**D2.2 – Use case requirements specification**

<table>
<thead>
<tr>
<th>Due date</th>
<th>30.11.2017</th>
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<tbody>
<tr>
<td>Actual delivery date</td>
<td>08.12.2017</td>
</tr>
</tbody>
</table>
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| Version        | 1.0                 |
| Dissemination level | PU                 |
| Status         | Final               |
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**ABSTRACT**

This document reports on the requirements and design of the QROWD business case “Intelligent urban transportation and mobility”. Besides the requirements and design for the business case, the document discuss the required datasets, and provides a detailed description of different scenarios of usage of the QROWD platform and the potential visualization of the results of the scenarios.
EXECUTIVE SUMMARY

This document reports on the requirements and design of the QROWD business case “Intelligent urban transportation and mobility” (WP2). The deliverable is public, but the main target readers of the document are developers of the QROWD project, as it provides an extensive list of requirements and an initial design for the business case. Therefore the document provides input not only to WP2, but also to the rest of the technical work packages of the project, as well as hints to the potential exploitation results of the project.

Besides requirements and design, the document breaks down the business case into more specific use cases. For each of the use cases the document provides a detailed description of different scenarios of usage of the QROWD platform, the required datasets and the potential visualization of the results of the scenarios.

The document is therefore the input to be used to develop the business case. It will be used to deliver the Municipality Dashboard (D2.3) and the apps (D2.4), as well as being a reference reading for the rest of the actions to be taken in the whole WP2. The document is also a source of requirements for the rest of the technical work packages (WP3 to WP7), the architecture (WP8) and offers hints and avenues for future exploitation (WP9).
1. INTRODUCTION

1.1 Purpose of the document
This document is the second deliverable of the business case WP2, Business case: Intelligent urban transportation and mobility. The document reports on the results of business case requirements and design (T2.1). To that extent, it provides the requirements and design for the business case, including the required datasets, a detailed description of different scenarios of usage of the QROWD platform usage and the potential visualization of the results of the scenarios.

1.2 Methodological approach for gathering requirements
In order to describe the requirements project partners’ agreed on following the same methodological approach, techniques and templates. It is a classical approach followed by many ICT projects (e.g., (Wikipedia), (Nuseibeh, 2000)). It is a lightweight methodology that takes into account several requirements categories and actors.

The deliverable describes the use cases both in a “business language”, and interpreted as simulated situations in which actors interact with the QROWD business case system to evaluate its viability and improvements with respect to the business case goals.

In the present document the domain knowledge acquired from the actors of the different use cases is described and, to some extent, formalised, deriving from this process the requirements that QROWD must satisfy from an end-user point of view.

In particular, in order to drill down into the requirements, the Trento business case defines several use cases. Each use cases will provide the different set of requirements according to the following structure:

1. Textual description of the business case: Before starting with the requirements gathering, an introductory definition of the context and the main business goals of the business case is provided.

2. Definition of use cases: These are the different use cases that will cover the business objectives. They are divided into mandatory/optional and for the Municipality/for the Citizen. More details about this categorization can be seen in further sections.

3. Business case requirements: The business case is specified through the following categories of requirements:

   a. The General requirements are subdivided in the following categories of requirements:

      i. Context requirements – i.e., generic “environment” requirements;

      ii. Big Data Value Chain requirements – i.e, data acquisition components requirements;

   b. The Specific requirements are subdivided in the following categories of requirements:
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i. List of actors;

ii. Functional requirements;

iii. Visualization requirements;

iv. Non-functional requirements.

1.3 Structure of the document

This deliverable is structured as follows: Section 1 gives an overview of the structure and main goal of the deliverable. In Section 2 we describe the main scenarios or business cases from a business perspective. Section 3 provides a detailed breakdown of the business cases into different use cases, and provides a set of requirements for each of them. Section 4 offers an initial overview of the design and sequence diagrams of some of the most important use cases. Section 5 concludes this deliverable.
2. BUSINESS CASE AND USE CASE DESCRIPTION

This section describes the business case from a generic perspective and dives into the different use cases that came up from the analysis of the needs obtained from the business case.

First of all a section summarizing their categorization in term of prioritization and intended users is provided. Second, a textual description of the business case is described, introducing some of the main issues detected by the Municipality of Trento related to the QROWD objectives.

The detailed description of the use cases, limited to the mandatory ones, includes following structure:

- Description: an introduction to the use case.
- Requirements: a description of the use case’s needs.
- Current methods: a brief description on how the problem is currently addressed (if addressed).
- Goal and scope: main use case purpose and results.
- Main success scenario: a section including a textual specification outlining how a user will interact with the solution to achieve a specific goal.
- Datasets: a list of datasets to be used within the use case which are described in more detail in D4.1 - Data catalog deliverable.
- Finally, an intended analysis to be performed should complete the use case description.

2.1 Description of the Business Case

For the last decade the Municipality of Trento has been combatting inner city traffic. Situated in a mountain valley, the city has limited options of expanding its road infrastructure and hence needs actively to discourage excessive car traffic in its city centre, a policy also enforced by regional law. While recent measures—such as the creation of a limited traffic zone, the deployment of bike sharing services, or the establishment of paid parking zones with variable fees—have had positive effects on traffic, the municipality has only limited means of quantifying these improvements and of understanding the underlying reasons. Reducing traffic also leads to a reduction in CO2 emissions and this objective has clearly been an important driver in the design of the use cases.

A key standard metric for understanding traffic is the modal split that tells the percentage of population using a particular type of transportation. However, the current practice of obtaining the modal split through population surveys is costly and, consequently, it is carried out only about once each decade. In the meantime, traffic still remains heavy, pointing towards a need for further measures.

Parking is also known for having a profound impact on city traffic and for being a source of pollution. As such, efficient parking policies are crucial when dealing with both these issues. However, the Municipality has little knowledge about usage of parking spots around the city, mainly limited to off-street, underground parking. A
The comprehensive analysis of **parking availability** would help the Municipality setting priorities for future policies.

Finally, having access to all this information on a **dashboard** is extremely valuable to the Municipality; a comprehensive overview of mobility in Trento is in fact a precondition for making knowledge-based decisions.

Furthermore, the Municipality wishes to setup a give-and-take strategy; while collecting data through, *inter alia*, citizen sensing, it wants to provide citizens with valuable services in exchange of their precious contribution. An assessment of the needs of the citizens of Trento has been carried out mainly through an ideas competition (reference is made to D2.1 - **Ideas competition**); results not only show an increased awareness of citizens in terms of traffic reduction and alternative mobility but also a need to be informed about mobility in Trento.

The QROWD project brings solutions to these problems by inducing an active collaboration of government, citizens, and industry based on shared interests. Through the combination and analysis of big data from the Municipality’s database, **participatory sensor data** from the mobile devices of citizens, lightweight electronic surveys on mobile devices, and data provided by the TomTom company, it becomes possible to address all these issues.

The modal split can therefore be computed yearly or even monthly as opposed to every ten years, at a fraction of the cost, with higher precision due to a continuous, comparable computation, and with finer granularity in terms of geographic coverage as it involves commuters other than resident citizens.

Parking availability will be analysed based on alternative data sources with a specific focus on on-street parking for cars, motorcycles and bicycles as well as on special parking areas such as parking for people with disabilities and for freight load/unload.

Finally, citizens of Trento will benefit from the QROWD project through an improved mobility experience in their daily life. Citizens are also motivated to partake sustainably in the endeavour by getting free access to a set of invaluable, **personalized services** offered by the QROWD project. We expect that this improvement in the mobility will lead to other benefits, such as reduction of the private cars with the subsequent reduction of the emissions of CO2.

**Division by Priority and Target**

Due to the large list of needs extracted from the analysis, a **prioritization** of the use cases has been established as follows:

- **mandatory** - use cases which have been identified as more useful for by the Municipality of Trento and must be implemented. For those use cases, a clear implementation strategy has been identified and it is fully described by means of a detailed definition, analysis of requirements and sequence diagrams.
- **optional** - use cases planned to be addressed but neither a feasibility study nor a clear definition have been provided at the closure of this document leaving their accomplishment subject to the availability of time and effort. For these use cases just a brief definition has been provided.

The use cases are also divided according to their **target** users, which can be:
Use cases for the **Municipality of Trento employees**, focused on solving the needs of the Municipality (i.e. modal split, evaluation of mobility policies, etc.).

Use cases for the **Citizens of Trento**, focused on providing them with new services and information (i.e. personal modal split, citizen dashboard, etc.).

The table below shows a summarization of the use cases identified so far along with their priority and target. It is worth noticing that the nomenclature of the use cases starts by the prefix “BC2”, meaning “Business Case 2”, the business case of the Municipality of Trento defined in WP2 (TomTom business case defined in WP1 is “BC1”).

<table>
<thead>
<tr>
<th>Use Case ID</th>
<th>Short Name</th>
<th>Brief description</th>
<th>Target</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-UC#1</td>
<td>Modal Split</td>
<td>Computation of multimodal transport in Trento: how people use different means of transport</td>
<td>Municipality</td>
<td>Mandatory</td>
</tr>
<tr>
<td>BC2-UC#2</td>
<td>Parking Availability</td>
<td>Information about the probability to find a parking spot for four- and two-wheeled vehicles</td>
<td>Municipality</td>
<td>Mandatory</td>
</tr>
<tr>
<td>BC2-UC#3</td>
<td>Completing mobility infrastructure information</td>
<td>Information about mobility infrastructure retrieved through spatial crowdsourcing</td>
<td>Municipality</td>
<td>Mandatory</td>
</tr>
<tr>
<td>BC2-UC#4</td>
<td>Municipality dashboard</td>
<td>A dashboard that can be accessed by employees of the Municipality and other public stakeholders displaying aggregated data about mobility in Trento</td>
<td>Municipality</td>
<td>Mandatory</td>
</tr>
<tr>
<td>BC2-UC#5</td>
<td>Personal Modal Split</td>
<td>Personal modal split providing general information about how a user moves around the city</td>
<td>Citizens</td>
<td>Mandatory</td>
</tr>
<tr>
<td>BC2-UC#6</td>
<td>Citizen dashboard</td>
<td>A dashboard where citizens can access useful information about mobility in Trento</td>
<td>Citizens</td>
<td>Mandatory</td>
</tr>
<tr>
<td>BC2-UC#7</td>
<td>Customized traffic service</td>
<td>A personalized service of traffic information</td>
<td>Citizens</td>
<td>Optional</td>
</tr>
<tr>
<td>BC2-UC#8</td>
<td>Services provided by the QROWD platform</td>
<td>A set of services will be made available on the QROWD platform in order to allow businesses and citizens to query these services and develop new ones</td>
<td>Citizens</td>
<td>Optional</td>
</tr>
</tbody>
</table>
2.2 Description of the Use Cases

2.2.1. BC2-UC#1 - Modal Split Use Case

Description
The modal split is a fundamental formal metric for understanding how citizens use various means of transport. It provides the percentage of travellers using a particular type of transportation for everyday travel. More details about Modal Split can be found in section 4.3.

Requirements
The computation of the modal split will help the Municipality have a more clear overview of mobility in Trento and take knowledge-based decisions for future policies. The modal split should be computed at least twice every year (ideally even more frequently) according to the requirements listed below.

Data to be collected for the computation
Generally, the modal split should be computed considering:
(i) all trips
(ii) of the people
(iii) on a specific day
(i) Regarding trips, the following information should be collected:
1. place of origin and time of departure
2. destination and time of arrival (travelling time can be inferred)
3. purpose
   a. work
   b. school / university
   c. accompanying reasons
   d. errands / personal reasons
   e. free time
   f. trips made for work purposes during working hours (to be excluded)
   g. return trip with reference to one of the abovementioned reasons
4. means of transport used
   a. car
   b. motorcycle / scooter
   c. train
   d. bus
   e. cableway
   f. bicycle (private; bike sharing / traditional; electric)
   g. foot
5. In the case of cars, motorcycles and scooters, the following should be specified:
   a. driver or passenger
   b. number of ride-on people
If trips can be subdivided in more stages, 4) and 5) should refer to each stage. Trips made for work purposes during working hours are deemed irrelevant and shall not be included in the computation.

(ii) Regarding **people**:

- **For each person**, the following **personal information** should be collected:
  - type:
    - resident / domiciled
    - commuter
  - occupation:
    - worker
    - student
    - other (unemployed, retired, stay-at-home)
  - age (16+)
  - gender
  - domicile and residence
  - number of people living in the same house
  - driving license
  - total number of vehicles available to all cohabitants (car; motorcycle, scooter, bicycle - including electric)

- To compute the **official modal split** for the whole city a **sample size** must be identified taking into account:
  - type (resident, commuter)
  - occupation (worker, student, other: unemployed, retired, stay-at-home)

(iii) Regarding the **day**:

- The modal split should be computed for both working and festive days

- To compute the **official modal split** for the whole city, a **typical day** should be considered and identified as follows:
  - a Wednesday
  - not festive
  - during school terms

**Current Method of Collection**
Currently, the modal split is computed about every five years mainly using traditional methods:

i) through a CATI (Computer assisted telephone interviewing) system, a costly process (as it involves a lot of human interaction) that does not provide a frequent update on the evolution of traffic and is limited in precision due to the small sample size and to uncertainty in the correctness of responses. The last computation was carried out in 2004 when 650 families/1500 people, were interviewed for the modal split calculation.

ii) using external data collected at the national level for statistical purposes - in 2011 the Autonomous Province of Trento elaborated on data stemming from the national
census to analyse the mobility of resident citizens from home to work. Additionally, an assessment of mobility patterns for study or work purposes has been carried out on the grounds of data originating from the National Institute of Statistics.

Goal and Scope
The Municipality is seeking a more efficient computation method based on alternative data sources that are either already available or are created by the QROWN project, with a more frequent periodicity (at least twice a year), with lower costs and covering different geographical zones (while specifically focusing on the neighborhoods located in the valley).

The QROWN project offers the unique possibility to leverage on the expertise provided by technical partners; as such, the Municipality will take advantage of:

1. **Data collection** from:
   - iLog, an application developed by the University of Trento (UniTN) which gathers stream sensor data from mobile devices and stream data from user feedback
   - Machine learning techniques (InfAI - c.f Deliverable 6.1)

Further details are listed in Annex 1.

2. **Visualization** tools:
   - Municipality dashboard (cfr. **BC2-UC#4 Municipality dashboard and User Interfaces - Modal Split sections**) displaying aggregated data (ATOS)

Main Success Scenario
- **Actors** – Municipality of Trento (MT); UniTN; SOTON; Citizens; InfAI; ATOS
- **Preconditions** – The datasets described below are available; requirements and objectives are clearly defined (MT); features of iLog are designed and improved for the purposes of the use case (UniTN); questionnaires to be submitted to users are properly defined (SOTON + UniTN)
- **Basic Flow** –
  - The Municipality properly promotes the download and use of iLog as a substitute of the CATI system for the computation of the modal split. Citizen engagement is encouraged through prize-based incentives and gamification activities
  - Citizens download the application and accept its terms & conditions so that sensor data can automatically be collected
  - Citizens provide some personal information (age, gender, domicile and residence, number of people living in the same house, driving license, total number of vehicles available to all cohabitants) by filling in a compulsory questionnaire
  - Sensor data collected is analysed with machine learning techniques to

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1 Further details about iLog are available here: [http://trams.disi.unitn.it/#services](http://trams.disi.unitn.it/#services)
infer transportation mode (c.f. Deliverable D6.1)

- When necessary, questions are submitted to users to validate sensor data
- The Municipality is interested in the analysis of all data gathered by the application but the official modal split will specifically focus on data referring to a typical day; the Municipality will inform users about which will be the precise day and will ask for a more attentive contribution so that data will be as accurate as possible
- The system responds:
  - The modal split shows the percentage of travellers using a particular type of transportation using different visualization techniques (i.e. pie charts, diagrams, maps, trends etc.)
  - The aggregated results of the computation will be displayed in a dedicated section in the Municipality dashboard

- **Exception Flows** –
  - The Municipality’s expectations concerning the number of people using the app are not met despite the efforts towards encouraging its download and usage
  - Citizens don’t provide the necessary permissions to allow the application to collect the data
  - Citizens are asked too many questions; high resource (battery) consumption discourages citizens from using the application
  - Citizens delete the application

- **Post Conditions** –
  - Enough data has been gathered for the computation of the modal split
  - Analytics (InfAl): existing and sensor data are enhanced by machine learning techniques and feedback data is integrated (if necessary)
  - The computation of the modal split is successful
  - Aggregated data is displayed on the Municipality dashboard
  - MT can compare the modal split to previous computations
  - MT can compute modal split more frequently

Further details about how information is collected through iLog can be found in subsection 4.3.1. Modal Split (BC2-UC#1) sequence diagrams.

**Datasets**

The modal split will be computed taking into account existing datasets and data generated by the QROWD project. For an exhaustive description of available data sources, please refer to the QROWD deliverable D4.1 - Data catalogue.

Available open and private datasets:
D2.2 – Use case requirements specification

- **Traffic counting sensors** (1009) already deployed in the city that are able to discriminate between different means of transport (motorcycles, cars, trucks, buses, tractors);
- **Traffic sensors on provincial roads** (1055) (1038) collecting data in near-real-time (hourly)
- **Bike sharing data**: position of “E-motion” bike stations and real-time available bicycles (1014), position of “C’entro in bici” bike stations (1027)
- **Transport data**: bike lanes (1016), cycle paths (1019), cyclopedonal paths (1043) (1044), railway timetables (1046) (1047) (1048) (1049) (1050) (1051), bus lines (1007) (1008)
- **Parking data**: (1017) (1018) (1022) (1024) (1035) (1052) (1054)
- **Data concerning services and facilities around the city** such as schools, green areas and libraries (1025) (1026) (1028) (1029) (1030) (1031) (1032)
- **Data from previous modal split computations** (1057)

Data to be collected as part of the QROWD project:

- **app-based sensor data** (3001), anonymous mobile sensor data collected via iLog
- **app-based manual feedback** (3002), anonymous user-declared data collected via iLog through questionnaires

Analysing the Information

Analytics for the modal split service will be performed by InfAI. The core of the analytics will be to combine together data from the app and data from the already existing catalogues of the Municipality. These analytics will be enhanced by machine learning techniques and validated by feedback (if necessary).

### 2.2.2. BC2-UC#2 - Parking Availability Use Case

**Description**

This use case aims to provide information about the availability of on-street parking spots for cars, motorcycles and bikes. This information will be based on real-time data (where available) and on historical analysis of parking probabilities (when no real-time data is available).

**Requirements for On-street Car Parking**

On-street car parking in Trento can be of two types, paid and unpaid. Analysis of parking availability can be conducted for each type respectively:

- **on-street paid parking** - availability is determined from real-time information from parking meters owned 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. However, for a more comprehensive view on paid parking availability, reference is made to TomTom’s BC1-UC#2 Parking Services in D1.1 Datasets Release for Model Region. This use case concerns historical
information about the expected parking availability on public streets in certain city areas. This information combines data owned by TomTom (Parking Probabilities) and static data owned by the Municipality on parking and extends it with real-time data from parking meters;

- **on-street unpaid parking** - real-time data concerning specific parking spots (people with disabilities, freight load and unload) will be available in the future and will be used to determine their occupancy. For those parking spots where real-time data is not available, a historical analysis will be performed using TomTom data concerning historical parking probabilities.

The case and required datasets for Off-street parking are described in *BC1-UC#2 Parking Services* in D1.1 Datasets Release for Model Region. The integration with TomTom datasets is expected to both improve municipality's understanding of the overall parking situation and TomTom commercial services that in turn could be offered to citizens.

### Requirements for Motorcycle Parking

The availability of parking spots for motorcycles will be calculated based on alternative data sources generated by the QROWD project:

- iLog user voluntary feedback will provide information concerning availability/occupancy of parking spots for motorcycles (*cfr. Annex 1 and deliverable D3.1*);
- ideally, *ad-hoc* monitoring cameras covering a limited number of parking spots for motorcycles will be installed. Initially, images resulting from these cameras will be scrutinized using crowdsourcing (paid microtasks on crowdsourcing platforms) to determine occupation of parking spots at specific hours, thus creating a first historical analysis; optionally, if feasible, machine learning techniques will then substitute this process and will determine availability of parking spots in real-time directly from the cameras.

### Requirements for Bike Parking

The availability of parking spots on a bike rack will be calculated using alternative data sources generated by the QROWD project:

- iLog user voluntary feedback will provide information concerning availability/occupancy of bike racks (*cfr. Annex 1*);
- ideally, *ad-hoc* monitoring cameras covering a limited number of bike racks will be installed. Initially, images resulting from these cameras will be scrutinized using crowdsourcing (paid microtasks on crowdsourcing platforms) to determine occupation of parking spots at specific hours, thus creating a first historical analysis; optionally, if feasible, machine learning techniques will then substitute this process and will determine availability of parking spots in real-time directly from the cameras.

### Goal and Scope

The Municipality has a limited understanding of the availability of on-street parking places for both four- and two-wheeled vehicles around the city. The very few existing
data sources do not cover the totality of parking spots as are limited to off-street, underground parking areas. The Municipality is therefore seeking an analysis of the availability of parking spots based on real time data (where available) extended by crowdsourced data (where applicable - cfr. BC2-UC#3 and Annex 1 and deliverable D3.1). For those parking spots where real-time data is not available, a probabilistic analysis will be run based on TomTom data concerning parking probabilities. The output of the analysis will be displayed both on the Municipality dashboard and on the Citizen dashboard (cfr. BC2-UC#4 and BC2-UC#6).

Main Success Scenario

- **Actors** – Municipality of Trento (MT); TomTom; UniTN; Citizens; InfAI; ATOS
- **Preconditions** – The datasets described below are available; new datasets are made available (MT); features of the application are designed and improved for the purposes of the use case (UniTN)
- **Basic Flow** –
  - Information concerning availability of on-street car parking spots comes from real-time data from parking meters
  - These information will be improved by integrating TomTom data concerning historical parking probabilities and data owned by the Municipality on parking
  - The Municipality properly promotes and encourages the download and use of the application through prize-based incentives and gamification activities
  - Information concerning availability of parking posts for motorcycles and bikes is crowdsourced via iLog:
    - availability/occupancy is reported through iLog as part of BC2 - UC#3 Completing information about mobility infrastructure through spatial crowdsourcing
  - Crowdsourced data from iLog are validated by paid workers performing validation microtasks on crowdsourcing platforms (SOTON)
  - Information concerning availability/occupancy of parking spots for motorcycles and bikes is retrieved from ad hoc cameras
  - Initially, data from ad hoc cameras are analysed by paid workers performing validation microtasks on crowdsourcing platforms (SOTON) to determine availability of parking spots; optionally, if feasible, machine learning techniques will be employed (InfAI) as a substitute for crowdsourcing and will provide real-time information based on data from cameras
  - The Municipality is interested in the data integration and analytics to determine availability of parking spots for all three parking areas
- **Exception Flows** –
  - The Municipality’s expectations concerning the number of people using
the app are not met despite the efforts towards encouraging its
download and usage

- Citizens don’t provide the necessary permissions to allow the
  application to collect the data
- The application’s GUI variant is not intuitive and users are required to
  perform many actions
- Instructions to report information concerning parking
  availability/occupancy are not properly defined and described
- Citizens delete the application

- Post Conditions –
  - Sufficient data has been successfully crowdsourced
  - Integration and analytics of all datasets is successful
  - Data are successfully displayed on both the Municipality and the
    Citizen dashboards

Datasets
Parking probabilities will be determined based on different data sources according to
each type of parking area.

On-street car parking
Available open and private datasets:

- **Parking payments** (1035), from parking meters
- **TomTom Parking probabilities** (2005), indicates the likelihood/chance for a
driver to find a free parking spot on a particular street. Computed from 2012
  until 2016. Each road segment comes with 24 time slots, for each day of the
  week (Mo-Sun). Probability can be established for each combination of day
  and time (e.g. Sat 13-14 o’clock or We, 02-03 o’clock)
- **Open data on parking**: list of parkings (1017), parking streets (1053), paid
  parking zones (1022), parking meters (1052), parking areas and slots (1054)

For an exhaustive description of available data sources reference is made to D4.1 -
Data catalogue.

Motorcycle parking
Data generated by the QROWD project:

- **app-based manual feedback** (3002), anonymous data voluntarily provided
  by users via iLog
- **data from ad-hoc cameras**
- **app-based sensor data** (3001), anonymous mobile sensor data collected via
  iLog
Bike parking
Data generated by the QROWD project:

- **app-based manual feedback** (3002), anonymous data voluntarily provided by users via iLog
- **data from ad-hoc cameras**
- **app-based sensor data** (3001), anonymous mobile sensor data collected via iLog

**Analysing the Information**
Integration and analysis of datasets are different for each parking area (car, motorcycle, bike) and depend on the availability of data.

- **On-street paid parking**
  - real-time availability - based on real-time data from parking payments (when available) owned by the Municipality
  - historical analysis - the bulk of the analysis will rely on the analysis performed under BC1-UC#2 Parking Services. For further details, reference is made to D1.1 Datasets Release for Model Region.

- **On-street unpaid parking**
  - real-time availability - based on real-time data from sensors (when available) only for parking for people with disabilities and freight load/unload
  - historical analysis - based on privately owned (TomTom) data on Parking Probabilities integrated with static data owned by the Municipality

- **Motorcycle parking and bike parking**
  - historical analysis - based on iLog user voluntary feedback, ad hoc cameras (when available) and crowdsourcing (validation microtasks)
  - (optional) real-time analysis - inferred from machine learning techniques to be applied to data from *ad hoc* cameras (when available)

**2.2.3. BC2-UC#3 - Completing information About Mobility Infrastructure Through Spatial Crowdsourcing**

**Description**
This use case will leverage on crowdsourced data 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. The Municipality wishes to gain knowledge about both the (i) existence and the (ii) availability/occupancy of these entities so as to pursue knowledge-based policies.

**Requirements**
Crowdsourced data will be gathered in two ways:

- **iLog** can be used by citizens of Trento to indicate (i) where and (ii) whether mobility infrastructure is available (*cfr. Annex 1*) - MT;
paid workers will perform identification microtasks on crowdsourcing platforms\(^2\) to provide information concerning (i) existence and (ii) availability of mobility infrastructure (cfr. deliverable D3.1) - SOTON.

Most likely, the truthfulness of data crowdsourced from the citizens of Trento will need to be validated. To do so, paid workers will perform validation microtasks on crowdsourcing platforms.

Current Availability of Information Concerning Mobility Infrastructure
The Municipality does not have a complete picture of existence, location and availability of infrastructure concerning mobility. Although it is in the process of mapping location of bike racks owned by the Municipality, contribution from citizens is much appreciated as some infrastructure is not directly controlled by the Municipality / has a different owner. This also applies to parking spots: although the Municipality has access to some datasets related to parking, it lacks information as far as existence and availability of on-street parking spots is concerned, with particular reference to parking spots for people with disabilities, for freight load and unload, and for motorcycles.

Goal and Scope
Completing information about mobility infrastructure through spatial crowdsourcing will contribute directly to extend the database of the Municipality as well as to complete UC#2 Parking availability (with reference to parking spots for motorcycles and bicycles). Ultimately, this use case will potentially serve as a tool of government policy since leveraging on crowdsourcing will promote a knowledge-based decision making process.

As far as visualization is concerned, crowdsourced data concerning mobility infrastructure can be integrated in both the Municipality dashboard and the Citizen dashboard (cfr. BC2-UC#4 and BC2-UC#6).

Main Success Scenario
- **Actors** – Municipality of Trento (MT); UniTN; Citizens of Trento; SOTON; paid workers on crowdsourcing platforms; InfAI; ATOS
- **Preconditions** – New features of iLog are designed and existing features improved for the purposes of the use case, allowing to gather additional data through crowdsourcing (UniTN). Gamification for spatial crowdsourcing and is properly defined (MT + SOTON). Crowdsourcing platforms are available (SOTON).
- **Basic Flow** –
  - The Municipality properly promotes and encourages the download and use of the application through prize-based incentives and gamification activities (MT)
  - Instructions to perform spatial crowdsourcing activities (map entities &

\(^2\) See Crowdflower for an example of crowdsourcing platform: [https://www.crowdflower.com](https://www.crowdflower.com)
report availability) are properly defined (MT + SOTON)

- Citizens use iLog to map POIs around the city and to provide information concerning availability of mobility infrastructure
- Crowdsourced data from iLog are validated by paid workers performing validation microtasks on crowdsourcing platforms
- Paid workers on crowdsourcing platforms perform identification microtasks to map POIs around the city and provide information concerning availability of mobility infrastructure
- Crowdsourced data from identification microtasks is compared with the data owned by the Municipality if available (AI4DB/InfAl)
- Data coming from citizens of Trento and paid workers on crowdsourcing platforms are integrated (InfAI)

- **Exception Flows** –
  - The Municipality’s expectations concerning the number of people using the app and providing data are not met despite the efforts towards encouraging its download and usage
  - Citizens don’t provide the necessary permissions to allow the application to collect the data
  - The application’s GUI variant is not intuitive and users are required to perform many actions
  - Instructions to map POIs and report information in real-time are not properly defined and described
  - Citizens delete the application

- **Post Conditions** –
  - Sufficient data are successfully crowdsourced both from citizens of Trento and from paid workers and integrated to extend the Municipality’s database and to complement UC#2 - Parking availability (with reference to parking spots for motorcycles and bicycles)
  - Crowdsourced data concerning mobility infrastructure can be visualized both on the Municipality dashboard and on the Citizen dashboard

Further details about how involve crowd workers to get data about existing infrastructure in the city can be found in subsection 4.3.2. *Crowdsourced information (BC2-UC#3)* main diagrams.

Deliverable D7.1 demonstrates an on-demand data quality assessment on integrated (RDF) datasets using crowdsourcing platforms applied to this use case.

**Datasets**
Crowdsourced data to be collected as part of the QROWD project are:

- **app-based manual feedback** (3002), anonymous data voluntarily provided by users via iLog *(cfr. User feedback section in Annex 1)*
D2.2 – Use case requirements specification

- **data from microtasks** performed on crowdsourcing platforms
- **app-based sensor data** (3001), anonymous mobile sensor data collected via iLog *(cfr. Sensor data section in Annex 1)*

**Analysing the Information**

Analytics will be performed by InfAI. The core of the analysis will focus on integrating data from the citizens of Trento with data coming from paid workers on crowdsourcing platforms. To do so, the following process must be considered:

- data coming from iLog will be mainly in the form of feedback *(cfr. User feedback section in Annex 1)*, enhanced by sensor data (mainly GPS) to determine the position of entities (users)
- data coming from iLog will be validated by paid workers on crowdsourcing platforms which will perform specific validation microtasks
- data coming from the tasks accomplished by paid workers will be compared with the data owned by the Municipality (if available) for a more reliable result.

**2.2.4. BC2-UC#4 - Municipality Dashboard Use Case**

**Description**

The Municipality dashboard will mainly display the outputs of the mandatory use cases for the Municipality. This valuable tool will provide the Municipality with a comprehensive overview of mobility in Trento.

**Requirements**

The dashboard will display the following aggregated data concerning:

- Modal Split
- Parking Availability
- Information about mobility infrastructure

Additionally, the following information based on data owned by the Municipality, open data and privately owned data can be visualized:

- traffic on urban and provincial roads
- bike sharing (position of bike racks; real-time availability of bikes / number of free spots)
- real-time underground parking availability
- weather conditions
- air quality
- TomTom city

If deemed valuable and if feasibility allows, more data generated by the project could be displayed on the dashboard. In particular, integration of origin destination analysis carried out by TomTom with other currently available and future datasets could provide useful insights on mobility in Trento based, for instance, on transportation used, geographic area and day of the week.
Goal and Scope
By visualizing all this information on the dashboard, the Municipality will be able to carry out a more effective evaluation of past and current mobility policies.

Main Success Scenario
- **Actors** – Municipality of Trento (MT); ATOS; TomTom; Citizens
- **Preconditions** – The datasets described below are available; new datasets will be made available; analytics have already been performed for the purposes of other use cases (InfAI)
- **Basic Flow** –
  - The municipality dashboard is properly designed; the dashboard GUI is as user friendly as possible (ATOS)
  - All information described in the Description and requirements section are integrated (pending their availability)
  - New data generated by the project could be displayed on the dashboard, if feasibility allows
- **Post Conditions** –
  - Municipality is provided with one comprehensive solution to access useful information concerning mobility

Datasets
Data resulting from the mandatory use cases for the Municipality concerning:
- Modal split (UC#1 - Modal Split)
- Parking availability (UC#2 - Parking availability)
- Information about mobility infrastructure (UC#3 Completing information about mobility infrastructure)

Available open and private datasets:
- **TomTom data**: TomTom city
- **Bike sharing data**: “E-motion” available bicycles (1014) “C’entro in bici” stations (1027)
- **Parking data**: real-time status of underground parking (1018)
- **Weather data**: meteo stations (1001) (1004) (1005), weather forecast (1002) (1003) (1042), heat index (1006), air quality (1036)

Data generated by the project and future datasets:
- origin-destination analysis (TomTom)
- Viaggia Trento & Rovereto Play&GO - paths
- real-time bus position
- data from sensors embedded in bike lanes
D2.2 – Use case requirements specification

- sensor-detected data from intelligent lampposts
- pedonal paths

Analysing the Information
The municipality dashboard will display all data that is deemed relevant for the Municipality. Analytics already performed for the purpose of other use cases (e.g. modal split under UC#1, availability of parking spots under UC#2 - Parking availability etc.) as well as possible new ad hoc analytics (to be performed when new data will be available) will be used.

2.2.5. BC2-UC#5 - Personal Modal Split Use Case

Description
iLog collects data from citizens, automatically or through feedback, to complement data for the computation of the modal split. At the same time, a personal modal split service can be offered to users providing them with a general report about how they move around the city of Trento. Although mandatory, this use case is subject to changes following suggestions from citizens (obtained through focus groups) which are not yet available at the time of writing this deliverable.

Requirements
Generally, to calculate the personal modal split, the same data collected for the modal split apply but with reference to a single user (cfr. Requirements section in BC2-UC#1 Modal Split).

Briefly, the personal modal split should focus on: (i) all trips (ii) of a specific person (iii) on a specific day.

Current Solutions
Transportation is the main type of service for citizens, given the prominence of mobility in current urban environments. Although there are many transportation apps, usually based on a specific mean such as public transport, few apps provide users with a report of their travels according to the different means of transportation used, the majority of them only recognizing individual movements i.e. walking, running or riding a bike.

Goal and Scope
This personalised service should allow users to visualize information concerning their daily trips and based on the means of transport used during the day. This will contribute to increase citizen awareness by providing a quantified-self-like view and, ultimately, to reduce the use of unwanted vehicles such as cars (of interest for the Municipality) in favor of public transportation. This service can be visualized both in the app and in the Citizen dashboard upon authentication (cfr. BC2-UC#6 Citizen dashboard use case).
Main Success Scenario

- **Actors** – Citizens; Municipality of Trento (MT); UniTN; SOTON
- **Preconditions** – The datasets described below are available; new features of the application are designed and existing features improved for the purposes of the use case; questionnaires to be submitted to users are properly defined (SOTON + UniTN)
- **Basic Flow** –
  - Citizens download the application and accept its terms & conditions so that sensor data can automatically be collected
  - Citizens promptly reply to pop-up questions mostly intended to validate data gathered automatically
- **Exception Flows** –
  - Citizens don’t provide the necessary permissions to allow the application to collect the data
  - Citizens don’t reply to questions
  - Citizens delete the application
- **Post Conditions** –
  - Citizens provide accurate replies
  - The personal modal split is successfully computed and citizens gain an accurate quantified-self-like view. Increased awareness concerning personal mobility discourages citizens from using private vehicles to move around the city

Datasets

Data to be collected as part of the QROWD project:

- **app-based sensor data** (3001), anonymous mobile sensor data collected via iLog
- **app-based manual feedback** (3002), anonymous user-declared data collected via iLog through questionnaires

**Analysing the Information**

Similarly to other use cases, this service will leverage mainly on data collected from the citizens’ personal devices. No further analysis is needed, since this service will visualize the personal modal split based on the results of the analytics on BC2-UC#1 data, in a non aggregated form but rather at the user level. The final output will visualized as a report of the user’s individual modes of transportation.

**2.2.6. BC2-UC#6 - Citizen Dashboard Use Case**
Description & Requirements
Citizens should be able to visualize useful aggregated data concerning mobility on a web-based citizen dashboard similar to but different from that of the Municipality. The citizen dashboard is intended as a one-stop-shop where citizens can access different useful information concerning mobility.

This information can stem from:

- existing and available open and private datasets
  - traffic on urban and provincial roads
  - bike sharing (position of bike racks; real-time availability of bikes / number of free spots)
  - real-time underground parking availability
  - weather conditions
  - air quality
- TomTom
  - TomTom city
- analytics already performed for the purposes of other use cases
  - availability of parking spots
  - information about mobility infrastructure
  - personal modal split - upon authentication (can be an isolated view to be shown in the scope of iLog and not from the dashboard)
- new *ad hoc* analytics performed once new data will be available (if feasible and pending their availability)
  - real-time position of buses
  - number of passages based on sensors placed on cycling paths
  - number of passages based on sensors placed on intelligent lampposts
  - pedonal paths
  - location of services (PA offices, schools, libraries, hospital, sport facilities, theaters, cinema...) and other related (dynamic) information (e.g. opening hours)

Goal and Scope
Currently, citizens can only access separate dashboards showing specific data, such as Viaggiare in Trentino\(^3\) which displays real-time data concerning traffic and traffic restrictions. No solution similar to a comprehensive citizen dashboard has ever been provided to citizens of Trento who would nevertheless much benefit from accessing useful information concerning mobility all in one place. The London city dashboard\(^4\) is a good example of how information could be displayed.

Main Success Scenario
- **Actors** – Municipality of Trento (MT); ATOS; TomTom; Citizens
- **Preconditions** – The datasets described below are available; new datasets will be made available; analytics have already been performed for the purposes of other use cases (InfAI)

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\(^3\) [http://www.viaggiareintrentino.it/it](http://www.viaggiareintrentino.it/it)
\(^4\) [http://citydashboard.org/london/](http://citydashboard.org/london/)
Basic Flow –
- The citizen dashboard is properly designed; the dashboard GUI is as user friendly as possible (ATOS)
- All information described in the Description and requirements section are integrated (pending their availability)
- New, ad hoc, analytics is performed as soon as new data are available (InfAI) if feasibility allows

Post Conditions –
- Citizens are provided with one comprehensive solution to access useful information concerning mobility

Datasets
The citizen dashboard will display information based on alternative datasets.

Data resulting from the mandatory use cases concerning:
- Parking availability (UC#2 – Parking availability)
- Information about mobility infrastructure (UC#3 Completing information about mobility infrastructure)
- Personal modal split (UC#5 – Personal modal split, to be shown independently of the dashboard upon authentication from iLog)

Available open and private datasets:
- Urban and provincial traffic data: urban traffic sensors (1009), provincial traffic sensors (1055), RSS traffic (1038), data from cameras for traffic monitoring (1011)
- TomTom data: TomTom city
- Bike sharing data: “E-motion” available bicycles (1014), “C’entro in bici” stations (1027)
- Parking data: real-time status of underground parking (1018)
- Weather data: meteo stations (1001) (1004) (1005), weather forecast (1002) (1003) (1042), heat index (1006), air quality (1036)
- Cultural events (1037)

Additional data about mobility that might be available in the future:
- real-time bus position
- data from sensors embedded in bike lanes
- sensor-detected data from intelligent lampposts
- pedonal paths

Analysing the Information
The citizen dashboard will display all data that is deemed relevant for providing useful information to citizens concerning mobility in Trento. Analytics already performed for the purpose of other use cases (e.g. availability of parking spots under UC#2 – Parking availability) as well as possible new ad hoc analytics (to be
2.2.7. BC2-UC#7 - Customized Traffic Service

**Description & Requirements**
An added value for the adoption of i-Log is that it could optionally provide dedicated citizen services. However, any further definition of these services relies on the output of the focus groups and trials before the city-wide involvement of users. One interesting option is to develop a personalized service of traffic information based on the inferred citizen travelling habits in terms of routes, in order to help them avoid wasting time in traffic. The service will result in a simple visualization/notification system from traffic data.

**Goal and Scope**
The goal of this service is to provide citizens with a service that helps them optimize their daily commute. It will account for the whole municipality and be especially relevant for commuters. Currently, apart from traffic information on the Italian radio, which however does not provide info at city level but only at major roads level, there is the Waze app\(^5\) that allow users to contribute with information about traffic. The difference in this use case is that Waze has to be turned on during the trip, which requires users to remember to turn it on/off and also actively send out info on road blocks, accidents and so on, whereas i-Log is always running on users' smartphones and collects much more comprehensive data.

**Datasets**
The datasets from which to compute the data required by this service are as follows:

- **Urban and provincial traffic data**: urban traffic sensors (1009), provincial traffic sensors (1055), RSS traffic (1038), data from cameras for traffic monitoring (1011)
- **TomTom data**: TomTom city
- **Local transport data**: real-time bus position (1034)
- **Weather data**: meteo stations (1001) (1004) (1005), weather forecast (1002) (1003) (1042), heat index (1006), air quality (1036)
- **Cultural events** (1037)
- **app-based manual feedback** (3002), anonymous user-declared data collected via iLog through questionnaires;
- **app-based sensor data** (3001), anonymous mobile sensor data collected via iLog.

**Analysing the Information**
This service will leverage on the route/trip analysis computed for the personal modal split in BC2-UC#5, which will provide typical or average trip of a citizen, and match it with real time traffic information computed by the other information sources to update

2.2.8. BC2-UC#8 - Services Provided by the QROWN Platform Use Case

Goal and Scope
A set of services will be made available on the QROWN platform. Ideally businesses and citizens should be able to query these services (e.g. microservices) and integrate them to develop new, valuable applications/services thus complementing and improving existing public services.

3. INTELLIGENT URBAN TRANSPORTATION AND MOBILITY REQUIREMENTS

In the following section the general requirements set for the intelligent urban transportation and mobility business case are reported. These are the “foundation requirements” that provide a general sense of what kind of solutions QROWN is potentially addressing, despite the necessary (rather focused) boundaries provided by the business cases.

Nomenclature:
- Business case: BC2 (corresponds to the business case),
- Type of requirement: C (context requirements), WP (corresponding work packages’ requirements), A (actors), FR (functional requirements), VR (visualization requirements), NF (non-functional requirements)

3.1 General Requirements

3.1.1. Context Requirements

In the following table the mandatory requirements arising from the general context under which BC2 is going to run are listed.

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-C1</td>
<td>Data feeding – streaming sources</td>
<td>QROWN must be able to integrate different sources of stream</td>
</tr>
<tr>
<td>BC2-C2</td>
<td>Data feeding – structured data sources</td>
<td>QROWN must be able to acquire information from pre-selected and structured data sources</td>
</tr>
<tr>
<td>BC2-C3</td>
<td>OASC compliant</td>
<td>QROWN might be coherent with the OASC vision to enable adoption of results to other cities</td>
</tr>
<tr>
<td>BC2-C4</td>
<td>Standard-based solution</td>
<td>QROWN must be based on standards as much as possible to ensure replicability</td>
</tr>
</tbody>
</table>
D2.2 – Use case requirements specification

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Responsible WP</th>
<th>UC</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BC2-C5 Service delivery – web</td>
<td>The functionalities should be delivered via an analytic dashboard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BC2-C6 Crowdsourcing feedback</td>
<td>Main functionality could be supported by feedback coming from citizens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BC2-C7 Data confidentiality</td>
<td>QROWD must be able to protect the confidentiality of Personal Data acquired by sensor or manual feedback</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.2. BC2 Requirements for QROWD Components

In the following table requirements affecting other work packages in order to accomplish BC2 use cases are listed.

Table 3: Big Data Value Chain components requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Responsible WP</th>
<th>UC</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BC2-WP1 App-based sensor data</td>
<td>Mobile sensor data collected via a mobile app will be provided through i-Log: i.e: occupancy is derived from iLog taking into account sensor data</td>
<td>WP2, WP7, WP8</td>
<td>BC2-UC#1</td>
<td>Mandatory</td>
</tr>
<tr>
<td></td>
<td>BC2-WP2 iLog improvements</td>
<td>iLog features would be improved to allow citizens to take pictures to prove the existence of bike racks, and reply to pop-up questions to indicate how many free spots there are</td>
<td>WP2 WP3</td>
<td>BC2-UC#3</td>
<td>Optional</td>
</tr>
<tr>
<td></td>
<td>BC2-WP3 App-based manual feedback</td>
<td>Through crowdsourced data infrastructure and availability mobility (bike racks and parking spot) will be reported: i.e: citizen will both report the existence of, for instance, a bike rack, but also its real-time availability such as</td>
<td>WP2 WP3</td>
<td>BC2-UC#2</td>
<td>Mandatory</td>
</tr>
<tr>
<td>Use Case</td>
<td>Number of Free Spots</td>
<td>Description</td>
<td>Dependencies</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>-------------</td>
<td>---------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>BC2-WP4</td>
<td>Datasets acquisition</td>
<td>The QROWD data acquisition components should be able to incorporate needed datasets to the system for analytics and visualization components.</td>
<td>WP4 WP8</td>
<td>all Mandatory</td>
<td></td>
</tr>
<tr>
<td>BC2-WP5</td>
<td>Streaming and static processing</td>
<td>The algorithms should be able to perform the analysis taking into account datasets with different nature: streaming and static</td>
<td>WP6</td>
<td>all Mandatory</td>
<td></td>
</tr>
<tr>
<td>BC2-WP6</td>
<td>Sensor/personal data and public data integration</td>
<td>Analytics will combine together data from the app and data from the already existing catalogues from the Municipality</td>
<td>WP6 WP8</td>
<td>all Mandatory</td>
<td></td>
</tr>
<tr>
<td>BC2-WP7</td>
<td>Mode of transportation deduction</td>
<td>The system will be able to compute the mode of transportation by means of analysing integrated data provided by QROWD components</td>
<td>WP2 WP3 WP6 WP7 WP8</td>
<td>BC2-UC#1 Mandatory</td>
<td></td>
</tr>
<tr>
<td>BC2-WP8</td>
<td>Probability of availability for on-street car parking spots</td>
<td>Probability of availability based on historical analysis for parking spots: - on-street paid and - on-street unpaid parking spots not controlled by a parking meter (through app-based sensor data, cameras, perhaps some crowd), with special focus on parking spot for people with disabilities, freight load and unload</td>
<td>WP1 WP6</td>
<td>BC2-UC#2 Mandatory</td>
<td></td>
</tr>
<tr>
<td>BC2-WP9</td>
<td>On-street car parking availability</td>
<td>Real-time data about specific parking spots and parking meters</td>
<td>WP2 WP6 WP7</td>
<td>BC2-UC#2 Optional (if available and feasible)</td>
<td></td>
</tr>
</tbody>
</table>
enhanced by real-time data could be stored and analyzed to improve the “probability of availability” and provided real-time parking availability

<table>
<thead>
<tr>
<th>BC2-WP10</th>
<th>Real-time analysis on images for motorcycle parking and bike parking</th>
<th>Machine learning techniques will be applied to perform a RT analysis on images in RT from cameras</th>
<th>WP6</th>
<th>BC2-UC#2</th>
<th>Optional (if available and feasible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-WP11</td>
<td>NGSI-comp liant</td>
<td>The streaming acquisition system (or part of it) should enable a component which implement the NGSI standard interface for the exchange of information</td>
<td>WP4 WP7 WP8</td>
<td>all</td>
<td>i.e: Context broker from FIWARE ecosystem</td>
</tr>
</tbody>
</table>

### 3.2 Specific Requirements

#### 3.2.1. Actors

In the following table, the actors\(^6\) of BC2 are listed, i.e: iLog user, internal user, demo administrator, system administrator. The section Notes describes the required data for each specific actor.

<table>
<thead>
<tr>
<th>ID</th>
<th>Actor name</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-A1</td>
<td>iLog user</td>
<td>A citizen reporting actively or allowing background data collection through iLog app</td>
<td>Crowdsourced data, app-data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-A2</td>
<td>Municipality dashboard user</td>
<td>Personnel from the municipality (e.g. mobility service, investee companies etc.)</td>
<td>Requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-A3</td>
<td>Citizen dashboard user</td>
<td>All citizens (no authentication required)</td>
<td>Requirements</td>
</tr>
</tbody>
</table>

\(^6\) An “actor” is one subject that intervenes in the use case (e.g., “end-user analyst”, “information provider”, “registered user”, “web surfer”, etc). In this general section of the document only the broad categories of actors should be listed, with the aim of giving the reader a general feeling of the spectrum of problems tackled by the UC2 solutions.
3.2.2. Functional Requirements

This section specifies the analysis of requirements of each mandatory use case. As pure visualization use cases that show data and results from other uses cases, no functional requirements have been provided for the Municipality dashboard use case (BC2-UC#4) and the Citizen dashboard use case (BC2-UC#6). The set of visual requirements provided for these two use cases can be seen in Section 3.2.3.

Table 5: Modal split (BC2-UC#1) functional requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-FR1</td>
<td>Alternative data sources</td>
<td>The computation should be based on alternative data sources that are either already available or are created by the QROWD project</td>
<td>NA</td>
</tr>
<tr>
<td>BC2-FR2</td>
<td>Frequency of computation</td>
<td>The frequency of computation should be at least twice every year (ideally even more frequently)</td>
<td>NA</td>
</tr>
</tbody>
</table>
| BC2-FR3 | Temporal reference for computation        | The temporal reference for the computation are:  
  - a typical day  
  - working or festive days  
  - a specific day of the week (Monday, …)  
  - a whole day (24h modal split)  
  - working day hours (7-19)  
  - peak hours (7 - 9; 17 - 19)  | NA    |
| BC2-FR4 | Target of computation                     | The modal split should be computed:  
  - for the whole sample  
  - only for residents  
  - only for commuters  
  - according to occupation status (worker, student, other)  
  - by different age ranges  
  - by gender  | NA    |
| BC2-FR5 | Geographical scope of computation         | The modal split should be computed:  
  - for the city of Trento as a whole  
  - with a specific focus on the neighborhoods located in the valley  | NA    |
| BC2-FR6 | Accuracy of computation                   | The computation of the modal split should be more accurate as it is based on sensor data and manual feedback                                                                                   | NA    |
### Table 6: Parking availability (BC2-UC#2) functional requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-FR7</td>
<td>Historical analysis of parking availability</td>
<td>The system should be able to compute parking availability/occupancy aggregations from 2012 to the most recent over TomTom historical traffic data. These fine-grained data allow for a preferred combination of days/hours</td>
<td>NA</td>
</tr>
<tr>
<td>BC2-FR8</td>
<td>Several data sources nature</td>
<td>The availability/occupancy will be based on real-time data (where available) and on historical analysis of parking probabilities (when no real-time data is available).</td>
<td>NA</td>
</tr>
<tr>
<td>BC2-FR9</td>
<td>Car parking</td>
<td>The use case will be able to provide information about the availability/occupancy of on-street parking spots for cars: on-street paid parking and on-street unpaid parking (with special focus on parking spot for people with disabilities, freight load and unload)</td>
<td>The information could be in the form of probabilities or real availability depending on the available datasets</td>
</tr>
<tr>
<td>BC2-FR10</td>
<td>Motorcycle parking</td>
<td>The use case will be able to provide information about availability/occupancy of parking spots for motorcycles</td>
<td>The information could be in the form of probabilities or real availability depending on the available datasets</td>
</tr>
<tr>
<td>BC2-FR11</td>
<td>Bike parking</td>
<td>The use case will be able to provide information about availability/occupancy of parking spots on a bike rack</td>
<td>The information could be in the form of probabilities or real availability depending on the available datasets</td>
</tr>
<tr>
<td>BC2-FR12</td>
<td>Availability attending different temporal categories</td>
<td>The system should be able to compute parking availability/occupancy aggregations attending different temporal categories (by day of week, by working day/holiday) for a period of time</td>
<td>I.e: The system should be able to compute parking occupation aggregation by working day/holiday and for</td>
</tr>
</tbody>
</table>
D2.2 – Use case requirements specification

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-FR13</td>
<td><strong>Availability evolution</strong></td>
<td>The system should be able to compute parking availability/occupancy aggregations (avg) that change over a period of time: annual (from last years), monthly (selecting a year), and weekly (selecting a year and a month) availability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>i.e.: See “monthly occupation for 2006” on Mockup monthly aggregation.</td>
</tr>
<tr>
<td>BC2-FR14</td>
<td><strong>Geographical scope of computation</strong></td>
<td>The system should be able to compute aggregations for the city of Trento (with a specific focus on the neighborhoods located in the valley).</td>
</tr>
<tr>
<td>BC2-FR15</td>
<td><strong>Spatial resolution</strong></td>
<td>The spatial granularity should refer to: - predefined paid parking zones - specific streets - areas (regions) in the city.</td>
</tr>
</tbody>
</table>

Table 7: Completing mobility infrastructure information (BC2-UC#3) functional requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-FR16</td>
<td>Mapping of infrastructure through crowdsourcing</td>
<td>The final aim is to gain deeper knowledge about existing infrastructure (type and position) based on crowdsourced data from citizens (app-based sensors and manual feedback).</td>
<td>NA</td>
</tr>
<tr>
<td>BC2-FR17</td>
<td>Reporting availability/occupancy of infrastructure</td>
<td>Crowdsourced data will extend to the analysis of availability/occupancy of mobility infrastructure</td>
<td>NA</td>
</tr>
</tbody>
</table>

Table 8: Personal Modal Split (BC2-UC#5) functional requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-FR18</td>
<td>Personal data</td>
<td>The computation should be based on data collected from the user’s personal device</td>
<td>NA</td>
</tr>
</tbody>
</table>
### 3.2.3. Visualization Requirements

This section specifies the visualization requirements for the mandatory use cases in the business case.

#### Table 9: Modal split (BC2-UC#1) visualization requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR1</td>
<td>Possibility of filtering for different criteria</td>
<td>Filtering by data available in QROWD, such as neighborhood, dates, demographical data, type of transportation</td>
<td>BC2-UC#1</td>
<td>i.e: See Mockup modal split</td>
</tr>
<tr>
<td>BC2-VR2</td>
<td>Graphics</td>
<td>The modal split should be visualised as simple graphs (i.e. tables, bar charts, pie charts, histograms and embedded into maps)</td>
<td>BC2-UC#1</td>
<td>Pending availability of historical data related to meteo</td>
</tr>
<tr>
<td>BC2-VR3</td>
<td>Evolution of modal split</td>
<td>The modal split should be comparable with previous computations (i.e: time series over a period of time)</td>
<td>BC2-UC#1</td>
<td></td>
</tr>
<tr>
<td>BC2-VR4</td>
<td>Correlations of the computation</td>
<td>The modal split should be visualised taking into account:</td>
<td>BC2-UC#1</td>
<td></td>
</tr>
</tbody>
</table>
striking days, public events
• data from previous modal split computations

### Table 10: Parking availability (BC2-UC#2) visualization requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR5</td>
<td>Temporal criteria selection</td>
<td>The graphical component should allow the user to select aggregations for several temporal criteria: per day of week, per working day/holiday, per time period.</td>
<td>BC2-UC#2</td>
<td>i.e: See Mockup BC2-UC#2 - Temporal criteria selection</td>
</tr>
<tr>
<td>BC2-VR6</td>
<td>Spatial selection</td>
<td>The graphical component should allow the user to select different predefined area</td>
<td>BC2-UC#2</td>
<td>i.e: Through tabs, combobox, selecting an area on a map…).</td>
</tr>
<tr>
<td>BC2-VR7</td>
<td>Temporal categories, timeline and spatial visualization</td>
<td>The graphical component should allow the user to visualize parking availability/occupancy aggregations, through different data visualization techniques, (i.e: bar chart, timeline/series, tables, maps)</td>
<td>BC2-UC#2</td>
<td>i.e: See Mockup aggregation per working day/holiday - area, or Mockup monthly aggregation</td>
</tr>
<tr>
<td>BC2-VR8</td>
<td>Combination of temporal and predefined zones visualization</td>
<td>The graphical component should allow users to visualize parking occupation aggregations integrating temporal and spatial information</td>
<td>BC2-UC#2</td>
<td>i.e: See Mockup aggregation per working day/holiday - area picture</td>
</tr>
</tbody>
</table>

### Table 11: Completing mobility infrastructure information (BC2-UC#3) visualization requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR9</td>
<td>Graphical visualization of available mobility infrastructure information</td>
<td>The graphical component should allow the user to visualize number and position of parking spots, bikes racks and other mobility infrastructure on a</td>
<td>BC2-UC#3</td>
<td></td>
</tr>
</tbody>
</table>
### Images of available (occupancy status) mobility infrastructure information

The availability/occupancy might be completed with images (liable to the availability of images in the project)

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR10</td>
<td>Images of available</td>
<td>The availability/occupancy might be completed with images (liable to the availability of images in the project)</td>
<td>BC2-UC#3</td>
<td>liable to the availability of images in the project</td>
</tr>
<tr>
<td></td>
<td>(occupancy status) mobility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>infrastructure information</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 12: 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>
</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>See requirements in “Modal split use case visualizations” section</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>See requirements in “Parking availability use case visualizations” section</td>
</tr>
<tr>
<td>BC2-VR13</td>
<td>Completing mobility infrastructure results</td>
<td>The municipality dashboard will show results about available mobility infrastructure</td>
<td>BC2-UC#3</td>
<td>See requirements in “Completing mobility infrastructure … use case visualizations” section</td>
</tr>
<tr>
<td>BC2-VR14</td>
<td>Additional mobility information</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: If deemed valuable and if feasibility allows</td>
</tr>
<tr>
<td></td>
<td>(from public and private datasets)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR15</td>
<td>Additional mobility information</td>
<td>Additional mobility data originating from the project can be displayed on the municipality dashboard</td>
<td>BC2-UC#4</td>
<td>Optional: If deemed valuable and if feasibility allows</td>
</tr>
<tr>
<td></td>
<td>(from)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 13: Personal Modal Split (BC2-UC#5) visualization requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>UC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR16</td>
<td>Personal modal split web</td>
<td>A dedicated web will visualize the personal modal split accessible via an iLog app link. iLog will inform about when the personal modal split is ready to be viewed (weekly/monthly)</td>
<td>BC2-UC#5</td>
<td>Authentication to the personal modal split is required (i.e: using the same credentials as in iLog)</td>
</tr>
<tr>
<td>BC2-VR17</td>
<td>Possibility of filtering for different criteria</td>
<td>The graphical component should allow the user to filter information about its mode of transportation by selecting some filters such as neighborhood, dates, type of transportation</td>
<td>BC2-UC#5</td>
<td>See BC2_UC4 - Personal transportation mockup</td>
</tr>
<tr>
<td>BC2-VR18</td>
<td>Visualization of personal modal split</td>
<td>The graphical component should allow the user to visualize statistic through different data visualization techniques (i.e: pie charts, trends over time, maps..)</td>
<td>BC2-UC#5</td>
<td>See BC2_UC4 - Personal transportation mockup</td>
</tr>
<tr>
<td>BC2-VR19</td>
<td>Followed paths visualization</td>
<td>The graphical component might allow the user to visualize paths followed in its trips</td>
<td>BC2-UC#5</td>
<td>Optional</td>
</tr>
</tbody>
</table>

Table 14: 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>
</tr>
</thead>
<tbody>
<tr>
<td>BC2-VR20</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>See requirements in “Parking availability use case visualizations” section</td>
</tr>
<tr>
<td>BC2-VR21</td>
<td>Completing mobility</td>
<td>The citizen dashboard will show results about</td>
<td>BC2-UC#3</td>
<td>See requirements in</td>
</tr>
<tr>
<td>Use case requirements</td>
<td>Specification</td>
<td>“Completing mobility infrastructure … use case visualizations” section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR22 Weather conditions</td>
<td>Information about weather conditions which can be provided based on open data</td>
<td>BC2-UC#6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR23 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 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR24 Real-time underground parking availability</td>
<td>Real-time underground parking availability</td>
<td>BC2-UC#6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR25 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 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR26 Traffic information based on privately owned data (TomTom)</td>
<td>TomTom City Trento</td>
<td>BC2-UC#6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR27 Air quality</td>
<td>Information concerning the quality of air</td>
<td>BC2-UC#6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR28 Cycling and cyclopedonal paths</td>
<td>Number of passages based on data (sensors) available in the future</td>
<td>BC2-UC#6 Optional: pending availability of future datasets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR29 Pedonal paths</td>
<td>Pedonal paths determined involving citizens, e.g. through mappathons</td>
<td>BC2-UC#6 Optional: pending availability of future datasets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-VR30 City facilities</td>
<td>Location of services (PA offices, schools, libraries, hospital, sport facilities,</td>
<td>BC2-UC#6 Optional: pending availability of</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2.4. Non-Functional Requirements

In the following table the non-functional requirements of BC2 are listed:

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Performance requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-NF1</td>
<td>Capacity</td>
<td>The system will provide scalable and efficient storage capabilities able to deal with the huge amount and variety of data captured from social networks</td>
<td></td>
</tr>
<tr>
<td>BC2-NF2</td>
<td>Response Time</td>
<td>The system will provide fast search capabilities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integration requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-NF3</td>
<td>Software API</td>
<td>The system will provide the results (for some use cases such as modal split-BC2-UC#1) as raw data in the form of API’s to allow easy integration with external components</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profitability requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-NF4</td>
<td>Modal split cost computation</td>
<td>The cost of computation should be lower than the cost of the paper-based survey</td>
<td>BC2-UC1</td>
</tr>
<tr>
<td></td>
<td>Usability requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC2-NF5</td>
<td>Usability</td>
<td>The system will provide a user friendly GUI</td>
<td>BC2-UC1</td>
</tr>
</tbody>
</table>

3.3 Requirements for visualization and services

3.3.1. REST APIs

Some of the results obtained from the analysis will be also offered as services to developers using REST APIs. At the point of finalising this document, the exact set of APIs is not entirely clear yet, as the Municipality of Trento is in the process of deciding which data and services is going to be opened to this end. The Ideas Competition deliverable D2.1 provides a timeframe for getting ideas from citizens and organizations from Trento about services and potential apps to be developed. Based on the results of this ideas competition, a final set of REST APIs will be
D2.2 – Use case requirements specification provided.

In the meantime, the current ideas about some of the resources that will be available programmatically is the following:

- Consumer, Service in charge of providing APIs to respond to http requests to allow developers the consumption of data analyzed by within the case studies presented in this document, such as modal split or parking probabilities.
- cityFacilities: This resource will be in charge of providing Trento city infrastructure by a set of integrated services, such as underground parking availability, position of bike racks, etc.

3.3.2. Visualization requirements and mockups
This section provides complementary visual representations to the use cases UC#4 Municipality Dashboard and UC#6 Citizen Dashboard described in section 2.2. However, these two use cases in reality provide visual support to almost all the reset of the use cases. Therefore, this section reports on potential visualizations in the dashboards for most of the use cases described in this document. The mockups are just intended as guidelines for the development of the dashboards. The final design and implementation of some of the widgets presented in the mockups may vary.

**Municipality and Citizen dashboards**
Sections 2.2 and 3.2 provide a description and a set of requirements for UC#4 and UC#6 (Municipality and Citizen Dashboards). The current idea is to provide a similar look and feel and interactions for both dashboards, reusing as much functionality as possible. The shift from one dashboard to another could be triggered by an authentication mechanism (i.e. municipality workers identification), or simply by deploying the two versions of the dashboard in different URLs or infrastructure.

The dashboard should therefore provide a modular architecture in order to allow its functionalities to be extended with minimal development and configuration effort. The idea is to build a user interface based on open source frameworks and free software such as Bootstrap templates [4], javascript visualization libraries (i.e JQuery [6] or leaflet for maps [7]) and HTML5 [8]. This visualization layer will communicate to the QROWD APIs and backend via a visualization service layer, where the visualization logic will reside. This way, the visualization will be decoupled from the backend, which provides a higher degree of flexibility and replicability of the solution.

A sample of the view of the homepage of the Municipality dashboard can be seen in the figure below.
Modal Split

The Modal Split UC#1 provides data about the use of different modes of transportation in Trento for a given period of time, as explained in section 2.2.1. The figure below shows in the right hand side a potential visualization of this data.

![Modal Split](image1)

**Figure 1: Dashboard homepage**

**Figure 2: Modal split mockup**

The same dashboard used by the Municipality of Trento for the modal split use case can be used for the parking usage analysis. In this case, an additional tab in the menu on the left can be added to show information about the parking situation in the city.

**Parking Availability Analytics**

The visualization of the UC#2 explained in section 2.2.2, could be done in different
ways. The visualization should be based on a search criteria entered by the end-user. The figure below shows an example of selection criteria to be implemented. Note that the selection may involve choosing between city zones (i.e. areas or neighborhoods in a map) and other filtering criteria.

**Figure 3: BC2_UC2 - Temporal criteria selection**

As a matter of example, the figure below shows a potential visualization of parking occupation by zone and time.

**Figure 4: BC2_UC2 - Aggregation per working day/holiday - area mockup**

The figure below shows another potential visualization, in this case the monthly aggregation by city area.
Figure 5: Mockup monthly aggregation by city area

The visualizations associated to this use case will be complemented with other maps and visualizations from TomTom to be developed in the scope of WP1.

City Mobility Infrastructure

The visualization of the city mobility infrastructure corresponding to the UC#3 explained in section 2.2.3, will normally be done in a map. The figure below shows an example of how underground parking or available bike racks could be shown.
3.4 BC2 KPIs

The tables below show the initial set of KPIs defined for the business case of the Municipality of Trento /BC2). Table 16 shows the main KPIs related to the municipality itself, while table 17 gives extra KPIs to potentially measure the satisfaction of Trento citizens with the main results to be shown to them (related mainly to the Citizen Dashboard).

### Table 16: KPIs for Municipality Services

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal split / frequency of measure</td>
<td>the frequency with which the modal split is measured</td>
<td>About once every ten years</td>
<td>Yearly (at least twice a year), possibly monthly</td>
</tr>
<tr>
<td>Modal split / cost</td>
<td>cost of computing the modal split</td>
<td>Approximately 40.000€</td>
<td>Equal to engagement costs</td>
</tr>
<tr>
<td><strong>D2.2 – Use case requirements specification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Modal split / results</strong></td>
<td>Statistical representativeness of the results</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Accuracy of results (sample type)</strong></td>
<td>Only resident citizens</td>
<td>Resident citizens and commuters</td>
<td></td>
</tr>
<tr>
<td><strong># of modal splits computed</strong></td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>*<em>Comparability with different (external) computations related to the modal split (<em>see UC#1)</em></em></td>
<td>0 (not comparable)</td>
<td>Comparable with 2 previous computations</td>
<td></td>
</tr>
<tr>
<td><strong>Coverage of car parking availability</strong></td>
<td>On-street paid car parking</td>
<td>No information</td>
<td>Historical probability of availability based on data from parking meters and data from BC1-UC#2 Parking Services in D1.1 Datasets Release for Model Region</td>
</tr>
<tr>
<td></td>
<td>On-street unpaid car parking</td>
<td>No information</td>
<td>Historical probability of availability for all types of on-street unpaid car parking based on data from BC1-UC#2 Parking Services in D1.1 Datasets Release for Model Region</td>
</tr>
<tr>
<td><strong>Coverage of motorcycle parking availability</strong></td>
<td>Historical probability of availability based on cameras + crowdsourcing</td>
<td>No information</td>
<td>2 parking areas</td>
</tr>
<tr>
<td><strong>Coverage of bicycle parking availability</strong></td>
<td>Historical probability of availability based on cameras + crowdsourcing</td>
<td>No information</td>
<td>2 bike racks</td>
</tr>
<tr>
<td><strong>Completing mobility infrastructure</strong></td>
<td>Reports concerning the existence of mobility infrastructure</td>
<td>0</td>
<td>200</td>
</tr>
</tbody>
</table>
through crowdsourcing (static)

<table>
<thead>
<tr>
<th>Description</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>New verified information concerning existence of mobility infrastructure based on reports</td>
<td>0</td>
<td>50</td>
</tr>
</tbody>
</table>

Completing mobility infrastructure through crowdsourcing (static)

<table>
<thead>
<tr>
<th>Description</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reports concerning availability/occupancy of mobility infrastructure</td>
<td>0</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 17: KPIs for Trento Citizens

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information provided to citizens through the citizen dashboard</td>
<td>Number of information included in the citizen dashboard</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Citizen satisfaction (0 to 5)</td>
<td>Citizen satisfaction with the dashboard</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>Personal modal split</td>
<td>The modal split computed for an individual citizen</td>
<td>Only available as aggregate</td>
<td>Each user has his or her own</td>
</tr>
</tbody>
</table>
4. INTELLIGENT URBAN TRANSPORTATION AND MOBILITY DESIGN

4.1 High-level Business Case Architecture

WP2 architecture is an instantiation of the QROWD architecture defined in WP8 in deliverable D8.1. The figure below shows the current version of the QROWD architecture including some aspects of the business cases and the storage modules on the right hand side.

Figure 7: Architecture diagram refined for the business cases

4.2. Main Architectural Building Blocks

Data availability

As explained in section 2, the different use cases defined for the business case have need of some data, either static or dynamic. Static data comprises several datasets identified to support the use cases, such as the layout of the city, existing parking lots or bike racks, etc. Dynamic data comes from existing data streams (i.e. free underground parking slots) and from crowdsourcing services. The Municipality of...
Trento has provided a list of available datasets and their potential use for each of the use cases.

Data acquisition

The business case will make use of the different tools and methods developed in the project for data acquisition. In particular the static datasets will be imported into a QROWD CKAN [8] instance to make them available and accessible for further usage using WP4 acquisition techniques. Also using WP4 tools, this static data will be transformed to RDF [9] where needed for further usage for other modules (such as interlinking, analysis or integration). The data gathered via data streams will be either added directly to the Context Broker (i.e. public transport streams), integrated via the Stream Integration component, or processed by the Hybrid Data Integration component and stored appropriately. Especial mention is to be done to the data coming from the iLog app (iLog Streams), which will be processed and analysed within the business case, stored in a separate repository and the analytic results will be made available either to the Context Broker or to the QROWD storage modules for further usage.

Data Storage

QROWD offers a set of storage modules that will collect data extracted and produced by the processing of the use case logic. This data will be made available to the business case by a set of APIs produced in WP7 for its consumption. The business case will be also using static data available in the QROWD CKAN repository as well as business case-specific data storage, such as the Cassandra database provided by the University of Trento.

Data analysis

WP2 will be using services from WP5 and WP6 for interlinking and analysis related to mobility.

Data usage and visualization

The business case main interface will be the Trento Dashboard and the iLog app developed in the scope of WP2. The dashboard will use data and services stored in the different storage modules provided in the project as well as contextual data available through the Context Broker. The dashboard will be the main showcase of the results of the business case.

4.3. Main Sequence Diagrams

This section provides an overview of the main sequence diagrams of some selected use cases presented in this document. The main focus of this section of to provide a first glance to the interaction between components for the main use cases. It is not
D2.2 – Use case requirements specification

the intention to cover the whole set of interactions between components for all the use cases, but rather to illustrate the selected use cases,

4.3.1. Modal Split (BC2-UC#1) sequence diagrams

The main Modal Split sequence diagram can be shown in the figure below:

![Modal Split Sequence Diagram](image)

**Figure 8: Modal Split Sequence Diagram**

This diagram shows the main interactions that allow the system to gather information from the citizens using the iLog app until its storage in the internal Cassandra database and the QROWDDB repository.

The steps are the following:

1. Engaged citizen generates sensor measures that are captured via I-Log, and written into the Cassandra component of our hybrid storage.
2. The AI component (Developed in WP6) gets sensor data and segments and classifies the measurements to automatically determine the number of trips and the transportation mode.
3. It is expected that in some cases the machine cannot determine with 100% certainty all the trips and transportation modes. For those cases, the component will request the opinion of the crowd to the Crowd component via the context broker.
4. The crowd component will generate the appropriate question for the citizen and push it to I-Log, that will ask it to the citizen.
D2.2 – Use case requirements specification

5. After the answer is collected, the AI component will update model and classification.

4.3.2. Crowdsourced information (BC2-UC#3) main diagrams

The sequence diagram below shows an example of how crowdsourcing could help to gather information about city infrastructure. In this particular case, the sequence diagram shows the steps to involve crowd workers to get data about existing bike racks in the city.

![Crowdsourced information sequence diagram](image)

**Figure 9: Crowdsourced information sequence diagram**
5. CONCLUSIONS

The deliverable reports on the requirements and design of the QROWD business case “Intelligent urban transportation and mobility” (WP2). The deliverable is public, but the main target readers of the document are developers of the QROWD project, as it provides an extensive list of requirements and an initial design for the business case. Therefore the document provides input not only to WP2, but also to the rest of the technical work packages of the project, as well as hints to the potential exploitation results of the project.

This document provides the requirements and design of the QROWD business case “Intelligent urban transportation and mobility”. The document specify different use cases or scenarios in which the business case is divided. For each of the use cases the document provides a detailed description of different scenarios, the required datasets and the potential visualization of the results of the scenarios.

A summary of the main use cases defined in the document is the following:

Use cases for the Municipality of Trento:
- A more efficient computation of modal split with a more frequent periodicity, with lower costs and covering different geographical zones (BC1-UC#1).
- Analysis of the availability of parking spot based on real-time data extended by crowdsourcing (BC1-UC#2).
- Extend the Municipality city infrastructure database (BC1-UC#3).
- Tool for government policies (BC1-UC#3).
- A dashboard to carry out a more effective evaluation of past and current policies (BC1-UC#4).

Use cases for citizens:
- Information about their daily trips (BC1-UC#5)
- A comprehensive dashboard to provide useful information concerning mobility (BC1-UC#6)
- Service to help them to optimize their daily commute (BC1-UC#7)
- Service to develop new and valuable applications by business and citizens (BC1-UC#8)

The document reports also on the visualization requirements and provides a preliminary set of screenshots for both the Municipality Dashboard and Citizen Dashboard. It also provides background information about the architecture of the business case and a set of preliminary sequence diagrams showing the interaction of the different QROWD components to be delivered by the technical work packages.

The document is therefore the input to be used to the development of WP2. It will be used to deliver the Municipality Dashboard (D2.3) and the apps (D2.4), as well as being a reference reading for the rest of the actions to be taken in the whole work package.
6. REFERENCES

7. ANNEX 1 - i-Log FUNCTIONALITIES

iLog is an application developed by the University of Trento (UniTN) and mainly designed to collect data from (i) a smartphone's internal sensors as well as through (ii) user feedback\textsuperscript{7}. iLog could also provide personalized services to users but feasibility of these features is yet to be assessed at the time of writing this deliverable.

iLog will be utilised as an alternative data source for the following UCs:

- UC#1 Modal Split
- UC#2 Parking availability - with reference to motorcycles and bicycles
- UC#3 Completing information about mobility infrastructure through crowdsourcing
- UC#5 Personal modal split

and will contribute to the following UCs:

- UC#4 Municipality dashboard
- UC#6 Citizen dashboard

Upon download, a user will see an official first page displaying information about the project (QROWD), the official partners involved in the development of the app (UniTN & MT) and the scope of its usage. The user will then be asked to grant permission to iLog as far as gathering of sensor data is concerned; for this purpose, along with the familiar allow/deny action types, messages explaining why certain data are essential will pop up intermittently.

Finally, the user will be redirected to an initial, compulsory questionnaire including questions referring to:

- resident / commuter
- occupation
- gender
- age
- domicile and residence
- number of people living in the same house
- driving license
- total number of vehicles available to all cohabitants
- means of transport used for daily trips order by distance travelled (km/h):
  - train
  - bus
  - cableway
  - private bicycle
    - traditional
    - electric
  - bike sharing bicycle
    - traditional
    - electric

\textsuperscript{7} \url{http://trans.disi.unitn.it/}
D2.2 – Use case requirements specification

- car
- motorcycle
- scooter
- foot
- availability of wifi connection

Users should be redirected to this questionnaire later in time in order to avoid causing distress. However, this is yet to be defined at the time of writing this deliverable.

**Sensor data**

As far as sensor data is concerned, certain aspects should be defined based on the final requirements for those use cases involving data collected through iLog:

1. Which sensors do we want to collect data from?
2. How frequently to collect sensor data without affecting users’ experience of the smartphone?
3. How frequently to download data from the users’ smartphones?

1) As an initial analysis, the most useful sensors on the citizens’ device for use cases #1, #2 and #3 are GPS sensor, accelerometer and gyroscope. The GPS provides information about the precise location of the user, with an accuracy of up to 3m - marked as sufficient for understanding on which road the user is and most likely also on which side of the road she/he is (left or right). In addition to the location in terms of coordinates, e.g., latitude, longitude, altitude, the GPS sensor also provides the speed of the smartphone (the user), a feature that can help in understanding what means of transport the user is actually using. As far as the accelerometer is concerned, it can help in empowering the insights produced by the GPS sensor and it can try to substitute it in case such information is not available. Finally, the gyroscope can help sense rotation. Multiple works by the research community leverage on these sensors to determine position and orientation. Additionally, it might be possible to leverage on hotspot connections around the city to track users (pseudonymised through smartphone id) and map paths. However, ethical concerns must be further examined.

The table below shows all sensors that will be used for the QROWD project (a list of all sensor data collected by iLog is available at: http://trams.disi.unitn.it/):

<table>
<thead>
<tr>
<th>Sensors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration</td>
<td>Position</td>
</tr>
<tr>
<td>Linear Acceleration</td>
<td>WIFI Network Connected to</td>
</tr>
<tr>
<td>Gyroscope</td>
<td>WIFI Networks Available</td>
</tr>
</tbody>
</table>

Table 18: List of sensors collected by iLog
2) Frequency of the data collected can be determined for each sensor. However, the rationale to define how frequently the data are collected could be summarized as follows: the faster the user is moving the more frequently data should be collected. As such, the analytics performed will be more accurate while limiting battery consumption.

3) How frequently to download data from the users’ smartphones? The default option is to download data every time a wifi connection is established so as to avoid excessive consumption of mobile data. However, further options should be examined in order to remove all restrictions to the collection of sensor data. For instance, automatic collection of data might be activated remotely in some situations. Alternatively, users could be asked to manually enable the downloading of data using their mobile data. All these options are yet to be examined at the time of writing this deliverable.

All the data are collected in compliance with the EU Privacy laws. From a technical point of view, all the collected data are linked with a random unique identifier that does not allow to link the data with the user who generated it. Users are properly notified when iLog is collecting data.

**User feedback**

User feedback can be of two types:

- questionnaires submitted to users
- input voluntarily provided by users

**Questionnaires submitted to users**

User feedback in the form of answers provided to questionnaires can be useful to validate sensor data in the case of UC#1 Modal split and UC#5 Personal modal split.

The default option to assess how users move around the city is to leverage mainly on sensor data (in combination with profile data), the accuracy of which could be enhanced by machine learning techniques. However, the analysis based on sensors might be unclear and user feedback in the form of questionnaires proves crucial to validate sensor data.

Questions should be formulated so as to avoid causing distress which would, in the long run, limit usage of the application and therefore bias our objectives. For these reasons, some aspects need to be defined:

1. How frequently to collect manual feedback without bothering users?
2. What kind of information should be collected through questions?
3. What kind of questions to ask?

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8 Further information available at: [http://trams.disi.unitn.it/](http://trams.disi.unitn.it/)
1) Ideally, user feedback should be collected when sensor data don’t allow for a close enough estimation of the user’s position. For instance, questions can be submitted to users to check what means of transport they just used when we detect (by analyzing the sensor data) that a travel has just ended (or started).

2) Questionnaires should be submitted to users to collect the following information (reference is made to the Requirements section under BC2-UC#1 - Modal Split):
   - purpose of a trip (this piece of information should eventually be learned by iLog, at least with reference to work and school/university)
   - means of transport (this piece of information can be inferred; question to be asked only when it is unclear)
   - driver of passenger
   - number of ride-on people

3) A clear definition of the types of questions to submit to users is essential. Each question should be as concise and precise as possible and can be followed by a subquestion if needed. Emphasis should be put on the interaction with the user from a semantic standpoint; as such, an initial greeting (e.g. ciao) and a final message (e.g. thank you) should be included. Each question should allow for a short answer (yes/no) or for a multiple choice. Further requirements concerning questions to submit to users might be defined taking into account the outcome of focus groups and iLog trials.

Input voluntarily provided by users
User feedback in the form of input voluntarily provided by users is necessary for the accomplishment of UC#3 Completing information about mobility infrastructure through spatial crowdsourcing and, partially, of UC#2 Parking availability (with reference to parking spots for motorcycles and bicycles). This feature of the application allows users to perform some specific activities as specified below.

1. Report the existence and position of an infrastructure. Users should be able to choose among different entities and take pictures of the entity chosen. The following table lists all entities a user can choose among:

<table>
<thead>
<tr>
<th>Entities</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike racks</td>
<td>Type / number of spots</td>
</tr>
<tr>
<td>Parking spots for motorcycles</td>
<td>Number of spots</td>
</tr>
<tr>
<td>Parking spots for people with disabilities</td>
<td>--</td>
</tr>
<tr>
<td>Parking spots for freight load / unload</td>
<td>--</td>
</tr>
</tbody>
</table>

2. Report the status of an entity in terms of availability/occupancy. Users should be able to choose among different entities and take pictures of the entity
chosen, indicate their availability and, if needed, provide further details (i.e. indicate the number). The following table provides an example of the features needed to accomplish this task:

### Table 20: Report availability/occupancy of entities

<table>
<thead>
<tr>
<th>Entities</th>
<th>RT info to provide</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike racks</td>
<td>Free spots</td>
<td>Indicate the number</td>
</tr>
<tr>
<td>Parking spots for motorcycles</td>
<td>Free spots</td>
<td>Indicate the number</td>
</tr>
<tr>
<td>Parking spots for people with disabilities</td>
<td>Free / occupied</td>
<td>--</td>
</tr>
<tr>
<td>Parking spots for freight load / unload</td>
<td>Free / occupied</td>
<td>--</td>
</tr>
</tbody>
</table>

User feedback in the form of input is part of a gamification activity under UC#3 and, indirectly, UC#2. Users are encouraged to take part in these activities through prize-based incentives which means that they can receive prizes depending on the points earned. On these grounds, iLog should first include instructions on how to perform the abovementioned activities but also display messages indicating the points earned after each task is accomplished.