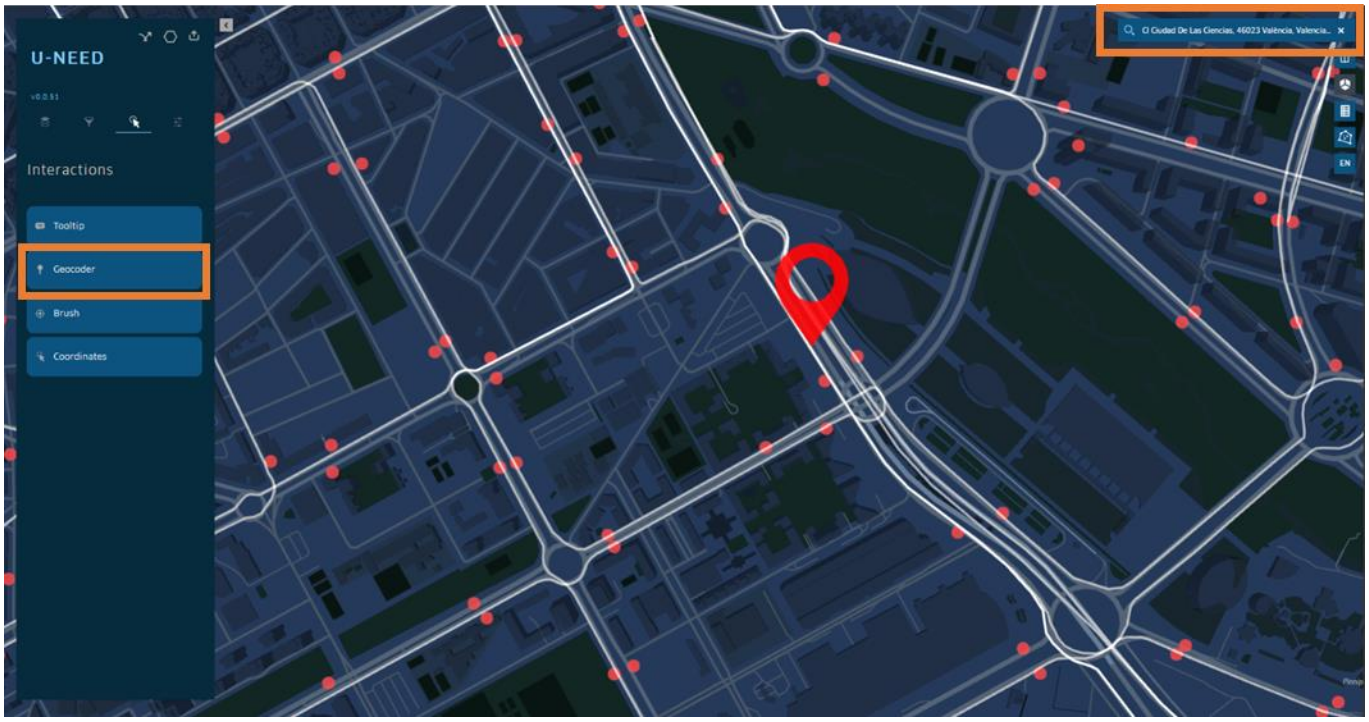


Figure 26 – Geocoder example

- Brush: Allows the user to highlight areas with the cursor based on a customized tolerance. When brush is turned on, all layers darken. Only the portion you hover over with the cursor is illuminated. Brush works well with arc and point layers.

Figure 27 – Brush example

- Coordinates: When this option is on, a panel containing latitude and longitude will follow the mouse.

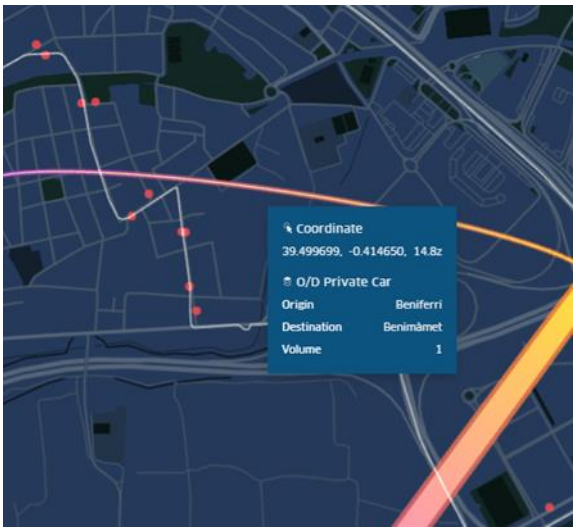


Figure 28 – Coordinates example

- Base Map:

  This is the last option of the KeplerGL's toolbar, which provides a set of Mapbox basemap styles as background map. The user can also add its own custom map style using the Mapbox style link (Add Map Style button). In this version of the tool, some predefined styles are provided, so, the user rarely will use this option.

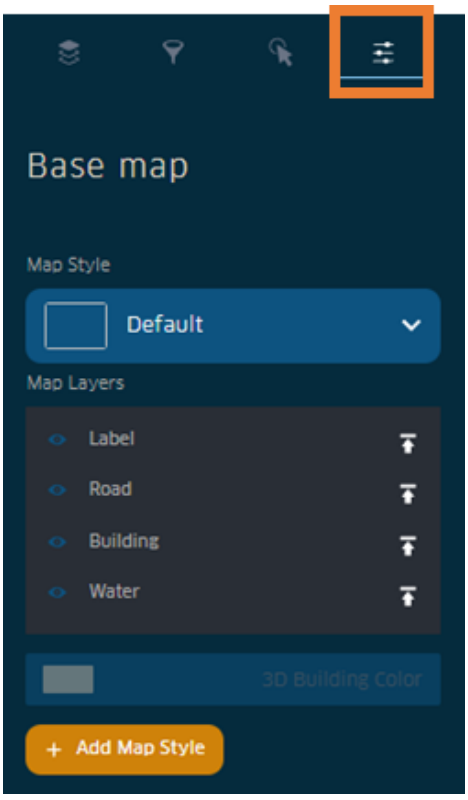


Figure 29 – Base Map option detail

6. Functionalities of U-NEED

6.1. Data integration and visualization features

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

6.1.1.1. Display of base-maps

On this first version of the tool, the user can visualize a default custom base map integrated from Mapbox and a satellite style with 3D buildings model. Accessing to the toolbar option, Base Map, the user can configure the base map showing or hiding some elements as: Labels, road geometries, 3D buildings and water areas. Also, the user can zoom in and zoom out using the mouse wheel, and move along the map dragging the pointer.

Figure 30 – Base map with satellite style and 3D modelled buildings

6.1.1.2. Display of roads and sections

The user can show or hide a translucent layer of roads by clicking on the eye icon on the left of the Road layer label.

Figure 31 – Base map with roads translucent layer

6.1.1.3. Display of neighbourhoods

The user can activate/deactivate the districts/zones layer on the Layers toolbar option. By default, the districts layer is retrieved from OpenStreetMap, but the user could import new GeoJSON layer using the option of import new GeoJSON data, as it could be the Visum's model zones distribution.

Figure 32 – Districts layer

6.1.1.4. Display of Points of Interest

By default, the services layer provides detailed information across various service categories and their geographical distribution on the map. At present, the service layer depicts essential amenities such as schools, stadiums, universities, hospitals and so on. All of this information is retrieved from OpenStreetMap, but if the users are interested, they can include their own data. Again, using the option of import new GeoJSON data.

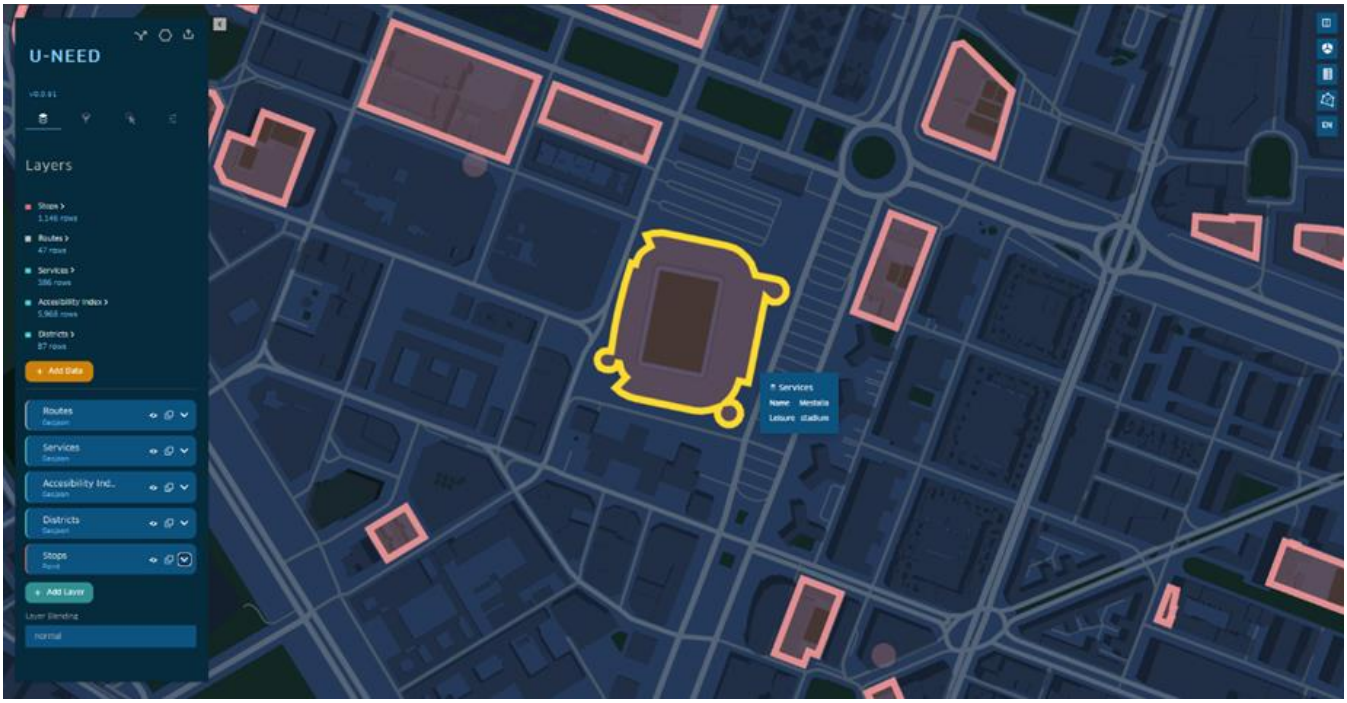


Figure 33 – Services layer

6.1.2. Integration and display of mobility assets static information

As the U-NEED primary aim is to provide information about Public Transportation services, the tool has loaded by default the static information of routes and stops provided by the GTFS standard format.

- Data requirements: GTFS

Previously, the site administration user role will need to configure the link to the GTFS data sources that can provide this information, using the Administration tool.

Then, the user can visualize routes and stops with their associated codes and names in two separated layers. Also, it is possible to click on each asset to emphasize the geometry and show a tooltip.

Routes layer:

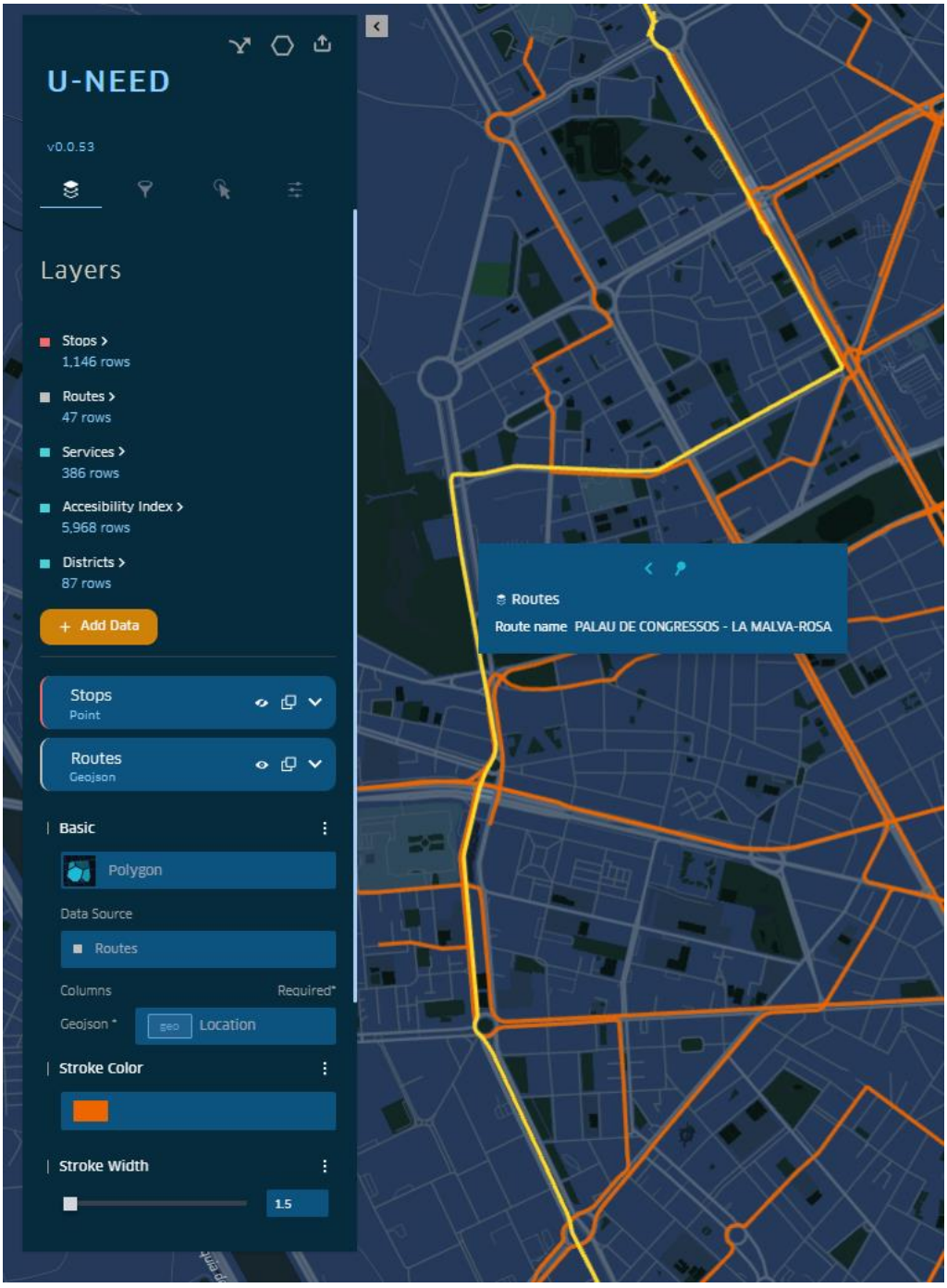


Figure 34 - Stops layer with tooltip detail

Stops layer:

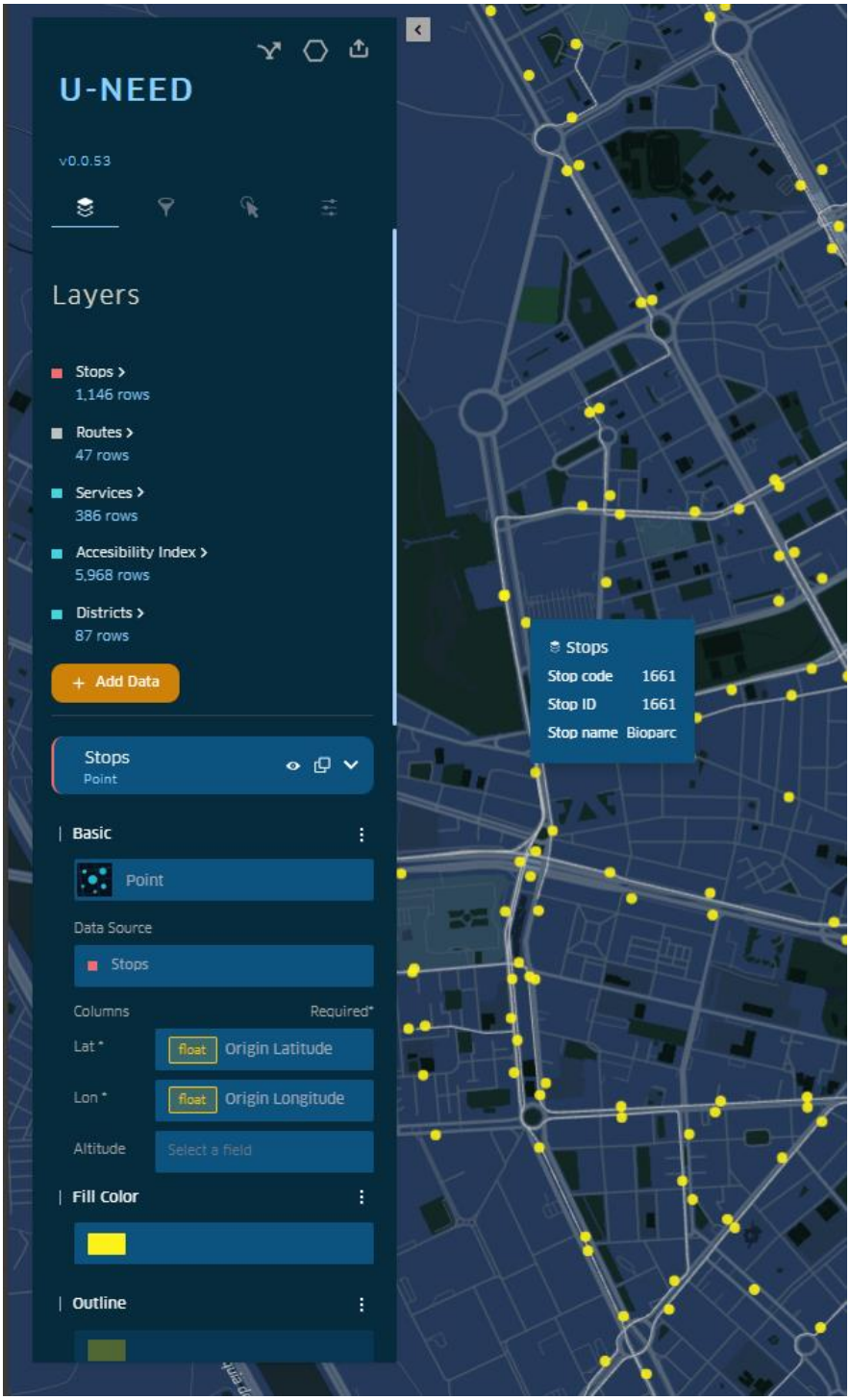


Figure 35 - Routes layer with tooltip detail

Both routs and stops layers activated:

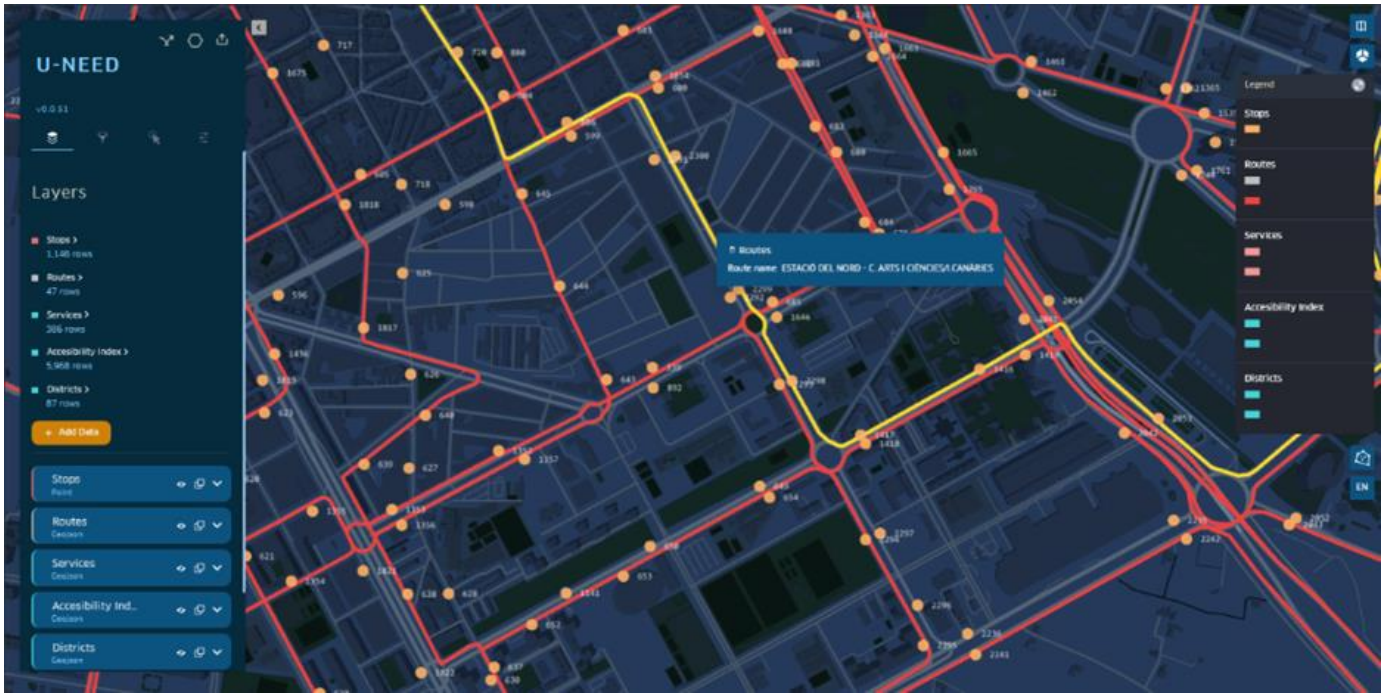


Figure 36 – Public Transport static information (GTFS)

6.1.3. Integration and display of historical traffic dynamics

In April 2025, the U-NEED tool will be able to display historical traffic data, filtered previously by date and time ranges, and aggregating the level of service taking into account that filtering options.

Based on this filtering and aggregation, the data will be able to be depicted in different ways over the map, for example, using colours and heights for depicting the different levels of traffic congestion.

6.1.4. Integration and display of historical PT operations data

6.1.4.1. Historical delays

In April 2025, the U-NEED tool will be able to display the aggregated delays by each stop and route using tooltips, i.e., on each stop the user will be able to visualize the aggregated delays by each route that passes that stop. The delay aggregations are based on the filtering options selected by the user previously, such as date and time ranges.

The data based on historical delays by stop has to be provided by Public Transport entities or, as an option, if the city is interested in the usage of the U-TWIN tool, it would be possible to store in time series the data provided by the GTFS-RT and other real-time formats. This data could be used by the U-NEED tool to depict the historical delays by stops and routes, making it easier to see where delays are occurring.

6.1.5. Integration and display of Origin-Destination matrixes in different visualizations

6.1.5.1. Origin-Destination matrices integration

The U-NEED tool will be able to display O/D information stored in the system from different transport modes (private vehicle, bus, metro, tram…) through the module Import O/D data (see section 5.2.2.1).

Particularities applied depending on transport mode:

- Public Transport

  In case the O/D matrix is not available, the tool will provide a functionality of inferring the drop-off stops (see section 6.3.1). Although the algorithm is already developed, the functionality would be available in April 2025.

  This is really useful when no O/D matrices can be provided, and the use of the ticketing information is available. Through this algorithm, the system can generate O/D matrices with high accuracy, based on the information provided.

  Data requirements:

  - GTFS of operators providing services in the selected city/metropolitan area
  - O/D matrices
  - Calendar with weather type per day and working/holiday days marked

- Private vehicles

  In case of the private vehicle, the tool is ready to show O/D data from TomTom O/D Analysis API.

- Micromobility services

  It is possible to integrate O/D matrices from different micromobility services (bike sharing, e-scooters and so on), if such information is facilitated by the operator or authority. However, even if no O/D information is provided, it is possible to integrate other kind of available metrics, such as counts by stop. In this case, and particularizing to the bike sharing system as an example, it is possible to visualize the historical usage of bike sharing services by stop (the aggregate number of users taking a bike in the selected date and time intervals). This functionality would be also available in April 2025.

  Data requirements:

  - GBFS
  - Calendar with weather type per day and working/holiday days marked

The tool provides different kind of visualizations of the O/D matrixes, described below in the following sections: Arcs, heatmap and 3D bars.

Integration of O/D matrices from pedestrian traffic can also be integrated, if available.

6.1.5.2. Arcs visualization

The origin/destination pairs can be Public Transport stops or geographical zones, depending on the information stored and the context of the data. For example, in case of Public Transport services the most common is having the information aggregated by stops. In case of traffic O/D information, the most common is using zones of the city.

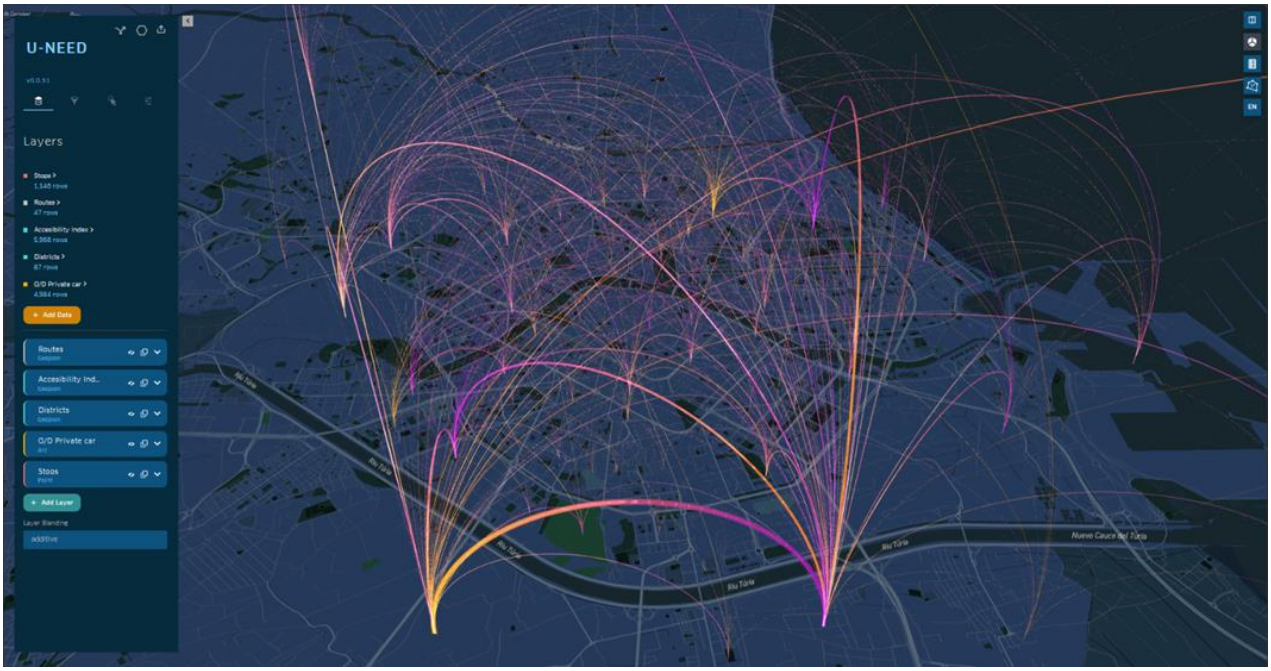


Figure 37 – O/D Arcs layer

The arcs will be displayed with a default style, but it is always possible to be modified by the user to make the map more readable. For example, change the origin/destination colours, the stroke width of the arc and so on.

6.1.5.3. Heatmap visualization

The heatmap visualization depicts which origin stops/zones of the city are more important in terms of volume of passengers/trips.

Figure 38 – O/D Heatmap layer

6.1.5.4. 3D bars visualization

The 3D bars visualization shows the density of points aggregated by squares. Each square can be depicted in 2D or 3D, in this case, using the number of passengers as height. The squares can be customized (in terms of size, colours, height scale…).

Figure 39 – 3D bars layer

6.1.6. Data filtering

6.1.6.1. Filtering O/D using a modal window

When the user wants to depict O/D information over the map, the data has to be filtered first, using a step-by-step form. The filtering is based on the following parameters:

- Type of transport
- Date ranges
- Time ranges
- Day of the week
- Type of day
- Weather type

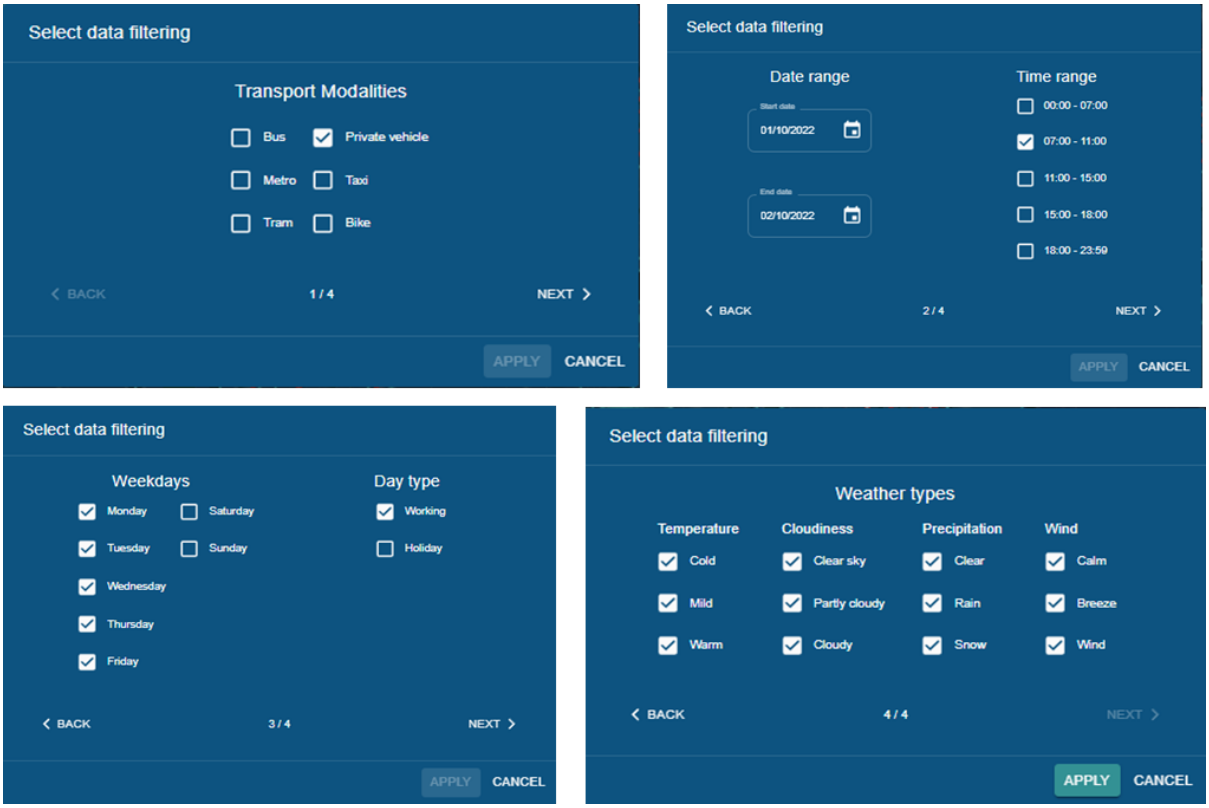


Figure 40 - Data filtering parameters

6.1.6.2. Filtering O/D data using a polygon depicted over the map

Also, the user can filter O/D information using a polygon or rectangle with the “Draw on map” (see section 5.2.1) functionality.

Figure 41 – Filtering with a polygon/rectangle

6.1.7. Accessibility analysis

Accessibility refers to the ease of reaching activity opportunities through different spatial points, such as specific locations or areas. It integrates the difficulty of travel to different points in space with the availability of opportunities. This measurement involves weighting opportunities by the ease of interaction, emphasizing closer destinations in determining overall accessibility levels. In essence, accessibility reflects how easily people can access various activities based on their location and intended activities[1].

In this module, the user can select the transport mode used for the visualization of the different scorings of accessibility to the different amenities of a city.

The algorithm developed to calculate the accessibility index scorings has been based on different parameters to obtain the time of trips between points. Mainly, it pre-processes the road network data from OpenStreetMap to create a routable graph. It uses Dijkstra's algorithm and its optimizations for efficient route planning. And also, it incorporates speeds and restrictions from OpenStreetMap data to estimate travel times between points.

The restrictions from OpenStreetMap that the algorithm considers are:

- One-way streets: Directions in which vehicles are allowed to travel.
- Turn restrictions: Prohibitions on certain turns at intersections.
- Weight restrictions: Limits on vehicle weight on certain roads or bridges.
- Height restrictions: Clearances under bridges or other overpasses.
- Width restrictions: Limits on vehicle widths, important for narrow roads.
- Access restrictions: Roads restricted to certain types of vehicles.
- Speed limits: Maximum speed allowed, which affects estimated travel times.
- Traffic signals: Presence of traffic lights which can affect travel times due to stops and delays.

All of these rules have been taken into account to accurately model movement along the road network.

The current transport modes that the user can select and the new one in development phase, are:

- Walking: Depicts the scoring of accessing by walk to the different amenities of the city.
- Driving: Depicts the scoring of accessing by car, motorcycle…, to the different amenities of the city.
- Cycling: Depicts the scoring of accessing by bike, e-bike, e-scooter…, to the different amenities of the city.
- Public Transport: This is an important solution that the U-NEED tool can provide for better understanding long-term planning of public transport networks, showcasing each one on a single map and its accessibility indexes to the various services within the city.

  Available in April 2025.

[1] *Miller, Eric J. Measuring accessibility: Methods and issues, 2020. International Transport Forum Discussion Paper No. 2020/25*

Figure 42 – Current available accessibility modes

And the amenities that can be analysed are:

- School
- Hospital
- Clinic
- Shopping
- University
- Industrial
- Public Transport (not in driving mode)
- Bike sharing (not in driving mode)

Depending on the selected mode, the user can visualize a tile of hexagons overlayed on the map (hexagons size: 200m of diameter). Each hexagon has associated a tooltip where the user can read the different accessibility indexes.

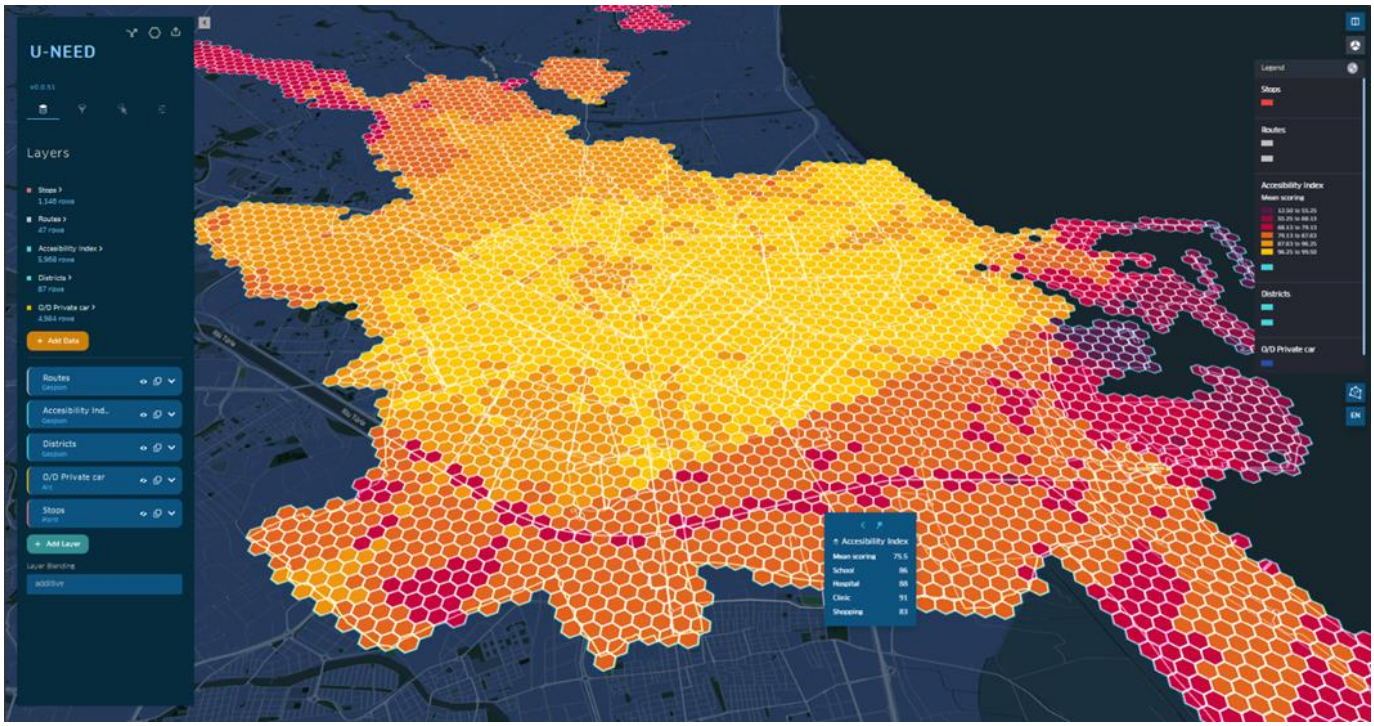


Figure 43 – Example of Accessibility layer visualization

Figure 44– Accessibility layer detail with legend

6.2. Data analytics features: Detection of inefficiencies in the PT offer

6.2.1. Inefficiencies based on poorly covered geographic areas

The U-NEED tool will be able to perform a coverage analysis to determine the Public Transport network coverage in a city, especially identifying those areas poorly covered or underserved by the existing network.

The tool will have the ability to display information as isochrones maps using buffering techniques, focused on Public Transport stops, and showing the areas of the city with 10-minutes' walk access to PT stops.

This feature will be available in April 2025.

6.2.2. Inefficiencies based on accessibility to services

The accessibility indexes could provide information on how easy or difficult the different services in the city could be accessed from every point in the city using the Public Transport.

The city is divided in equal size hexagons and each of them get a score based on the different mobility modes and the services the city provides. This score is a simple way on how easy is to get to the nearest service of each kind like hospitals, schools, or universities.

This feature will be available in April 2025.

6.2.3. Inefficiencies based on historical traffic level of service

Analysing inefficiencies in Public Transport based on historical traffic level of service involves leveraging data analytics to explore the relationship between traffic patterns and Public Transport performance.

For instance, periods of high traffic congestion may lead to delays and decreased reliability in Public Transport services, affecting overall service quality.

Furthermore, identifying specific corridors or areas with consistently poor traffic level of service can pinpoint locations where Public Transport operations may face greater inefficiencies or challenges in maintaining reliable schedules.

Through this analysis, Public Transport authorities can address potential inefficiencies by implementing targeted solutions such as optimized routing, schedule adjustments, or infrastructure upgrades to mitigate the impact of historical traffic level of service on PT operations.

U-NEED will display information as segments or lines with different colours and heights to give an easy way of depict traffic level of service. This information will have been previously filtered and aggregated by date and time ranges, days of the week, type of day (working/holiday) and so on.

This feature will be available in April 2025.

6.2.4. Inefficiencies based on historical PT delays

Identification of recurring delay hotspots, peak times of delay occurrence, and common contributing factors can help Public Transport operators pinpoint areas of inefficiency in the network.

After filtering and aggregating data of Public Transport delays by stop, and based on date and time ranges, days of the week, type of day (working/holiday) and weather type, U-NEED will depict over the map the Public Transport stops where the delays are more accumulated.

This feature will be available in April 2025.

6.2.5. Inefficiencies based on accessibility to restricted access zones

By examining historical data on Public Transport in relation to Zero Emission Zones, insights can be gained into the effectiveness and efficiency of Public Transport in facilitating access to environmentally restricted areas.

This analysis can shed light on any gaps or inefficiencies in PT services' connectivity to these zones, as well as the impact on passenger travel patterns.

Understanding historical trends can help Public Transport authorities identify areas where accessibility may be limited, leading to potential inefficiencies, such as longer travel times, increased transfers, or reduced coverage.

Similar to how U-NEED will display the accessibility index and buffering for stop or geographical areas, it will also be able to display the accessibility of the Zero Emission Zones, displaying buffers on it to be able to check how easy is to get to any part of the city using the Public Transport or micro mobility vehicles (like bikes from bike sharing stations around the city).

This feature will be available in April 2025.

6.2.6. Inefficiencies based on P&R’s location

By examining historical data on Public Transport near of P&R locations, insights can be gained into the impact of those locations on overall transport efficiency.

This analysis can help identify any discrepancies or inefficiencies in the placement of P&R facilities, such as underutilized sites, inadequate capacity, or limited accessibility, which may impede their effectiveness in encouraging modal shift.

Understanding historical trends can guide city authorities in optimizing P&R location strategies, improving intermodal connections, and aligning P&R provision with commuting patterns and demand.

All this information will be displayed over the map to check how easy is to get to the main POIs of the city from the P&R locations and how well public transport and micromobility services cover locations in the vicinity of the P&R location.

This feature will be available in April 2025.

6.2.7. Inefficiencies related to variable factors (events, weather…)

By examining historical data on Public Transport in relation to weather patterns, insights can be gained into the specific challenges and inefficiencies posed by these variable factors.

This analysis can help identify patterns of decreased reliability, increased demand, or service disruptions during events or adverse weather conditions, signalling potential inefficiencies in PT operations.

Leveraging historical data, Public Transport operators can enhance operational readiness and responsiveness to variable factors, ensuring a more efficient and reliable Public Transport network for passengers.

Most of the information in the tool that will be displayed on the map, like O/D matrix, delays, or traffic service levels, could be filtered using variable factors, like special events calendars, weather, day of the week, range times or if the days is a working day or not.

These filtering allow the user to detect inefficiencies in the service based on the variable factors.

This feature will be available in April 2025.

6.2.8. Report of inefficiencies in the PT offer

In April 2025, the user will be able to generate a report based on the information filtered and displayed in a readable way, like showing percentages of the city or zones that are not well covered by the current public transport services or that happens based on the variable factors the user has filter.

6.2.9. KPIs calculation

In April 2025, based on the information displayed in the reports, KPIs of the public transport offer could be worked out and displayed in the reports. This information could be available to be shared between the other U-TOOLS of the project.

6.3. Advanced Features

6.3.1. OD matrix generator: drop-off stop inference

An algorithm has been developed to infer the drop-off stop and generate the Origin/Destination (O/D) matrix in cases where no O/D matrices are available, utilizing daily ticketing information. This functionality will be directly available in April 2025.

The process of inferencing starts essentially with the data of all the validations of travel cards/tickets made by the passengers in the same day (card identifier, date, time, route, bus, get-in stop).

From this information, it is inferred at which stop the passenger drops-off, using the next ticket validations. Each ticket validation is review sequentially. For the first validation of the day, it is recorded the associated bus line without inferring any drop-off stop yet. In a subsequent validation, this bus line is used for the inference process. The algorithm tries to identify the nearest bus stop that matches that bus line, based on geographical data associated to the ticketing information. If the inference is successful and a relevant stop has been found on the current bus line, it is inferred as the drop-off stop. Next to this, if more validations exist, the current bus line is updated with the new validation done by the user. In case the inference is not successful (no matching near stops found), it is presumed that there might be a transition to another bus line. This validation is marked as a possible line change and the process of inference goes on with the next validation (if exists).

6.3.2. Prediction of PT demand

- Data needed: O/D matrices

In April 2025, the U-NEED development plan is to integrate a prediction of Public Transport demand based on the historical information provided. There are different ways of analysing the prediction, as it follows:

- Time series analysis: Use of historical origin and destination data to create time series models. Trends, seasonality and fluctuation patterns of demand over time can be captured.
- Regression models: Regression models can be built to predict demand using explanatory variables such as time of day, day of the week, special events, weather conditions or other relevant variables. These models allow to quantify the relationship between explanatory variables and public transportation demand.
- Machine learning models: Use Machine Learning algorithms to learn patterns and make predictions based on historical origin and destination data. These models can capture nonlinear and complex relationships in the data.

The different options will be analysed and the most suitable one will be chosen.

6.3.3. Simulation of mitigation strategies

U-NEED is intended for analysing the Public Transport demand and detect inefficiencies with respect to the PT offer. Once the user identifies the main inefficiencies, it will be able to use U-SIM.plan in order to simulate different mitigation strategies to select the most suitable one.

This feature will be available in April 2025.

7. Data Management

7.1. Importing Data

Apart from the U-NEED tool itself, an Administration tool will be offered. This tool will allow to import different data to the U-NEED tool.

7.1.1.1. VISUM format

One of the formats that would be possible to be imported with the Administration tool are the Visum format for O/D matrices and shapes for the geographical zones. This data format has been considered due to the future integration with another tool of the UPPER project, the U-SIM.plan tool (Visum). This feature will be available in April 2025.

7.1.1.2. GeoJSON format

For GeoJSON format, the data could be imported directly in the U-NEED tool each time is needed to be used, or imported with the Admin tool to be stored.

Some examples of using external GeoJSON files would be:

- Different LEZ areas to analyse the Public Transport inefficiencies by each one.
- Different P&R's areas to analyse the Public Transport inefficiencies by each one.
- Include new layers of data such as: New amenities or particular locations to analyse the Public Transport inefficiencies associated.

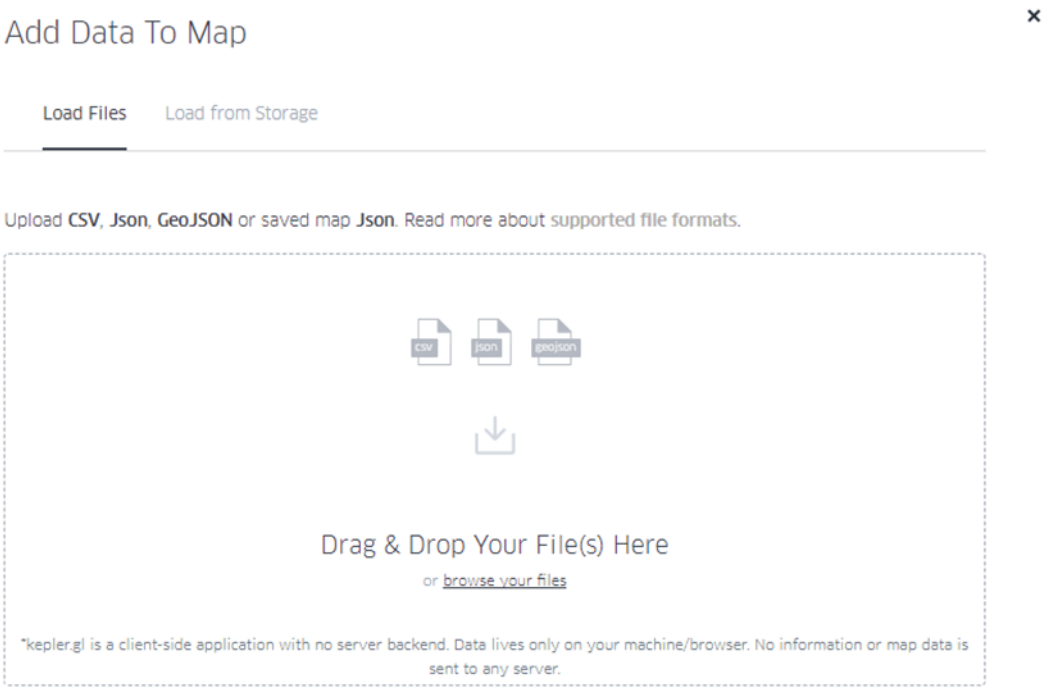


Figure 45 – Add data to U-NEED

The data imported with this modal window, inherited from KeplerGL, will not preserve information for future sessions, in case the user closes the web browser, for example.

To preserve the information in future analysis, the user has to import data using the Admin tool or import the GeoJSON file each time it opens the U-NEED tool.

7.1.1.3. GTFS format

In order to use the application, the static GTFS should be imported to the tool. This data could be imported with the Admin tool and will be processed and adapted to be used in the tool. At the moment, only static GTFS are supported, but more formats like SIRI static data will be added in next versions.

7.2. Exporting Data

The Share module option (see section 5.2.2.1) can be used to export the data visualized over the map.

For those users willing to export O/D information filtered in U-NEED to VISUM format, a new module will be developed to do so (available in April 2025). This module will be accessible from the modules section Share.

Figure 46 – Share functionality options

On this version, the Share module helps the user to export images, data and map views.

- Export Image: The user can select the ratio of the screen, the resolution and if the map legend is added or not.

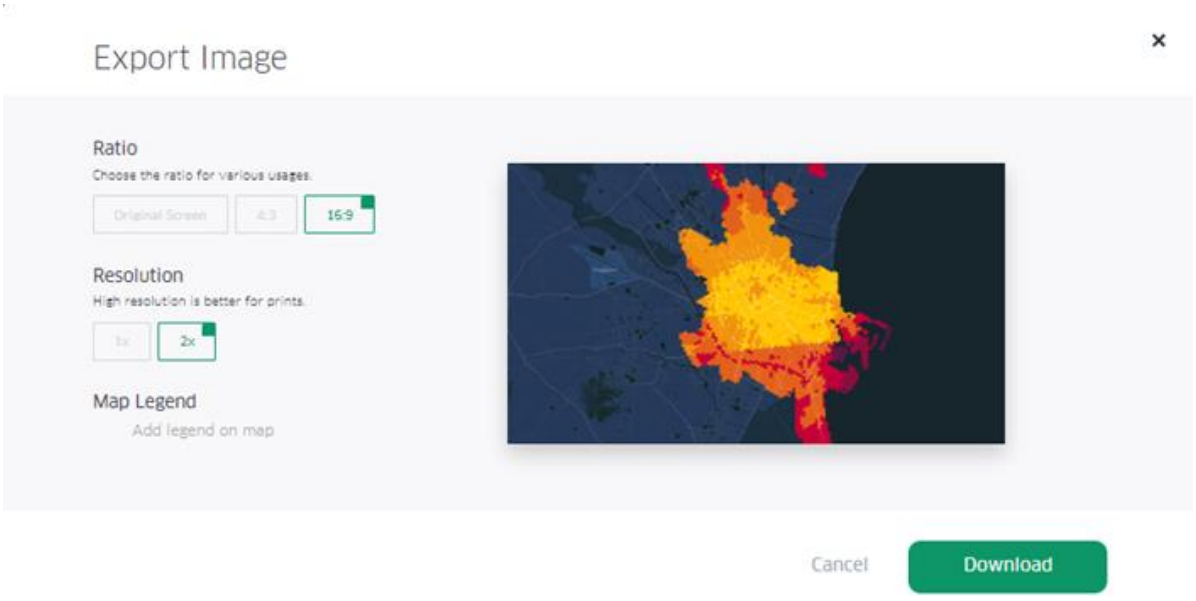


Figure 47 – Export Image detail

- Export Data: The user can export the datasets loaded in U-NEED, in CSV format with filtered or unfiltered data.

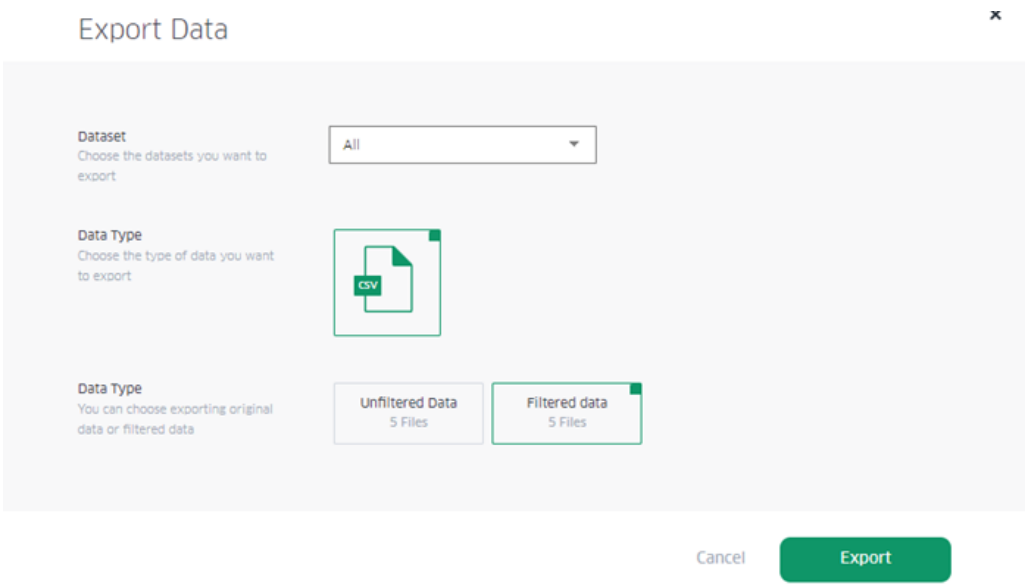


Figure 48 – Export Data detail

- Export Map: The user can export a map in html or JSON formats, adding the Mapbox access token if needed and allowing the users to only read or also edit the map itself.

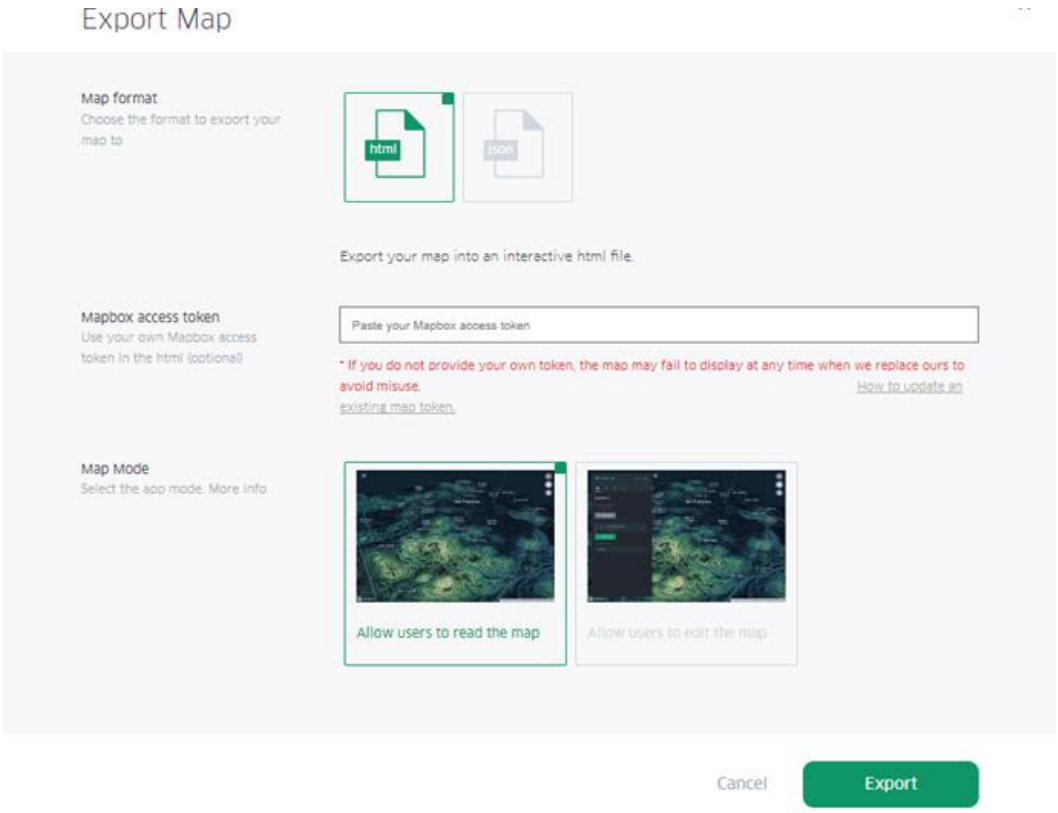
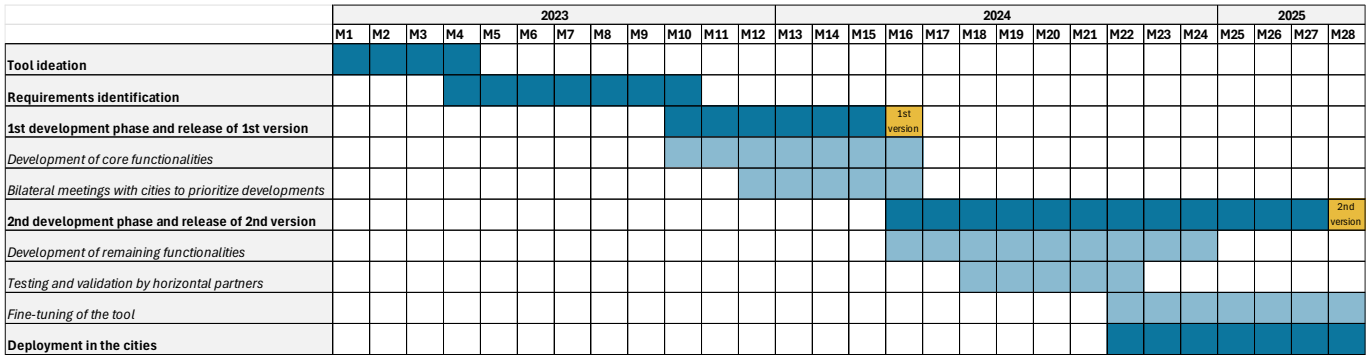


Figure 49 – Export Map detail

8.Development timeline

The development of the U-NEED tool is planned as following:



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.