QROWD - Because Big Data Integration is Humanly Possible

Innovation action

D2.3 – Urban mobility dashboard

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ABSTRACT

This deliverable reports on the current status of the Trento dashboards that give access to the QROWD mobility services, as well as the degree of fulfilment of the requirements of the Trento Municipality (D2.2) covered so far.
EXECUTIVE SUMMARY

This is an accompanying document to the Trento dashboard prototype developed in the scope of QROWD. The deliverable is public and it is intended to the general public, although the access to the current prototype is yet restricted at the discretion of the project members, as it is still in testing phase and not deployed in the final environment.

The dashboard and this document will help project partners and rest of the public audiences to understand how QROWD services can be leveraged to specific applications in a city. The dashboard is in itself the last mile of the QROWD goals, providing a front-end to access to the data, results of the analysis and crowdsourced information gathered within the project. Therefore, there is a plan to continue working in the visualization and access layers of the dashboard to show more results from QROWD as the project advances. The last version of the dashboard should be ready for showcasing and evaluation no later than M30 of the project (May 2019).

This document relies on the previous QROWD D2.2 “Use case requirements specification” and D4.1 “Data Catalog” deliverables. These documents set the ground to understand the results of the dashboard as well as the data displayed.

The main output is therefore the current version of the dashboard prototype, which will be subject to further work in the coming months, giving birth to the deployment of the final versions of the so-called Trento Municipality and Citizen dashboards.
1. INTRODUCTION

This document reports on the implementation of the so-called Urban Mobility Dashboard for the Municipality of Trento, developed in WP2 in the scope of the task 2.3. The deliverable is of type “Demonstrator”, and therefore this is an accompanying document of the prototype of the Dashboard released so far. The current version of the dashboard can be found in the following URL: http://<domain>/qrowdDashboard/

At the time of writing this deliverable, the <domain> is in a server in testing mode (substitute <domain> by 130.206.127.63:8180). In future releases the <domain> change. In case of doubt, to be able to know the most recent URL, please contact project members.

Although the Dashboard was initially scheduled for M18 (end of June 2018), during the execution of the work to be done in WP2 there was a redefinition of priorities for the Municipality of Trento not only related to the dashboard, but to other objectives of the WP2 (i.e. the application sensorCivico was no longer in their goals). The result of this discussion crystallized in the requirements gathered in deliverable D2.2. In that document the existence of not only one, but two dashboards (Municipality and Citizen) is required. At the same time, access to data needed to fulfill the requirements is not complete so far, as some data streams (i.e. data from the parkmeters) belong to third-parties and will be accessible at a later time. Therefore, these issues affected the schedule of the implementation of the dashboard. The result of this is that the current state of the development covers only partially the requirements stated in D2.2 and is not completely aligned with the original schedule. However, the status is that there is a demonstrator of the Municipality Dashboard accessible online with many functionalities and visualization especially related to the mobility infrastructure of the city and the Modal Split use case. In this sense, there is a plan to continue working on the dashboards in the coming months to create a prototype that fulfills the majority of the requirements (from a total of 17 requirements, there are 8 are totally addressed, 5 partially and 4 non addressed so far). Therefore, there is a plan to submit a new version of this deliverable with the final status of the Dashboard no later than M30 of the project.

The document is structured as follows:

- Section 1 gives an introduction and an overview of the structure and main goal of the deliverable.
- Section 2 describes degree of fulfillment of the requirements related to the dashboard achieved so far.
- Section 3 provides the technical architecture of the dashboard in the scope of the QROWD architecture.
- Section 4 provides a detailed overview of the current version of the prototype of the dashboard front-end.
- Section 5 concludes this deliverable and gives a hint of the future work.
2. Recap on Requirements of the Dashboard and Their Fulfilment

This section provides a recap of the main requirements related to the Trento dashboard collected as part of the deliverable D2.2, as well as their fulfilment in the current version of the dashboard. Table 1 explains the visual requirements for the Municipality dashboard, while Table 2 provides the requirements for the Citizen dashboard. A flag indicating the degree of fulfillment of the requirement is added for both tables.

The nomenclature of the flag responds to:
- A - addressed
- NA - non addressed
- PA - partially addressed

Table 1: Municipality Dashboard (BC2-UC#4) visualization requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
<th>Fulfilment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR11</td>
<td>Modal split results</td>
<td>A dashboard will show aggregated data about transportations modes of citizens</td>
<td>BC2-UC#1</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>BC2-VR12</td>
<td>Parking availability results</td>
<td>The municipality dashboard will show real-time (where available) and historical information about parking availability</td>
<td>BC2-UC#2</td>
<td></td>
<td>PA</td>
</tr>
<tr>
<td>BC2-VR13</td>
<td>Completing mobility infrastructure</td>
<td>The municipality dashboard will show results about</td>
<td>BC2-UC#3</td>
<td>The crowdsourcing services is</td>
<td>PA</td>
</tr>
<tr>
<td>Use Case</td>
<td>Description</td>
<td>Integration</td>
<td>Requirement Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>-------------</td>
<td>--------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR14</td>
<td>Additional mobility information (from public and private datasets)</td>
<td>The municipality dashboard can complete the information provided by other use cases with additional mobility data coming from public and private datasets such as traffic on urban and provincial roads or bike-sharing availability.</td>
<td>BC2-UC#4</td>
<td>Optional. The required ones have been incorporated but it is not excluded the inclusion of more datasets. Due to: the second half of the project.</td>
<td></td>
</tr>
<tr>
<td>BC2-VR15</td>
<td>Additional mobility information (from QROWD)</td>
<td>Additional mobility data originating from the project can be displayed on the municipality dashboard such as: results from integration of privately owned data and future datasets</td>
<td>BC2-UC#4</td>
<td>Optional.</td>
<td></td>
</tr>
</tbody>
</table>

It is worth mentioning that at the time of closing this document only the Modal Split use case was fully defined and deployed. The rest of use cases are in different stages. Some of the use cases are still at their initial steps, such as the case of "completing mobility infrastructure" where only the left-side menu structure is defined so far. Some other user cases are not completed due to the lack of required datasets, such as the "parking availability" use case where the on-street paid car or motorcycling spot datasets are not yet available. These use cases will therefore be addressed in a second release of the dashboard.

A similar situation appears in the case of the citizen dashboard, as shown in Table 2. Those visualizations related to the main use cases: modal split, parking availability or completing infrastructure have not been fully addressed so far. However, other
requirements related to meteo information (weather, air quality, etc.), real-time information (showing mobility infrastructure like bike sharing system, underground parking availability, etc.) have been covered by the end of M18.

**Table 2: Citizen Dashboard (BC2-UC#6) visualization requirements**

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
<th>Fulfillment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR20</td>
<td>Personal modal split</td>
<td>The personal modal split will be visualized on the citizen dashboard upon authentication</td>
<td>BC2-UC#5</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>BC2-VR21</td>
<td>Parking availability results</td>
<td>The citizen dashboard will show real-time (where available) and historical information about parking availability</td>
<td>BC2-UC#2</td>
<td>Same notes as BC2-VR12</td>
<td>PA</td>
</tr>
<tr>
<td>BC2-VR22</td>
<td>Completing mobility infrastructure results</td>
<td>The citizen dashboard will show results about available mobility infrastructure</td>
<td>BC2-UC#3</td>
<td>Same note as BC2-VR13</td>
<td>PA</td>
</tr>
<tr>
<td>BC2-VR23</td>
<td>Weather conditions</td>
<td>Information about weather conditions which can be provided based on open data</td>
<td>BC2-UC#6</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>BC2-VR24</td>
<td>Real-time bike sharing information</td>
<td>Real-time information concerning bike sharing (e.g. availability of bikes / number of free spots)</td>
<td>BC2-UC#6</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>BC2-VR25</td>
<td>Real-time underground parking availability</td>
<td>Real-time underground parking availability</td>
<td>BC2-UC#6</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>BC2-VR26</td>
<td>Traffic information based on open data</td>
<td>Near-real time information concerning traffic based on sensor data from sensors placed on urban and provincial roads and based on data from cameras for traffic monitoring</td>
<td>BC2-UC#6</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>BC2-VR27</td>
<td>Traffic information based on privately owned data (TomTom)</td>
<td>TomTom City Trento</td>
<td>BC2-UC#6</td>
<td>A</td>
<td></td>
</tr>
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<td></td>
</tr>
<tr>
<td>BC2-VR28</td>
<td>Air quality</td>
<td>Information concerning the quality of air</td>
<td>BC2-UC#6</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>BC2-VR29</td>
<td>Cycling and cyclopedonal paths</td>
<td>Number of passages based on data (sensors) available in the future</td>
<td>BC2-UC#6</td>
<td>Optional. Pending availability of future datasets</td>
<td></td>
</tr>
<tr>
<td>BC2-VR310</td>
<td>Pedonal paths determined involving citizens, e.g. through mappathons</td>
<td>Pedonal paths</td>
<td>BC2-UC#6</td>
<td>Optional. Pending availability of future datasets</td>
<td></td>
</tr>
<tr>
<td>BC2-VR311</td>
<td>City facilities</td>
<td>Location of services (PA offices, schools, libraries, hospital, sport facilities, theaters, cinema...) and other related information</td>
<td>BC2-UC#6</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

In conclusion, to achieve a correct coverage of the requirements, the dashboard will evolve in the coming months, adding more details and increasing its functionality as the availability of datasets and other project’s artifacts progress.

3. DASHBOARD ARCHITECTURE

3.1. QROWN D Architecture

As it was commented in D8.1 “Requirements and architecture” different level of data integration can be established among WP3-WP7 in QROWN:

- Direct integration, where some components will need direct integration by means of interfaces;
- Data integration via Broker, some other will do the integration through a middleware broker such as Fiware Context Broker, and
- Static data exchange, where other components just will need “one-time static data transfer between them.
Picture below reflects, apart from main interactions between work packages, the connexion between input (data sources)/output (consumer) artifacts and the QROWD platform. Is in the context of “consumer” where the dashboard architecture, and more specifically the Backend Consumer component detailed in the following section, can be placed.

![QRWD Data Flow](image)

**Figure 1. Data Flow between QROWD components**

### 3.2. Dashboard architecture layers

The dashboard framework is composed of two main architectural layers:

- **Dashboard Widgets.** This is the front-end, web-based visual part of the dashboard in charge of presenting data and helping to the user explore data in different ways.

- **Backend Consumer component.** This server-side layer is in charge of interacting with the storage systems in the QROWD platform, these are the Broker and WP7-Data storage package in the picture before, and exposing its functionality to the front-end as REST API. One of the main consumer of this REST API will be the dashboard itself. Keeping the presentation layer away from the business layer brings more flexibility and reusability to the application.

Figure 2 shows the architecture of the Dashboard and its connections with main storages in the QROWD architecture, architecture derived from the QROWD architecture developed in the scope of WP8 and showed in Annex 1.
The Dashboard Widgets are a set of widgets developed in JavaScript and HTML5 that provides the actual front-end of the dashboard. In the current version there is no distinction between the Municipality and Citizen dashboards, but in future releases there will be separated deployments for each of them.

The Backend Consumer component provides integrated access to different storages offered in QROWD, namely the QROWDDB database, explained in deliverable D7.2 “Data Storage and access component”, the CKAN\(^1\) instance provided by QROWD to the Municipality of Trento, and the FIWARE Orion Context Broker\(^2\), an enabler from the FIWARE foundation\(^3\), able to manage context information of a smart city in a rather efficient way, where events and contextual state of the city is stored. This component provides a REST API which provides unified access to the data to the widgets of the front-end. Figure 2 shows how the backend consumer layer is composed of three main blocks, each of them capable of deal with a different type of data:

- The QROWD Consumer, is in charge of consuming data from QROWDDB, the main storage of the project that persists results coming from the analytical processes performed in the context of QROWD.

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\(^1\) https://en.wikipedia.org/wiki/CKAN
\(^2\) https://fiware-orion.readthedocs.io/en/master/
\(^3\) https://www.fiware.org/foundation/
D2.3 – Urban mobility dashboard

- The CKAN Consumer retrieves data relative to the city infrastructure. This data has been previously ingested by the data acquisition pipelines defined in WP4. The data stored in CKAN has typically a very low rate of change, and it is mainly related to city infrastructure (streets, bus stops, garages, etc.).
- The Context Broker Consumer reads data from the QROWN instance of the FIWARE Context Broker that is used in the scope of the use cases. The data stored in the Context Broker is typically more volatile and of real-time nature, such as availability of underground parking and bike sharing systems.

The numeration attached to each arrow in dashboard architecture corresponds to the type of information visualized in each widget, that is:

1. Modal split data
2. Parking on street availability (motorcycle parking monitored by cameras, bike racks)
3. Trento parking infrastructure (enhanced via crowdsourcing services)
4. Parking off street availability (underground), bike sharing availability (and optionally parking on street paid, that is car monitored by parking meter)
5. (optional) historical from time-series QROWNDB
6. Historic analysis based on privately owned data

3.3. Interaction between QROWN components

The goal of this section is to describe how the dashboard communicates or makes use of other QROWN components. In this sense, the dashboard is one application developed to showcase the usage of the QROWN services in the scope of the Trento business case. The dashboard is, however, only the tip of the iceberg that makes use of the complex system developed in QROWN to support the required functionality of the business case. Deliverable D8.1 provides an overview of the QROWN architecture where the different elements are outlined.

Since not all the uses cases are fully addressed at this point, only the main components involved in the modal split use case (BC2-UC#1) and real-time data flows for the parking probabilities use case (BC2-UC#2) are explained below.

Modal Split use case (BC2-UC#1)

As it has commented before, the modal split is not only the core use case in WP2 and QROWN, but also it is the most completed use cases so far. As evidence of that, Figure 3 below illustrates the components involved in the use case, where the majority of them can be found fully developed at the closure of this document.
Figure 3: QROWD components involved to fulfil the Modal Split use case

The elements of QROWD shown in Figure 3 are the following:

- (i-Log) Acquisition framework, is in charge of bringing sensor data coming from smartphones to the project. The data is stored in a Cassandra database at UniTN and it contains anonymous mobile sensor data.
- Analytical framework is in charge of processing raw data stored in Cassandra and apply machine learning algorithms to predict information relative to citizens trips, such as stop point classifications or transportation mode prediction. As any classical supervised analytical framework it comprises two stages: learning phase, that will train the algorithms used in the classificator component and the prediction phase, that will use the classificator to predict new data.
- Crowdsourcing framework capable of providing complementary functionality to improve/validate results obtained from the analytical process. Specially for modal split, it will validate the correctness of stop points detections produced by the classificator through a set of crowdsourcing channels such as: iLOG, Crowdflower, etc.
- Storage framework persisting the result performed by either the analytical
framework or any other additional process in charge of operating over QROWD data related to modal split.

- Dashboard framework (object of this deliverable). To finish the chain, the dashboard presents data and the results of the analytics to the end users.

(Underground) Parking probabilities use case BC2-UC#2

This section describes how the **BC2-UC#2** manages one of the type of information handled in the use case: the underground parking information. The information comes from an open Trento dataset that supply real-time information about underground parking in Trento. The dataset provides not only the location and other meaningful information but also provides the availability in real-time. This need of handling data with a high rate of update gives as a result the use of the Context Broker.

The solution, therefore, consists of following artifacts:

- The NiFi acquisition component (acquisition phase performed in WP4), an Apache NiFi\(^4\)-based infrastructure able to read/get information from http services and store them in a the broker.
- The Context Broker (acquisition phase, also performed in WP4), an intermediary data manager in charge of receiving the status of the city in a standardized format.
- And the dashboard framework (visualization phase), an infrastructure composed of i) a service layer (a NGSI consumer\(^5\) in charge of consuming data from Orion context broker), and ii) the very visualization layer.

![Diagram of QROWD components](image)

**Figure 4: QROWD components involved to fulfil the Parking Probabilities use case**

Figure 5 shows a partial view of the NiFi real-time acquisition framework. The figure shows the data flow involved in the acquisition of underground parking information,

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\(^4\) [https://nifi.apache.org/](https://nifi.apache.org/)

and within it can be appreciated several NiFI connectors: “TrentoParkingToFiware” able to request remote “HTTP get”, split the json, or even evaluate and transform the data. And the “FiwareRESTAPIHandler” connector mainly in charge of sending HTTP requests to the Fiware API in order to POST/UPDATE the status of the entities in the broker.

![Figure 5: Apache NiFi acquisition framework for underground parking data streams](image)

This work provides the data about parking availability ready to be consumed by the dashboard using the Backend consumer services developed to consume data from the Context Broker.

### 3.4. Technical implementation

From a technical point of view, the dashboard front-end has been developed using JavaScript, HTML5, JSP and Servlet technologies.

Open-source libraries of JavaScript, have been used to make the development process easier:

- **Bootstrap**\(^6\), be means of AdminLTE\(^7\) “Control Panel Template”, used as the admin dashboard panel.
- **Leaflet**\(^8\), as cited its website: “an open-source JavaScript library for mobile-

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\(^6\) [https://getbootstrap.com/](https://getbootstrap.com/)
\(^7\) [https://adminlte.io/themes/AdminLTE/index2.html](https://adminlte.io/themes/AdminLTE/index2.html)
\(^8\) [http://leafletjs.com/](http://leafletjs.com/)
friendly interactive maps” for the creation of maps. Due to the huge amount of mobility data that often involves location, it become necessary to display this information on maps. Plugins from Leaflet library have been used to visualize open-public datasets from Trento, results from the analytical framework, or maps containing data from TomTom Traffic Flow or Traffic Incidents coming from WP1 use cases.

- Highcharts\(^9\), used for different visualizations of the data. These graphics allow displaying information in a way that is more comprehensive and attractive to the user. It is also a way to interact with the data and understand how it can vary over time.

- \(R\)^10 is a free software environment for statistical computing and graphics. It has been used to manage the data and make transformations on the different datasets for displaying it in a better way using highcharts and leaflet.

- RESTful services: The server side of the dashboard provides a set of REST APIs to access to the data. Behind the scenes, this server side layer access to the different components of the QROWN framework using their specific interfaces (i.e. REST interface to access QROWNDB, a specific consumer using the NGSI API to access the Context Broker, or the CKAN API to access to CKAN).

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\(^9\) [https://www.highcharts.com/](https://www.highcharts.com/)
\(^10\) [https://www.r-project.org/](https://www.r-project.org/)
4. **Dashboard Front-End**

The Dashboard will allow the Municipality of Trento (as well as any other operator deploying the QROWD) to monitor in real-time data streams collected from various sources (existing infrastructure, crowdsourcing, etc.), as well as the results of the analysis performed in QROWD. The application also collects and displays statistics on traffic and the usage of various means of transport, allowing for the analysis and evaluation of the impact of the QROWD system.

The dashboard is in reality composed of two different dashboards targeting two different users:

- The Trento Municipality Dashboard targets municipality workers and decision makers. Therefore the intention is to be eventually deployed and used within the boundaries of the municipality IT systems.
- The Trento Citizen Dashboard targets mainly Trento citizens or any other person interested in the Trento mobility services. Therefore it will show public information to the users and will be accessible via web.

In practical terms, both dashboards share many of the functionalities and technology, but they will be eventually deployed as two different dashboards with different security and deployment constraints. At the time of closing this document, the dashboards are still deployed as one in a testing environment.

4.1. **Trento Municipality Dashboard**

4.1.1. **Structure of the dashboard**

The Trento Municipality dashboard aims to show data about mobility, including city infrastructure, modal split, status of parking, etc. It is intended mainly for city officers and workers of the municipality of Trento. The design of the dashboard front-end is following typical dashboards using Bootstrap templates. Figure 6 shows a screenshot displaying the main dashboard areas.

![Figure 6: Dashboard structure](image)

- Header: This is the area that can be tailored to the specific image of the pilot...
owners. In Figure 5 it showcases the QROWD logo, the time and a panel to change the language. It is worth mentioning that the baseline language of the dashboard is Italian, but the use of responsible design allows to use automatic translation to multiple languages.

- Left-hand menu panel: This panel shows the different menu options that give access to the functionality embedded in the dashboard. This can be tailored to the specific needs of pilots or customers.
- Main area: This is the area where the actual content and data will be shown based on the options clicked on the left-hand menu panel.

This design has been consensuated with the Municipality of Trento.

### 4.1.2. Home Page

The Municipality Dashboard home page is displayed when the dashboard is invoked using the following URL: http://<domain>/qrowdDashboard/

It shows different kind of data in different widgets in order to have an overview at first glance of the status of the mobility of the city in aspects such as traffic, weather and pollution:

- **Traffic** – Real-time data and visualization provided by Tomtom. Knowing the traffic in real time is one of the most important concerns for city workers dealing with mobility. For this reason, Trento municipality wants to visualize the traffic in the dashboard frontend as it is shown in the figure below.
Figure 7: Real time traffic visualization

- **Weather** – Weather is one of the key aspects that affect mobility in a city. Therefore it is important to show the forecast at first glance. Figure below displays how the weather is shown in the dashboard.

  ![Meteo Trento]

  **Figure 8: Weather widget**

- **Pollution** – Pollution has become one of the most important issues of the cities all over the world. Pollution is very much related to traffic and may lead to traffic restrictions or to evaluate policies. The dashboard shows condensed
information about the pollution in Trento in a widget in the home page (as it is shown in the figure below).

![Pollution widget]

Figure 9: Pollution widget

4.1.3. Modal Split

The modal split panel aims to visualize the results from the **BC2-UC#1 - Modal Split Use Case**, that provides an overview of the amount of travellers using a particular mode of transportation. In the case of QROWD, the modal split is calculated based on the number of trips of citizens and can be visualized from two different points of view:

- Filtered analysis of modal split: It constitutes the essence of the use case and shows the total number of trips made by citizens in the city of Trento in a period. Due to the calculation of the modal split is done considering different criteria, this page provides filters based on these features in order to facilitate the user with different views of the data. Below it can be shown a relation of the considered criteria:
  - number of trips by type of transportation: car, bus, train, motorcycle, cable car, bicycle, and on foot
  - number of trips by demographics criteria: type of citizen (resident, commuter) and occupation.
  - number of inter-districts trips or extra-district trips (with origin in a district and destination in another different district)
  - number of trips computed for a whole period or for a typical weekday
Comparison of modal split: Within the modal split section it can be found also a comparative analysis between different periods which could help the user to inspect the evolution in the use of the different modes of transportation along a set of selected periods at a glance.

Therefore, the left-side modal split menu is divided in two options: “modal split” and “historical analysis” which correspond to “filtered analysis of modal split” and “comparison of modal split” views respectively. The figures below show the two choices:

![Figure 10: Modal Split widget](image)

Figure 10 shows on the left hand side different filtering elements that correspond to each of the criteria explained before. “Date” selection, to allow the user pick up period of time, “Temporal” selection, to allow the user visualizes data for a concrete day of week or for a particular hour of the day. “Demographic” element, to allow the user filtering by the occupation of the user, or by citizen type (resident, commuter), or “Spatial” element, to allow the user filtering trips performed from/to a particular district. By default, the table will show statistics for all the trips, performed in the last period computized, for all the mean of transportations, for all types of citizens and for all the trips performed in the City of Trento.

The modal split table lists the number of trips for each type of transportation as well as the percentage with respect to the total of trips for each of them. Finally at the top of the table, it can be found a button to see the information computed for the whole period, or for a “typical” day in the period, understanding a “typical day” in QROWN as a Wednesday non festivity during school terms.
Figure 11: Modal Split comparison widget

On the other hand, Figure 11 shows a different way of visualizing the modal split. In this case the user can check at a glance how the usage of different types of transportation has evolved over last periods. The pickers at the bottom allow the user hide or unhide historic data for a particular means.

It is worth mentioning that the visualization provided of Modal Split in the Citizen dashboard follows the same visualization paradigms. The personal citizen dashboard could help to Trento citizens to have a better knowledge about their mobility patterns.

4.1.4. Parking availability

Having an easy way of accessing information about parking availability and for the infrastructure of the city related to the mobility may have a huge impact in the economy of a city, the people and the governance would take better decision according on the mobility that will affect to the environment and, obviously, in the way of living for having a real Smart city.

In order to provide this information, QROWD provides a set of components and services that collect data previously owned by the municipality or third parties complemented with newly acquired data derived from crowdsourcing or further analysis. The dashboard provides a way of displaying this information in a structured way.

Requirements for Car Parking

The data about car parking availability is shown as follows:

- **Parking Information** – Divided in districts, Trento has also a paid parking zones regulated by parking meters around the city center. A real time
approximation of the free parking spots in this paid parking zone will be given by the Municipality. This information is not available at the time of writing this deliverable; however, thanks to the QROWD project, the Municipality will have access to it. The following figures show the way the zones are visualized in the dashboard.

Figure 12: Parking zones widget

Figure 13: Parking zones widget
All of this information is completed with unpaid on-street parking like spots for people with disabilities and freight load and unload zones.

- **Historical analysis** – A historical analysis will be performed using TomTom data concerning historical parking probabilities. The probability and the average time for parking is given for more than 2300 streets. Divide in hours and depending if you are in a weekday or in the weekend, you can check whether is possible to park in some streets and the average time you will need to do it.
Figure 16: Historical analysis of parking probabilities widget

- **Traffic** – Checking in real time all the incidents that are happening concerning to the car traffic flow is the aim of this section. TomTom allows using its data and visualizations to show this information to the municipality and the citizens.

Requirements for Motorcycle Parking

The availability of parking spots for motorcycles will be calculated based on alternative data sources generated by the QROWN project. This is still not available, as it depends on analytics on iLog data still under development:

- **Parking Information**: Information obtained from iLog users voluntary feedback (type “Challenge”): iLog users will voluntary explore areas around the city, take pictures, and provide feedback concerning existence and availability of parking spots for motorcycles. The challenges are defined and it is expected having results for the second half of the project.

If feasible, a monitoring camera covering a group of motorbike parking spots will be installed. Images resulting from these cameras might be scrutinized using crowdsourcing to determine occupation of parking spots at specific hours. The feasibility check is still in progress at the closure of this document.

- **Historical analysis** – The data for the historical analysis might be obtained from storing iLog users feedback and if available, the scrutiny of images coming from the camera.

Requirements for Bike Parking

The infrastructure of bicycles has become very important in the physiognomy of cities. Real time data of the bike sharing spots will be fused with the availability of
- **Parking Information** – Divide in districts, the bike lanes of Trento run through the city.

![Figure 17: Bike lanes](image)

Real time information about the bike sharing station will be provided by the municipality of Trento.

![Figure 18: Real-time data about bike sharing stations](image)

If feasible, a monitoring camera covering a set of bike racks will be installed. Initially, images resulting from these cameras will be scrutinized using crowdsourcing to determine occupation of parking spots at specific hours. The feasibility check is still in progress at the closure of this document.

- **iLog user voluntary feedback** will provide information concerning
availability/occupancy of bike racks. Optionally, if feasible, machine learning techniques will then substitute this process and will determine availability of parking spots in real-time directly from the camera before commented. The visualization is ready, although the data is not yet available.

4.1.5. **Crowdsourcing information**

The BC2-UC#3 - "Completing information About Mobility Infrastructure Through Spatial Crowdsourcing“ use case will make use of the crowdsourcing services "to help the Municipality have a deeper understanding of mobility infrastructure around the city, with a focus on bike racks and parking spots for motorcycles, people with disabilities, freight load and unload“ (D2.2). The data is not available yet at the closure of this document, consequently the dashboard is not able to display information coming from the crowd, but just a schematic distribution of information defined as part of the visualization requirements. See below the information foreseen to be displayed in a dedicated tab:

**Information related to the infrastructure itself:**

- Bike racks location improvement. Contribution of citizens or crowd workers to complete locations of bike racks owned by the Municipality. The current dataset is shown, so when the data is ready it will appear automatically in the dashboard.
- Disabled parking spots. Contribution of citizens to the existence and availability of on-street parking spots for people with disabilities.
- Freight load / unload spots. Contribution of citizens to the existence and availability of on-street parking spots for freight load and unload.
- ALL, the previous information could be visualized all together
4.2. Trento Citizen Dashboard

The Trento Citizen Dashboard is created in a similar way to the Municipality Dashboard. The main difference with the Municipality Dashboard is the target users: The Citizen Dashboard will be public on the web and targets mainly Trento citizens. It will show mobility data to the users, which in most of the cases is common to that shown in the Municipality Dashboard. Therefore, the front-end of both dashboards is very much alike. Currently the Citizen Dashboard has not been deployed separately, so it is embedded in the Municipality Dashboard during the current testing phase. In future released it will two separate bundles for each dashboard and two different deployments.

The information that citizens will be able to visualize (besides the one explained before for the Municipality Dashboard) is the following:

- Car, Parking information, Historical analysis, Traffic.
- Bike, Parking information, Historical analysis
- Motorcycle, Parking information, Historical analysis.
- City infrastructure services.

![Figure 20: Visualization of city infrastructure](image)

Figure 20 shows precisely this last element: City infrastructure, which was not shown in the Municipality Dashboard. This comprises the location of city elements that although not directly related to mobility, are important to understand the layout of the city services and affect mobility. The datasets that used so far to display the information have been facilitated by the Municipality of Trento and involve so far the following data:

- Sport Zones.
4.3. Personal modal split visualization

The Citizen Dashboard is a public, web-based front-end, and therefore it uses no credentials to log in. However, there is a requirement to show personal information related to the so-called “Personal Modal Split”. This is a use case where a citizen would like to visualize his/her mobility footprint. It is very similar to the generic Modal Split, but using only the data of the movements of the specific user in the city. Therefore, the best way to show this data is not the Citizen Dashboard, but rather the mobile app that collects this type of data in the first place: iLog.

iLog provides authentication mechanisms to the user. This authentication will be used to get the personal data from the specific user and visualize the personal info in the app. The personal Modal Split of the citizen will therefore show only the modal split of the particular citizen who is checked in its own app, while the Modal split of the Municipality Dashboard will show the average mobility patterns of all the iLog users of the city.

The current status of this personal modal split is that there is a web-based front-end visualization showing it (Figure 21 below), while the data shown is still not connected to the actual QROWDDB info. This web visualization will be integrated into the iLog mobile app to show this info to the user. Security will be implemented based on OAuth.

Figure 21: Personal Modal Split
5. CONCLUSIONS AND FUTURE WORK

This document is accompanying the software prototype of the Trento Urban Mobility Dashboard. The dashboard can be accessed via web in a current version located in a test server via the following URL: http://<domain>/qrowdDashboard/, where <domain> can be substituted at the time of writing this deliverable by 130.206.127.63:8180.

As explained in section 1, the release of the dashboard was initially scheduled for M18 (end of June 2018). But during the first period of the project it became evident that the requirements for the dashboard, along with the availability of data a QROWD services were pushing the finalization of the dashboard far beyond the first period. In fact, the dashboard can be seen as the materialization of the usage of the QROWD components and services developed in the rest of the QROWD project. Therefore, it mimics the state of affairs in M18. The present version of the dashboard can be considered as an intermediate delivery of the dashboard that serves the purposes of both the QROWD project -by testing the functionality and services provided so far- and the Municipality of Trento -by providing a set of functionalities that enable a first glimpse of the results, a showcase and a testing environment-.

Besides, there has been a redefinition of priorities for the Municipality of Trento not only related to the dashboard, but also to the use of certain apps foreseen in WP2, such as sensorCivico. This last app was replaced by the intensive use of the iLog app to engage citizens and collect valuable information about mobility patterns in the city. The current version of the dashboard has been therefore affected by all these changes reflected in the requirements gathered in deliverable D2.2. In that document not one, but two dashboards (Municipality and Citizen) are required, and the use of iLog is explained. Data access has been also postponed in some cases due the negotiations with third-parties to access some data streams (i.e. data from the parking meters). All in all these issues affected the schedule of the dashboard, leading to its current state that covers only partially the requirements stated in D2.2, and shows misalignment with the schedule of WP2. However, we don’t consider this a major issue, as it is in line with the current project objectives.

The current status is that there is a demonstrator of the Municipality Dashboard accessible online with many functionalities and visualization widgets as explained in this document. The plan is to continue working in the dashboard until M30 to provide a complete version that will be finally evaluated in the scope of deliverable D2.5 due in M36.

The future work will be along the following lines:

- Separation of deployment of the Municipality and Citizen dashboards.
- Finalization of extra visualizations based on the data and services available. This affects mainly to data and analytics related to the city infrastructure (historical modal split comparisons, availability of crowdsourcing data from freight spots, disable people parking spots, free bike spots, etc.).
- Connecting to QROWD services, such as QROWDDDB, to get data. Currently the queries to QROWDDDB are under testing to ensure their performance in complex cases (such as the modal split queries that require access to multiple
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- records using for instance geolocation filters).
- Getting feedback from the Trento Municipality and users to the first version of the dashboard to improve the look and feel.

The idea is therefore to keep the implementation of the dashboard alive during the second half of the project. The plan is to resubmit this deliverable around M30 explaining the new data, analytics and improvements made.
6. **ANNEX 1 - QROWD ARCHITECTURE**

A more detailed picture of the general QROWD platform is illustrated below.

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Figure 22. **QROWD Architecture**