

SYNCHRONICITY

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Executive Summary

The primary objective of work package 3 is to specify, design, implement and deploy innovative IoT-based applications and services that leverage the SynchroniCity digital single market for IoT-enabled Smart Cities. Work package 3 consists of 4 tasks (T3.1 to T3.4) that are executed in three parallel application-oriented work streams. This document reports on the outcomes of Task 3.1, specifying the initial applications to be deployed on the SynchroniCity framework developed in WP2. These initial applications aim at demonstrating the benefits of the SynchroniCity framework to foster and attract others (e.g. SME's, cities) to join the ecosystem via the open call mechanism.

To optimally demonstrate both impact and scalability three different application themes are targeted: human-centric traffic management, multi-modal transportation and community policy suite. Each of these application themes addresses urgent urban challenges with a high societal and economic impact and confirmed priority and interest from the SynchroniCity reference zones. In extensive dialogues, the reference zones and other consortium partners have been closely working together to identify a specific target use case, or initial application, for each application theme. These initial applications aim to improve the quality of life of citizens leveraging the strengths of the SynchroniCity framework.

The initial applications are specified in a common format that starts with the description of the target use case, based on understanding the users and stakeholders provided by the cities in the reference zones. Secondly the value network of the target use case is represented, indicating all stakeholders involved including their relations. Thirdly, for each of the applications a basic mapping of the technical composition on the SynchroniCity reference architecture is provided. Finally, service specifications and an overview of the value proposition around the target use case is presented.

The reference zones associated with the theme of human centric traffic management (Milan, Antwerp and Eindhoven) have jointly defined the initial application of 'data-driven bicycle mobility'. This application leverages data from different sources in the city to provide an optimized bicycle experience (flows, waiting times, safety) and to increase efficiency around decision making for infrastructure and creation of policies/regulations. For instance, data on bicycle counting, shared bike usage, tracking of bicycles and accidents are brought together to enhance bicycle mobility.

Within the theme of multi-modal transportation, the reference zones (Porto, Helsinki, Santander, Milan and Carouge) have worked together to define the 'multi-modal assistant' initial application. This theme focuses on using different transport modes in a seamless and optimized way. Different modes of transportation have their own benefits and may fit different goals and desires of citizens. By finding the integration and combination of the different types of transportation a modern multimodal urban mobility can be shaped, helping our cities turn into sustainable smart cities.

In the third application theme around community policy-making, the reference zones of Porto and Manchester worked together to specify the target use case 'agile governance'. IoT provides cities with real-time data that is often used for day-to-day operational functions, but is not currently being utilized for service management or strategy development. The initial application around agile governance aims to improve and enhance efficiency around the adoption and implementation of new policies and regulations by utilizing IoT data in different ways. The application aims to extract information and intelligence layers from IoT systems and utilize this to enable authorities to operate in a more agile way.

This document provides similar specification for all three target applications and provides the basis for the subsequent tasks in work package 3 of Synchronicity.

Abbreviations

API	Application Programming Interface
ATM	Automated Teller Machine
D	Deliverable
EC	European Commission
GDPR	General Data Protection Regulation
POI	Point of Interest
WP	Work Package
WT	Work Task

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1 Introduction

This deliverable presents the results of Task 3.1 which aims to specify the applications underlying the initial pilots, i.e. the initial applications. These initial applications aim at demonstrating the benefits of the SynchroniCity framework and in addition also at fostering interest and attracting others (e.g. via the open call mechanism). It comprises service design for the baseline IoT services to be deployed on the SynchroniCity middleware developed and deployed in WP2. It provides conceptual specifications of the technological compositions, anticipated value networks and customer interactions for the target baseline services addressing the user needs.

The service design and implementation process focuses on 3 impactful application themes prioritized by the reference zones: human-centric traffic management (formerly context-adaptive traffic management), multi-modal transportation and community policy suite. To enhance user acceptance, stimulate endorsement by local communities, and optimize both economic and societal impact, services are designed in collaboration with cities and other further ecosystem stakeholders.

Building on the methods and tools created in T1.4, this task has been executed with direct involvement of local reference zone ecosystem partners and stakeholders to optimize impact and ensure user acceptance. For each application theme, the service design process has delivered a target use case and accompanying service specifications.

To truly demonstrate the creation of the digital single market enabling scalable commercial service deployment across a fragmented, heterogeneous IoT landscape, the design of the initial applications is rooted in the OASC minimal interoperability mechanisms defined by common API's, common data models and a reference architecture as defined in Deliverable 2.1 and further elaborated in T1.2 and T2.2. Leveraging the minimal interoperability mechanisms, initial IoT service design explicitly targets easy customization, replication and hand-over to other cities and local service providers.

1.1 Thematic approach

To optimally demonstrate both impact and scalability of the adopted approach, SynchroniCity is targeting the development of IoT-based solutions in a total of three different application themes: **human-centric traffic management**, **multi-modal transportation** and **community policy suite**. Each of these application themes addresses relevant urban challenges with a high societal and economic impact. Focusing on city needs that are common to multiple reference zones, IoT services developed within the selected themes can be expected to solicit broad demand that will drive replication across reference zones and stimulate ecosystem enrichment with both private-sector partners and city administrations. Finally, the selected application themes are expected to greatly benefit from the SynchroniCity-enabled urban information marketplace. Bringing together and exposing diverse and fragmented information streams to innovative IoT service providers and city stakeholders is expected to yield particularly impactful results in the chosen domains.

Adopting the procedures described in Section 1.3, the consortium partners have identified and specified one initial application for each prioritized need space. These initial applications focus on the improvement of quality of life in the reference zones while leveraging the strengths of the SynchroniCity framework.

1.2 Reference zones

SynchroniCity has established reference zones in 8 highly innovative cities across Europe that have been at the forefront of IoT innovation. Figure 1 provides an overview of which reference zones have indicated their interest in which application theme and contributed to the definition of the target use

case.

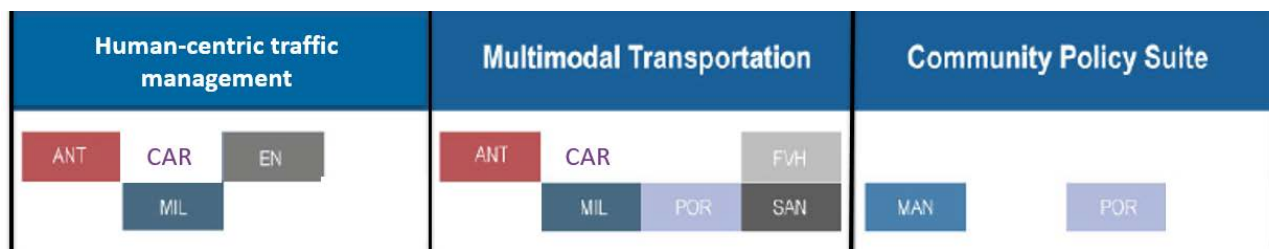


Figure 1: Thematic interest and contribution per reference zone

1.3 Service design methodology/procedure

With the application themes as a starting point the reference zones have closely collaborated through the 3 steps process as visualized in Figure 2.

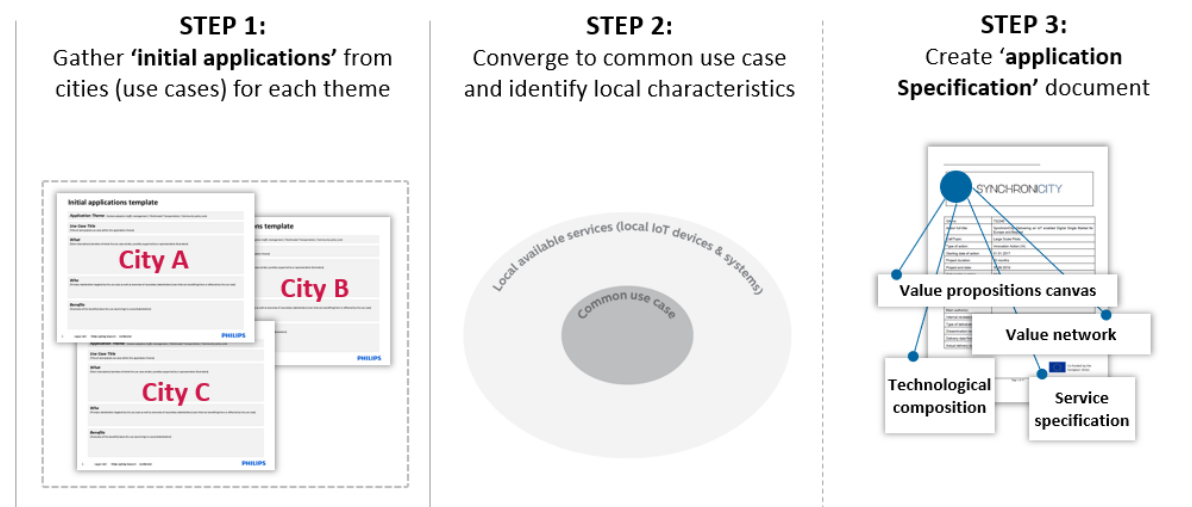


Figure 2: Application specification process

Firstly, in step 1 initial applications have been gathered from the reference zones around the 3 application themes. Through extensive discussions and dialogues, in which city representatives brought in specific city needs, these initial applications have been converged to 3 common use cases, one for each application theme. Following well-established service design procedures these common use cases are further specified in three parallel work streams. To optimize efficiency while maintaining consistency, identical service design procedures and methodologies have been adopted in three parallel work streams each targeting a single application theme.

The application specification (step 3) consists of 4 different elements:

1. Description of target use case
2. Value network and customer interactions
3. Technological composition of system
4. Service specification of target use case

1.3.1 Description of target use case

The first step in defining the initial applications was to identify the commonality amongst the reference zones associated with a particular application theme. To this end, reference zones provided their inputs and basic initial concepts through the initial application template, as indicated in Figure 3.

Initial applications template SYNCHRONICITY

Application Theme: Context-adaptive traffic management / Multimodal Transportation / Community policy suite

Use Case Title
(Title of anticipated use case within the application theme)

What
(Short description/narrative of what the use case entails, possibly supported by a representative illustration)

Who
(Primary stakeholder targeted by the use case as well as overview of secondary stakeholders/users that are benefiting from or affected by the use case)

Benefits
(Overview of the benefits/value the use case brings to users/stakeholders)

Figure 3: Initial applications template

These initial applications templates inputs were processed and refined by means of discussions and interactive sessions with the reference zones in the application themes. Based on these inputs common use cases were identified (paragraphs 2.1, 3.1 and 4.1).

To further specify the initial application, the Value Proposition Canvas¹, was adopted/employed. This methodology performs customer analysis to identify needs and eventually will lead to the definition of the target initial application that best matches the reference zones needs and ambitions.

The Value Proposition Canvas tool has two sides:

- The Customer Profile, which is composed of the following elements:
 - o Customer Jobs – describe what customers are trying to get done in their lives.
 - o Pains –bad outcomes, risks and obstacles customers are facing in their current activities.
 - o Gains –outcomes customers want to achieve or concrete benefits they are seeking.
- The Value Map, that lists the features of a specific value proposition for a product or service and consists of:
 - o Pain Relievers – how the product and services alleviate obstacles, issues or bad outcomes which customers are facing
 - o Gain Creators – how the product and/or services creates benefits or achievements that customers want to experience
 - o Products & Services – this is a list of all the products and services a value proposition is composed of.

¹ <https://strategyzer.com/canvas/value-proposition-canvas>

The value proposition canvases per application themes can be found in 2.1.1, 3.1.1 and 4.1.1, respectively

1.3.2 Value network and customer interactions

The value network provides a general overview of the roles and relations that different stakeholders have with each other. Firstly, it provides a description of the roles of the different stakeholders around each theme, and secondly it provides a visual representation of the 'network' in which also the type of relation is indicated. Relationship types can either be based on: money, information, goods/services or they can be intangible. A full network provides value in different ways, for example it helps to determine which relations need to be built or strengthened, it identifies users which stakeholder's needs need to be considered more seriously or it can identify potentially overlooked revenue streams. The value networks for the 3 different themes can be found in sections 2.2, 3.2 and 4.2.

1.3.3 Technological composition of system

This element provides a technical description of the system that will support the initial application. Firstly, it provides a visual representation of the (high-level) system architecture showing the different elements of the system required to address a target use case including a mapping of the architecture on the SynchroniCity platform.

Secondly it provides an overview of the functional (Log in and access control, Dashboard framework, Detailed UI requirements, User admin/advanced requirements) and non-functional requirements (Security / Safety, Accessibility, Availability, Deployment, Extensibility/Upgradability, Fault tolerance, Interoperability, Maintainability, Performance, Scalability, Usability).

These contents are provided, for the different themes, in 2.3, 3.3 and 4.3.

1.3.4 Service specification of target use case

To provide a more detailed insight of the target use case, this element contributes with a visual representation of the service use case. This visual representation, the service blueprint, provides a detailed visualization of the entire user journey and all individual components of the service. A service blueprint is a tool that helps to create a clear overview of service delivery over time. It describes, verifies and implements user interactions. A service blueprint helps to understand what needs to be delivered to provide a service/experience, which is done through visualizing different aspects and actors related to the service delivery. The blueprint consists of the following elements:

- Physical evidence: the environment in which a service is delivered
- User action: what does the user do during the service delivery time. Actions of the user influence the frontstage and the backstage
- Frontstage: user touchpoint, where a user "meets" the delivering party. The user receives something which can be experienced
- Backstage: to deliver a service or experience, the delivering party needs to create the frontstage user touchpoints. This sometimes happens backstage, out of the user's sight
- 3rd party processes: processes of 3rd parties which enables the service delivery (left out for simplicity)

The part that follows the service blueprint provides the overall summary of the value proposition around the target application. These contents are provided in sections 2.4, 3.4 and 4.4.

2 Application theme: human-centric traffic management

This chapter provides the description and specification of the application theme 'data-driven bicycle mobility'. Initially it provides a description and background information and describes the use case based on the initial applications template (paragraph 2.1).

Since urbanization is an increasing trend, cities will face all kinds of challenges. With more and more people living in cities, many new challenges will emerge such as challenges around liveability, sustainability, mobility and quality of life in general. To ensure liveability in bigger cities, a strong need to sustain and improve mobility is expressed by citizens, in addition it also has to be made sure that the correct decisions are taken towards the future.

Historically city roads have been optimized for throughput of motorised traffic. City traffic includes and affects active traffic users (motorized and non-motorized) and those who have to deal with the consequences of traffic. Cyclists, motorists, pedestrians and residents all have different needs regarding traffic. Other important aspects that are often largely ignored include, the quality of life for people living near these roads or the needs of non-motorized traffic participants.

Cities indicate that within the complex mobility landscape, bicycle mobility is an important topic. They want to make sure all different city users can experience their city as efficient as possible by bike, now and towards the future.

Cities do not currently have sufficient insights on the actual bicycle usage (as indicated by the reference zones). They need more information and accurate insights to make sure the correct infrastructure is created, and the best policy is formulated for the future. Cities also indicate that bicycle mobility comprises many different elements and objectives around bicycle mobility (and mobility in general) will be different on a city-by-city basis.

The initial application data-driven bicycle mobility aims to improve bicycle mobility in cities, in a balanced way. Meaning that the needs of other traffic users will be considered too. By leveraging and combining data from different IoT systems data-driven bicycle mobility aims to improve the overall cycling experience, safety, infrastructure planning and policy making for the future.

2.1 Description target use case (initial application)

Today's traffic management not always sufficiently considers aspects other than those related to motorized vehicles. To ensure liveability, mobility and quality-of-life in general, cities indicate that there is a strong need to sustain and improve bicycle mobility. Cities indicate that bicycle mobility comprises many different elements and goals will be different on a city-by-city basis.

By leveraging and combining data from different IoT systems, the initial application data-driven bicycle mobility aims to stimulate bike mobility by improving overall cycling experience, traffic safety, infrastructure planning and policy making. By gathering, combining and analysing data from relevant and existing IoT systems new information and insights can be generated that, in turn, can be utilised for improving bicycle mobility. Besides different needs/challenges around bicycle mobility, cities also indicate that available IoT systems and datasets will differ a lot in each city causing huge differences in the 'solution space'.

Antwerp, Milan and Eindhoven indicate that different systems are available which generate data relevant to the related use case. For example, a bike sharing system (which is available in Antwerp and Milan) generates data on usage frequency, availability and tracking of usage patterns, a camera system could bring in data on bicycle counting and usage frequency, in addition also non real-time data/information (e.g. information on accidents/incidents in relation to cyclists) could also be brought in. The initial application data-driven bicycle mobility combines these data sets to provide benefits in terms of bicycle mobility. E.g. using the data for more efficient actuation of traffic lights, or providing optimal safety/visibility. Moreover, cities also indicate the relevance of these data to improve decision making around infrastructure planning and policy making. By combining and integrating different

data sets the cities of Antwerp, Milan and Eindhoven hope to achieve the following:

- Improve bicycle flows: reducing travel times and waiting times
- Improve bicycle safety: reducing the number of conflict situations on crossroads, for instance by having green light for cars & for cyclists at the same moment
- Optimize bike (sharing) infrastructure
- Improve infrastructure planning and policy making towards the future

2.1.1 Value proposition canvas

Customer jobs

This paragraph provides an overview of the actions the stakeholders (e.g. cyclist, municipality, mobility agency) are currently involved in or what tasks they are trying to perform:

- Understand bicycle usage patterns, i.e. how is the city used from a bicycle point-of-view
- Improve different aspects of bicycle mobility:
 - o Improved bicycle safety
 - o Decreased bicycle traveling times
 - o Decreased waiting times for cyclists (e.g. traffic lights)
- Increase efficiency of decision taking around planning of bicycle infrastructure
- Improve and increase efficiency of decision making around policy-making and regulations
- Understand usage details of current bike sharing programs to make improvements

Pains

Based on the inputs from the cities in the reference zone the following pains (negative emotions, undesired costs/situations and risks) have been identified:

- Sub-optimal bicycle flow: bicycle movements throughout city can be more efficient, often waiting times are long
- Lacking bicycle information and trends: cities are lacking information on how the city is used from a bicycle point of view, e.g. in terms of usage patterns, spots of infrequent usage
- Unsafe situations for cyclists: sometimes cyclists are facing situations in which multiple parties (cyclists, cars, pedestrians) have a green light, which is a potential conflict situation, often roads are optimized for motorized traffic
- City planning does not have sufficient information, or does not sufficiently leverage existing information, to optimally plan for bicycle infrastructure and/or policy making

Gains

The following paragraph provides an overview of the benefits that cities expect or desire around the theme:

- On the highest-level cities indicate that improving quality of life for their residents and visitors is of key importance, mobility of people is indicated to be a key factor affecting quality of life and therefore needs to be improved
- Sustainability goals and air quality requirement are causing a lot of focus on stimulating bicycle adoption/usage. Cities indicate their ambitions to achieve/realize substantial improvements in this area

- Cities indicate that data will help to make better and more conscious decisions to influence traffic flows. For example, through the adaptive actuation of traffic lights
- Cities indicate that they would like to create better and more efficient policies and regulations based on data
- Cities indicate that they would like to improve the planning of infrastructure (streets, road, biking infra, etc.) based on data
- Cities indicate that they would want their traffic management systems and policies to be more inclusive and less focused on throughput of motorized traffic. They would want to also incorporate the needs of non-motorized traffic users (cyclists)

Pain Relievers

The initial application, or target use case, around data-driven bicycle mobility aims to achieve several things to alleviate customer pains. As the target use case addresses multiple stakeholders different pain relievers are identified for each, of which the most prominent ones are:

- Municipality: by leveraging data from many different and fragmented sources, insights and information on bicycle characteristics will be generated, allowing municipalities to make the right decisions with regards to their (biking) infrastructure. In addition, it will help in understanding how/which policies and regulations need to be created or adapted and how effective such measures are.
- Cyclists: by leveraging data from many different sources, insights and information can be generated that will allow for adapting traffic lights and public street lighting, while reducing waiting time, as well as increasing safety for cyclists

Gain creators

The target use case 'data-driven bicycle mobility' creates expected and desired benefits by leveraging data coming from data 'silos' in the city. Data that currently remain siloed, will be combined in order to generate comprehensive information and insights that help improve bicycle mobility in the cities in the reference zones.

Available data sources and infrastructure will vary per city; therefore, the exact way in which benefits are created will also be different for each city. Examples for the cities associated with this application theme include:

- Antwerp:
 - o Combining tracking data of shared bikes, and potentially normal cyclists as well, with counting data to improve bicycle experience (less waiting times, increased flows) and safety (less conflict situation with green lights for both cyclist and motorized vehicles) by either updated traffic management algorithms or real-time actuation of traffic lights and public street lighting
- Eindhoven:
 - o Acquiring counting data (through cameras, inductions loops) on bicycle usage and combining this with tracking data from route apps to improve bicycle mobility and flows at those moments that this is possible (by balancing flow optimization of motorized traffic with that for non-motorized traffic)
- Milan:
 - o Combining tracking data of bike sharing with other mobility related data (accidents data, traffic counters) the cities will be able to get better insights and information on their infrastructure efficiency and potential issues/problems with it. They will be able

to leverage the data and make good decisions to further improve their infrastructure. In addition, by understanding the data they will be able to create the correct policies and regulations towards the future

Product & Services

As mentioned before the available infrastructure and accompanying data streams will be different on a per-city basis, in addition the detailed needs and urgent issues will also be different per city. Based on the 'gain creators' described in 0 the cities in the reference will build their initial applications around the following 2 types of products & services:

- **Improvement of bicycle experience:** improved software, traffic algorithms, etc. that improve the overall bicycle experience. This software and algorithms, invisible to cyclists, will be a part of the traffic management systems or traffic lights (Antwerp, Eindhoven). To cater for the actuation of public street lighting, adaptiveness and responsiveness will need to build in.
- **Improvement of infrastructure planning and policy making:** this 'track' will lead to insights and information that will allow the municipality to make the correct decisions around infrastructure and policy/regulations. A software solution (reporting tool, dashboard) is a likely embodiment in this track.

Combining and consolidating the different elements in the previous paragraphs the following value proposition canvas will emerge, provided in image below.

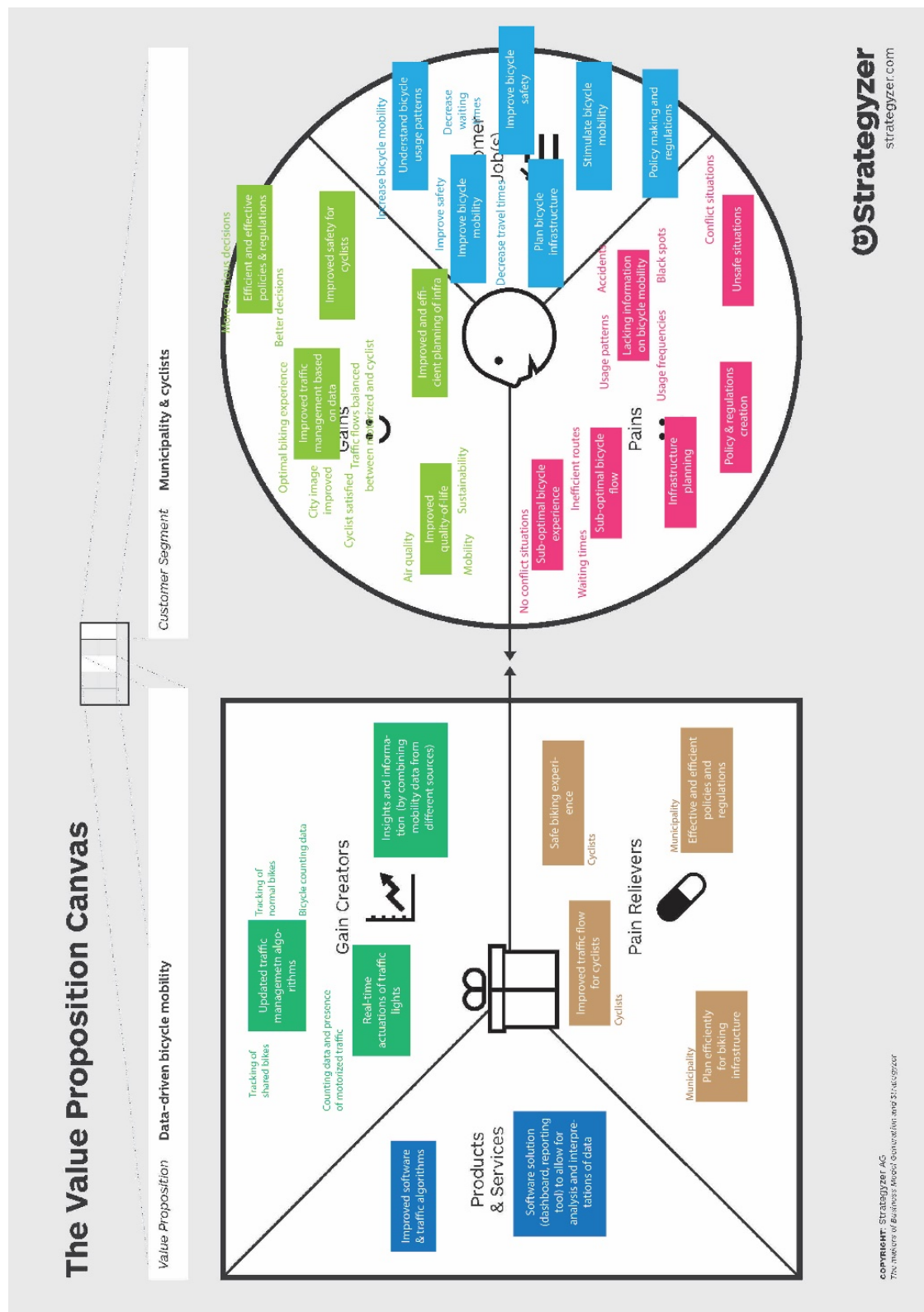


Figure 4: Value proposition canvas of data-driven bicycle use case

2.2 Value network and customer interactions

This chapter provides an overview of the different stakeholders (and their roles) involved around ‘data-driven bicycle mobility’ and a visual representation of the relationships the stakeholders have.

2.2.1 Descriptions of stakeholder profiles and their roles

The stakeholders and their roles around the initial target application in the reference zones Antwerp, Eindhoven and Milan are different, as indicated in Figure 5. The list provides an overview of the parties and their roles in the reference zone cities.

Municipality: the municipality is responsible for several roles that are of relevant for this application theme:

- Responsible for meeting air quality and sustainability goals, e.g. through stimulating bicycle and public transport usage and discouraging car usage
- Responsible for increasing quality of live in dense urban areas, e.g. by providing good biking infrastructures and allowing for efficient traveling by bike
- Responsible for creating policy and regulations around mobility
- Responsible for infrastructure planning, e.g. infrastructure to stimulate bicycle usage
- Responsible for configuring and the settings of traffic management systems

All in all, the city has the responsibility and ambitions to stimulate current bicycle usage and to make sure the right decisions in terms of infrastructure and policy/regulations are taken towards the future. On a per-city basis different partners might be involved around the topic, e.g. Milan has a mobility agency as a separate entity from the municipality, whereas in both Eindhoven and Milan this is part of the municipality.

Traffic management solution/system provider: this party provides traffic management solutions which aim to optimize different aspects of traffic, for example traffic management systems with algorithms that determine settings of traffic lights. The involvement and role of this party heavily depends on the type of traffic management systems that are present in the municipality. Eindhoven for example has an intelligent traffic management, provided and managed by an external party², that also allows for control over traffic lights based on external data sets (through traffic management scenarios).

Bike (sharing) operator: this party is responsible for maintaining the bike sharing infrastructure. They ensure that sufficient bikes are available on different locations, whilst also ensuring maintenance of the biking equipment. Furthermore, they manage the data coming from the infrastructure such as usage patterns, location of dockings, availability and tracking.

Mobility agency: the mobility agency can be part of the municipality but also might be a separate entity (as is the case in Milan). Typically, responsible or concerned with planning and implementing projects in both mobility and environmental domains. Urban traffic planning, regulation and control of local public transport, environmental planning in matters of air, energy, electromagnetic and noise pollution, and urban land use planning are among its tasks.

Data provider: some cities have partnered, or will partner, with external data providers, for example, to acquire floating data of traffic information. Other parties, e.g. a public transport provider, could

² External party managing traffic lights in Eindhoven: Technolution

also serve as data providers around the target use case.

Installer/integrator: the party responsible for installation and integration of traffic management systems (e.g. Heijmans in the Eindhoven eco-system). These parties are often very well connected with the municipality and aware of the local needs/issues of the city.

Cyclists (and pedestrians): the cyclists are the stakeholders who are experiencing the way traffic is managed, the state of the infrastructure and the efficiency and effectiveness of policies and regulations.

Motorists: the drivers in their cars and trucks who are experiencing the flow of traffic in the city.

Police: secondary stakeholder that might be relevant as a source of data. They might for example have access to camera systems with valuable information, in addition they might have information regarding accidents and dangerous locations which might be helpful in policy making and infrastructure planning.

2.2.2 Visual representation of stakeholder network

The visual representation of the value network can be found in the image below. It contains the relations that the different stakeholders have and shows how value is being exchanged in the network. The colour of the lines indicates which type of value is being exchanged between stakeholders. Four different types of value are distinguished: monetary, information, goods & services and intangible. The direction indicates who is giving and who is receiving the value.

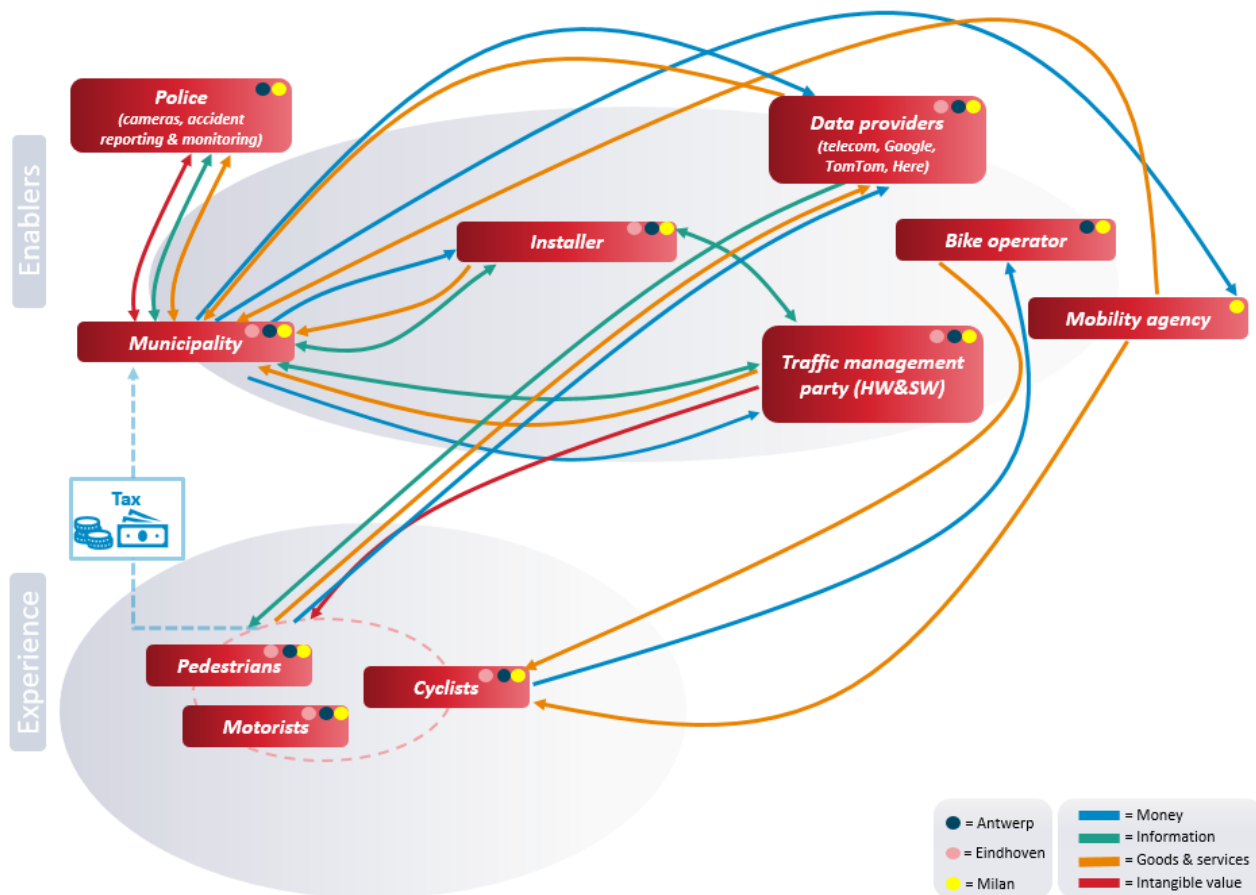


Figure 5: Value network for data-driven bicycle mobility use case

This value network shows the relations between (some of) the most important stakeholder around 'data-driven bicycle mobility', the coloured dots indicate which stakeholder is relevant for which respective city. Note that additional stakeholders might be present on a per-city basis and that this value network is not exhaustive. One important element that can be derived from the value network is that the cyclist, who typically would be the end-user, mostly have indirect relations. In addition, money flows are also indirect (mostly via taxes).

2.3 Technological composition of system

This chapter provides a (1) visualization of the high-level system architecture including a mapping of the architecture on the Synchronicity platform (application, IoT devices, data sources) and (2) a description of functional and non-functional requirements.

2.3.1 Visual representation of the (high-level) system architecture

A visual representation of the target use case (initial application) can be found in Figure 6. It starts with an overview of the potential data inputs available in the reference zones around this theme. These data sets will be exposed via the SynchroniCity framework where they will be consumed to enable 2 types of applications/services as indicated in the lower part of the figure.

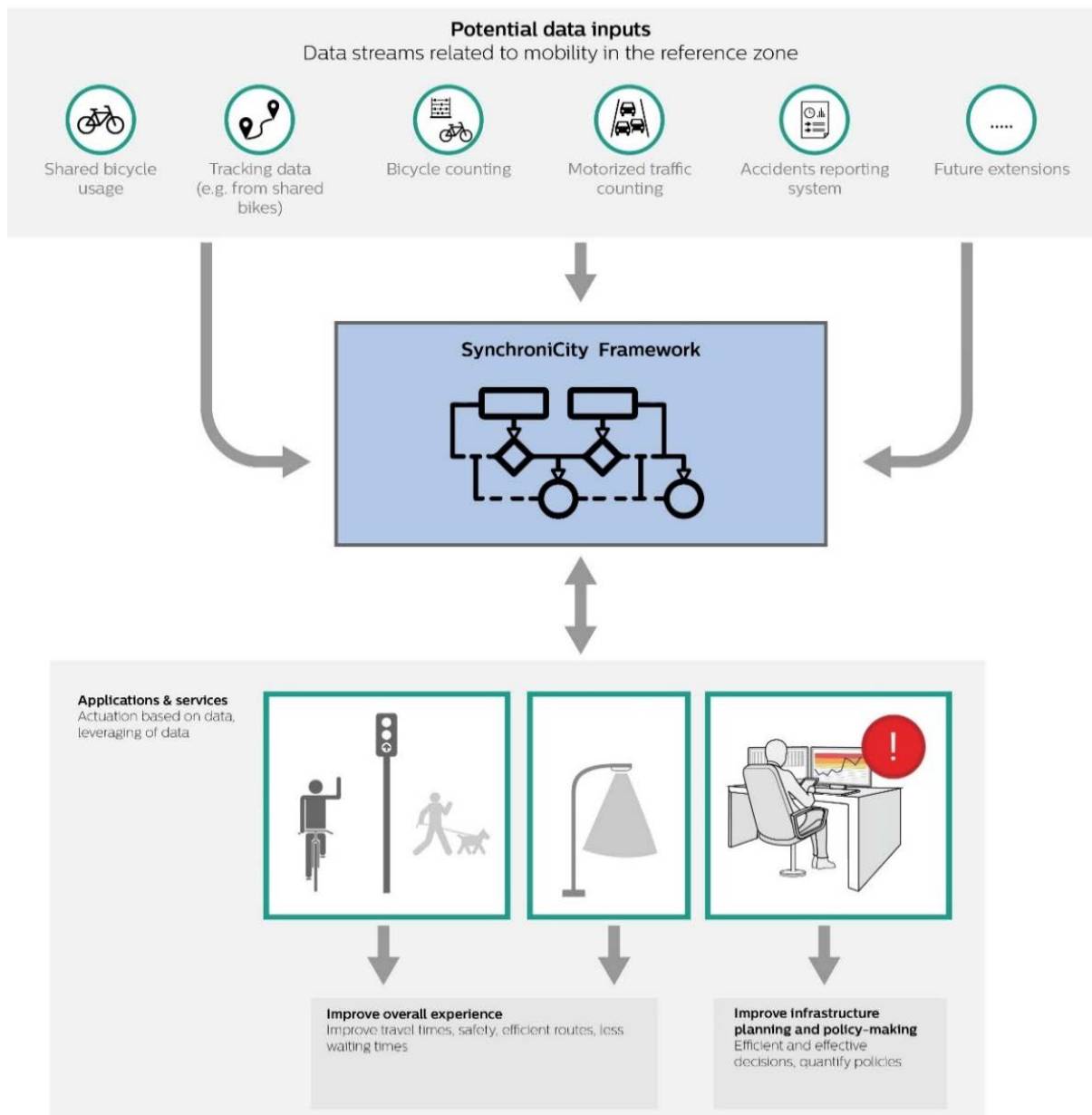


Figure 6: Visual representation of the data-driven bicycle mobility use case

Subsequently the (high-level) system architecture is mapped onto the Synchronicity platform defined in WP2. The aim of Figure 7 is not to define all technical details, it merely provides the application/service and an overview of 'legacy data sources/ IoT devices' (green) required for the use case.

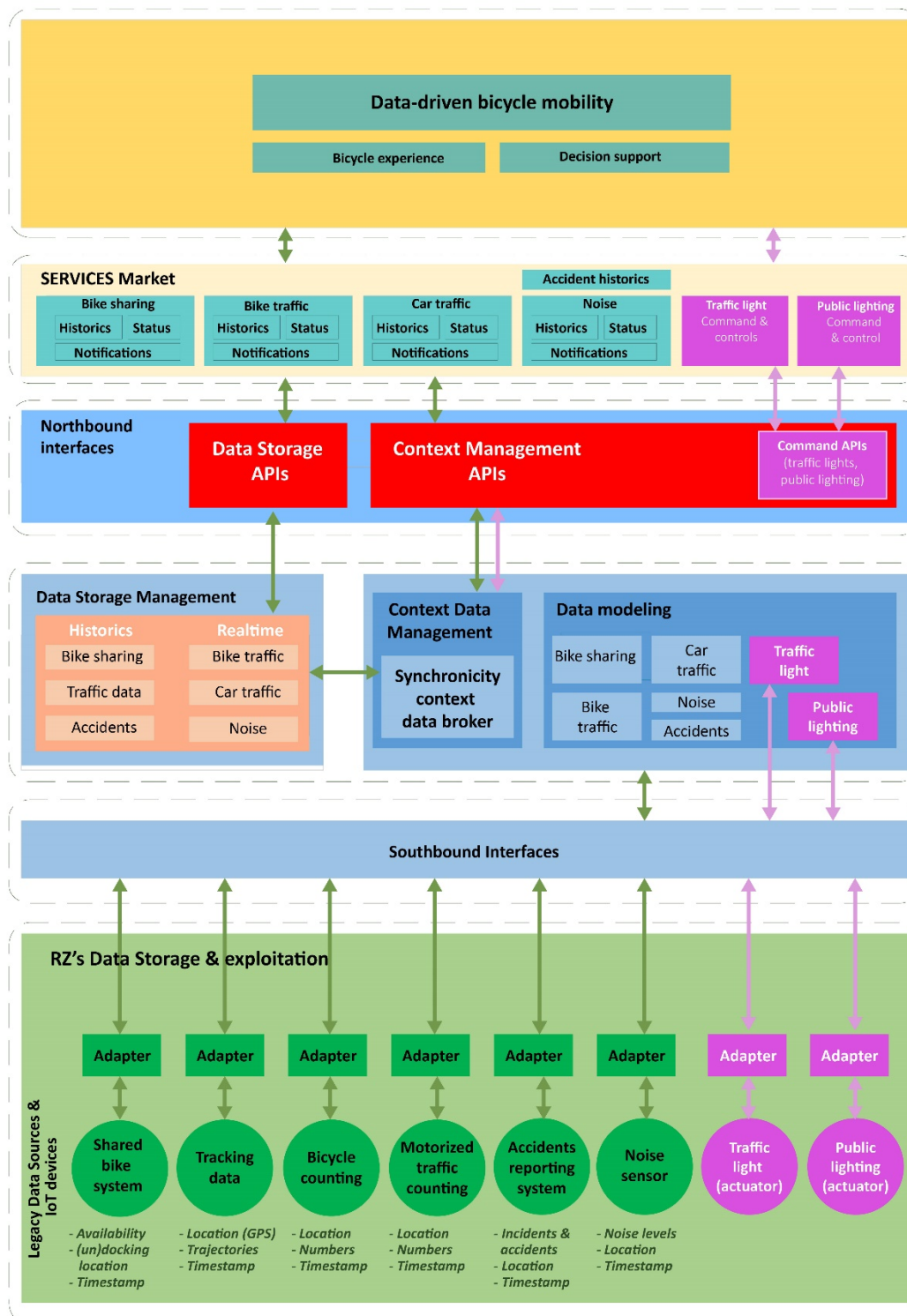


Figure 7: Initial application mapped onto Synchronicity Architecture

2.3.2 Key functional and non-functional requirements for the system architecture

Data-driven bicycle mobility shall leverage data from different (IoT) systems available in the cities to (1) improve overall bicycle experience and (2) provide support to make better and data-driven decisions regarding infrastructure planning and policy making. The described functional and non-functional requirements (2.3.2.1 and 2.3.2.2) are based on inputs from the different reference zones. These inputs were gathered through dialogue sessions with relevant people in the reference zone cities.

2.3.2.1 Functional Requirements

Table 1: Functional requirements of data-driven bicycle mobility

ID	Sub-category	Description
FR-1	(1)	System must process data from multiple sources/sensors in real-time
FR-2	(1)	System should recognize preconfigured traffic situations and classify these situations in real-time
FR-3	(1)	System should select optimal traffic light decision and actuation based on classified traffic situations in real-time
FR-4	(1)	System should select optimal public street lighting decision and actuation based on classified traffic situations in real-time
FR-5	(1)	The system must provide user identification and access control at least by a username/password basic security
FR-6	(2)	The system must provide flexibility in terms of viewing, or having access to, certain data sets (e.g. through dashboard widgets)
FR-7	(2)	The system may provide a map as the main way of interaction to superimpose data sets
FR-8	(2)	The system should provide different views on the superimposed data sets
FR-9	(2)	The system should provide user admin features to control their teams via admin panels
FR-10	(2)	The system should allow selection of specified time window and display corresponding aggregated data over the selected time window
FR-11	(2)	The system may provide advice/prediction based on aggregated historical data
FR-12	(2)	The system may allow for annotation specified time windows

2.3.2.2 Non-Functional Requirements

Table 2: Non-functional requirements of data-driven bicycle mobility

ID	Sub-category	Description	Related to
NFR-1	(1) + (2)	System should consume the minimum amount of resources as reasonably possible	Efficiency
NFR-2	(1) + (2)	System should offer flexibility to be deployed either as an 'on-premise' service, or as a cloud-based service	Deployment
NFR-3	(1)	System must process data in real-time (i.e. within a few seconds)	Performance
NFR-4	(1) + (2)	System must adhere to privacy laws	Privacy
NFR-5	(1) + (2)	System should have high up-time	Reliability
NFR-6	(1) + (2)	System should demonstrate a high level of security and include latest data encryption methods	Security
NFR-7	(1)	System should provide intuitive and responsive experience to user	Usability
NFR-8	(2)	System should be available on the most recent browsers and screen resolutions	Accessibility
NFR-9	(1) + (2)	System should be backed up, data-loss should be prevented	Accessibility
NFR-10	(1) + (2)	System software & code base should comply with the most recent standards at time of development	Compliance
NFR-11	(2)	System should have fast response time that is not inconvenient to users	Performance
NFR-12	(2)	System should be easy, enjoyable and intuitive to use	Usability
NFR-13	(1) + (2)	System must use standard data models.	General
NFR-14	(1) + (2)	The application must be compliant with the EU GDPR (General Data Protection Regulation and national regulations)	Privacy

2.4 Service specification for target use case

2.4.1 Service blueprint

The target use case, or initial application, around bicycle mobility consist of two important tracks (1) Improvement of bicycle experience and (2) Improvement of infrastructure planning and policy making. For these two tracks separate service blueprints are created, presented in sections 2.4.1.1 and 2.4.1.2.

2.4.1.1 Service blueprint: improvement of bicycle experience

Context and starting point:

Martha, female, aged 39, banker in the city, commutes from home to work on a daily basis. On a normal day Martha uses her bicycle to commute from her home to work in the morning and afternoon. Along the route she interacts with other traffic participants; other cyclists, motorists and pedestrians. Martha, and all other cyclists, move through the city on bicycle lanes and normal roads, passing traffic lights and different objects. While commuting, Martha receives “cyclist privileges” without actively doing something other than turning her pedals.

Service blueprint description:

Physical evidence: different individuals, incl. Martha, make use of the city’s infrastructure (roads, traffic lights etc.). Interaction takes place between all traffic elements. During Martha’s 20 minutes bike ride she interacts with this dynamic environment in a non-obtrusive way. Here presence, as does the presence of other cyclists, is detected and will lead to changes in the infrastructure.

User action: several types of interactions take place on the way from home to the office. Martha will experience interactions around her in an active and passive way. E.g. active user action in this case would be that Martha is at home, finds her bicycle a few meters outside from her house (where she always leaves it), and she walks to her bike, unlocks it and hops on. During the bike ride she interacts with different types of traffic users (e.g. pedestrians, motorists and other cyclists), gives and gets right of way, stops when traffic lights turn red. Martha also passively (indirectly) interacts with her environment which influences her smooth traffic experience. Martha experiences a “green flow” and in addition also the street lighting level is adapted to make sure her visibility is optimal. When Martha is on her way, her presence, while considering her privacy, is detected by different counting mechanisms (e.g. cameras, inductive loops). Martha arrives at the bike parking site. She knows her way and parks her bike and continues her journey on foot to the office.

Frontstage: there are several user touchpoints in Martha’s journey. As already described in the *User action*, Martha “receives” a smooth traffic experience as traffic lights turn green in favour of her and her fellow cyclists. In addition, also street lighting levels are adapted to make sure her safety is optimal, the functional lighting increases her visibility for the motorists.

Backstage: as Martha moves from A to B, sensors integrated within the infrastructure (e.g. cameras, inductive loops) pull in data. This data is enriched with data from other sources e.g. traffic management systems, telecom parties and navigation service providers. The data collection and integrating is a continuous process. Data is sent to the back-end and analysed. Algorithms are in place to prioritize which type of traffic users has the right of way. In the backstage, a snapshot of the data processing is displayed as it is a continuous process.

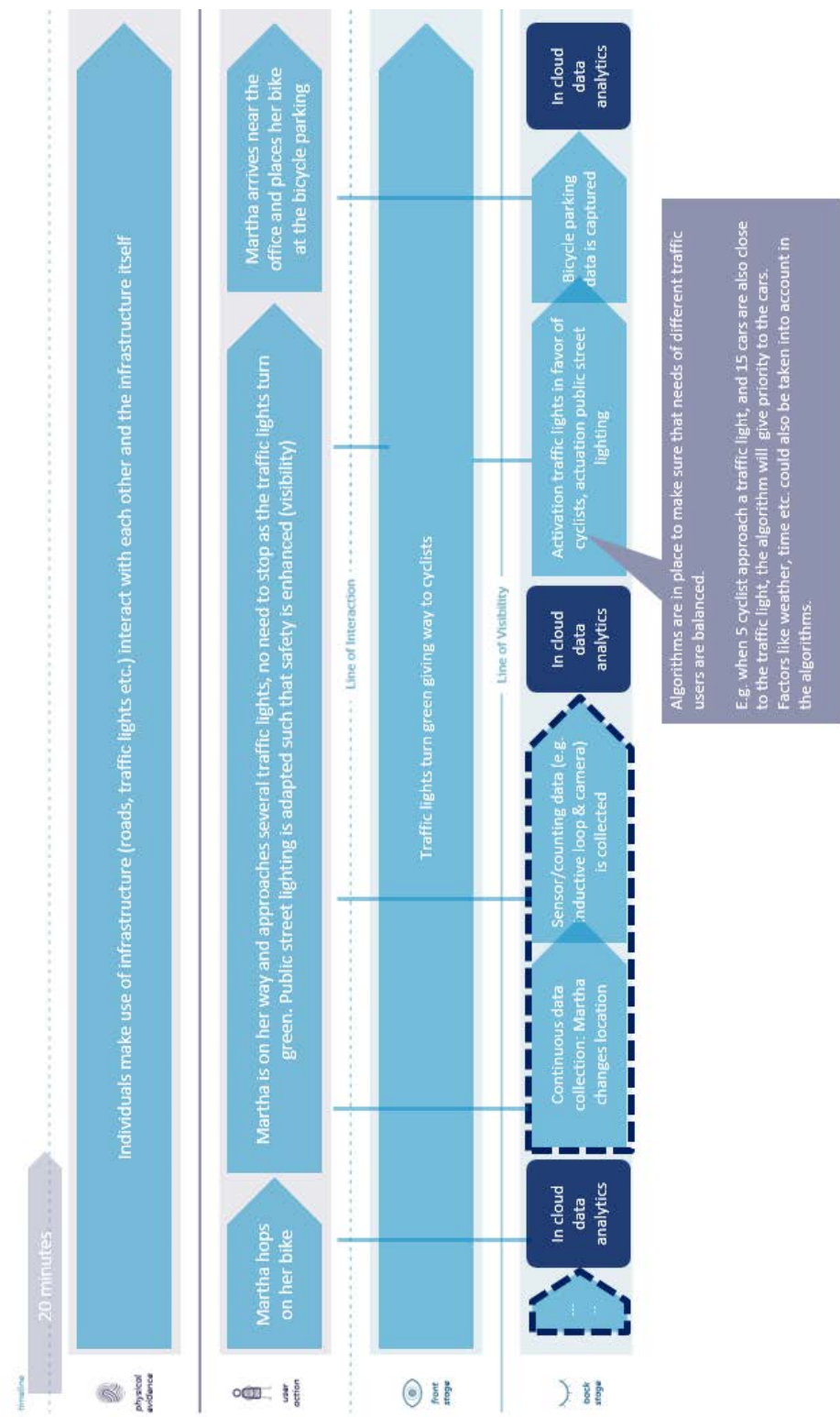


Figure 8: Service blueprint: improvement of bicycle experience

2.4.1.2 Service blueprint: improvement of infrastructure planning and policy making

Context and starting point:

Marco, male, aged 44, works as an Urban Planner at a municipality. Marco's main goal is to create a future-proof urban environment that balances the needs of different traffic stakeholders in a more 'human-centric' way. To get a better understanding of city's bicycle traffic he will consult the City Traffic Database. The information in this database helps him to make well founded decisions regarding planning of future infrastructure.

Service blueprint description:

Physical evidence: at the office where Marco works, a city database application is consulted in case someone would like to analyse e.g. cyclist traffic behaviour.

User action: Marco logs in and needs to select e.g. a city location, type of data set/or combination and a time frame to get a better understanding of the traffic behaviour. He selects different data sets to see how traffic is flowing. He interacts with the data and performs data analyses. To capture the visualized data and the analysis results, he clicks on the data reporting option in the application. A dedicated folder is made, and Marco logs out to continue working on something else.

Frontstage: as Marco makes use of the City Traffic database, several interactions took place with Marco and the application. He logs in, and is confronted with several options which he needs to fill in/selects. The interface changes as Marco interacts with the datasets and variables. As he decides to capture a data set, a folder can be seen in which is e.g. can capture his work. Logout interface can be seen as he is login out.

Backstage: data is continuously captured via sensing devices in the city's infrastructure and analysed in the back-end. When Marco selects the data sets the backstage is bringing data sets together in such a way that the frontstage can work with it. After Marco's data selection is complete, a folder is setup to store his data, after which the log out process takes place.

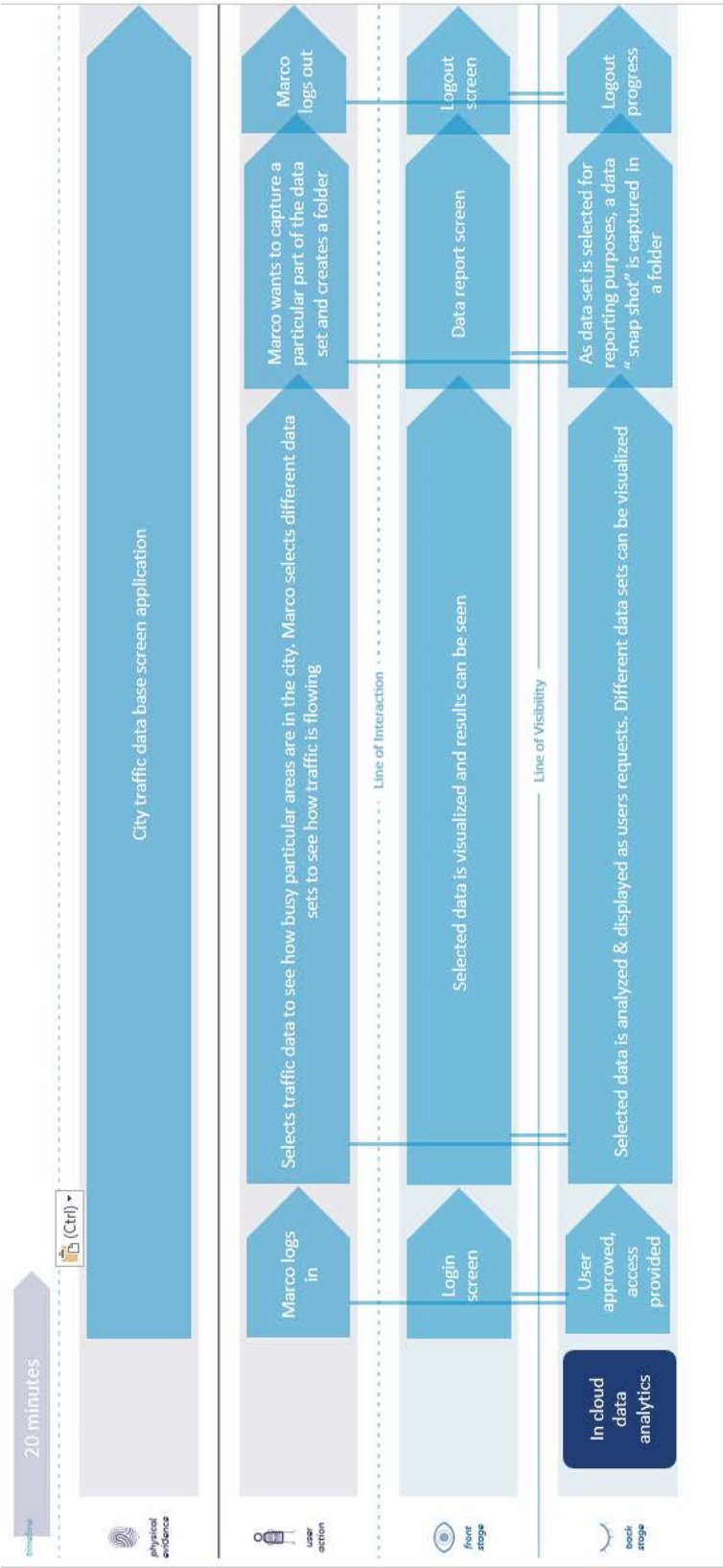


Figure 9: Service blueprint: improvement of infrastructure planning and policy making

2.4.2 Value proposition description

This paragraph shows a description of the target application, visualised in Figure 10.

Data-driven bicycle mobility

The 6 W's

Why: cities want to improve overall biking experience and want to make better and more efficient decisions regarding infrastructure and policy making
What: by leveraging (IoT) data from different sources (1) overall biking experience is improved and (2) analytics will provide improved insights and information around required/desired infrastructure and policies/regulations

With: (1) intelligent actuation of traffic lights & public lighting and (2) a dashboard with aggregated and consolidated data
Who: (1) cyclists in the city, and (2) city operator
When: (1) daily when moving through traffic on bicycle, and (2) daily operation by municipality to improve traffic flow
Where: (1) cyclist on the road in the city and (2) traffic department of municipality



User requirements

- Experience fluent bicycle flows
- Less waiting time
- Efficient routes
- Less conflict situations (green light for cyclists and cars)
- View and analyze usage patterns of shared bikes
- View and analyze absolute bike numbers
- View and analyze frequently used pathways and identify 'black spots'

Figure 10: Description of value proposition data-driven bicycle mobility

3 Application theme: multi-modal transportation

With more and more people living and working in cities, one of the key urban challenges is mobility. Day by day, the use of private cars in cities is having a high impact on mobility, sustainability and the overall quality of life. The increase of traffic is impacting negatively on different aspects, such as high levels of noise and air pollution, and causes increasing amount of traffic incidents and, in fact, fatalities, in particular in big cities.

The solution for these problems is not simply to "stop cars", but requires a comprehensive approach that considers all the different aspects of mobility in the cities and the different needs of people. Such a comprehensive approach is necessary to shift mobility habits from the use of private vehicles to the use of integrated mobility services that are available and can be used when they are needed.

Improved and more efficient mobility will alleviate the impact that traffic can have on cities; a way to obtain these results is to provide citizens with appropriate tools which support and assist the transfer between and within the cities, providing the correct information, facilitating in the use of both public and private transports available in the cities (such as metro, buses and trains), car parking, vehicle sharing services (such as car, scooter and bike sharing), or mobility infrastructures (escalators, elevators, etc.) in a seamless way and guiding step by step in the use of different means of transportation. A general representation is shown in Figure 11.

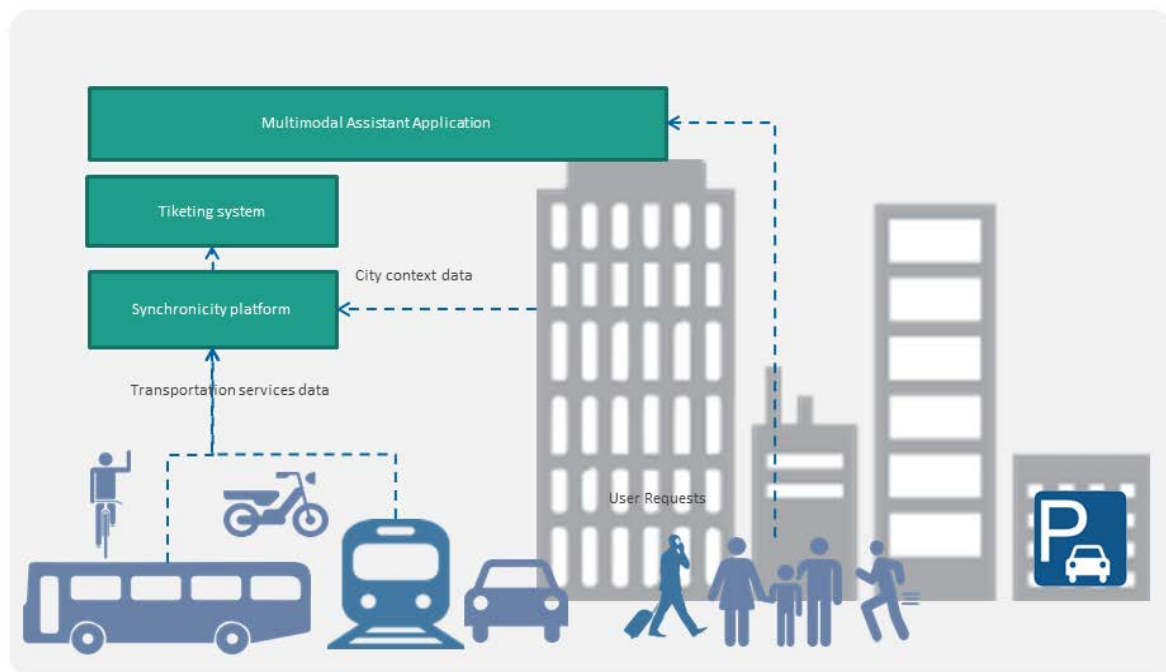


Figure 11: General view of the multimodal transportation application theme.

Optimal and seamless combinations of transportation modes are a key ingredient for turning our cities into sustainable smart cities, as each mode has its own benefits and may fit different goals and citizen desires. The **key goal** in a modern **multimodal urban mobility solution** is to integrate public transport with other modes as well as with new mobility services based on the sharing paradigm.

This approach is enabled by two key factors:

- **Technology:** large adoption of smart mobile devices (e.g. smartphone) that are location-aware and enable people to access information and services in mobility;

- **Data:** availability of data, in terms not only of information freely accessible to users (e.g.: time tables, ticket prices, location of train stations and of bus stops, etc.) through dedicated web sites of mobile applications, but also in terms of open data provided in a machine-readable format and in terms of ability to easily and rapidly exchange data between the different IT systems that manage this information.

From a city perspective, one of the overarching aims is to provide travellers with an attractive alternative to the use of private vehicles (in particular, cars), embracing also the Mobility as a Service (MaaS) paradigm that blends public and private means of transportation and providing a single-access point to manage trips.

3.1 Description target use case (initial application)

A multimodal assistant application that will inform citizens about their mobility options and will facilitate their use in a multimodal way. Citizens will be able to plan and use public transport, bike, scooter and other sharing services and transport modes, including mobility premises like public escalators, elevators or cables, without the need to make new registrations on each service/companies platforms (indeed the application could exploit already existing user accounts or could give the user the chance to insert personal information once and use them to register the user to all the platforms available in a unique solution). Information about parking areas and parking lots will also be used, aiming at providing an easier way to access the city, save time and reduce traffic and pollution.

The application will combine conventional public transports (train, bus and metro) with other transportation modes (motorised or non-motorised), new concepts of vehicle ownership (shared) and urban mobility infrastructures, to provide optimized and efficient routes. Citizens will be able to plan their itineraries considering more variables such as real-time data from transportation systems or vehicles, air quality, noise, availability of pram spots in the buses or traffic flows to enable smoother and more pleasant choices of transport modes. In the end, citizens will be able to pay for all the used mobility services in a seamless way.

Who

The main users of the Multimodal Assistant are represented by inhabitants, commuters, travellers, city visitors, tourists and possibly also city workers that will use the application to access, use and pay mobility services, and to find real-time useful information, such as free parking lots, time tables and city conditions, etc.

Alongside them, an important role is played by other three actors: providers of transport and parking services (they provide means of transportation used by the main users), providers of ticketing and payment services (they provide services enabling the unified payments of tickets and of used means of transportation) and finally the City Council that manages mobility policies (lines, restricted access zones, etc.).

Involved actors are summarized below:

- Users (inhabitants, commuters, travellers, city visitors and tourists)
- Transport and parking service providers
- Ticketing and payment service providers
- City Council

A more detailed analysis of stakeholders is reported in 3.2.2.

Benefits

Users (inhabitants, commuters, travellers, city visitors and tourists) will benefit from having an accurate journey planner based on real and updated mobility data and on personalised preferences and requirements. They will also benefit from having a wider and complementary offer of transportation modes, which will, potentially, allow them to go from any point A to point B within the city without using a self-owned vehicle.

Since the Multimodal Assistant may comprise embedded ticketing and payment features, users will also benefit from having a mobility wallet, which will enable them to use any transportation mode with a single digital ticket, and to smoothly and easily access new private transportation services (such as bike-sharing and scooter-sharing), without the need to register in different platforms. Besides, by facilitating the integration of new companies with the Multimodal Assistant system, more companies are expected to provide mobility services, thus increasing the mobility options available and the competition among them (which in the end, will reduce end-user's costs).

Although the main driver is to promote the use of public transport and mobility infrastructures, the Multimodal Assistant can incorporate parking information (such as location and availability of free parking lots), in order to facilitate and reduce the traffic associated with finding a free parking lot. Besides, this parking information will also be combined with public transport and Park & Ride services.

Users will also benefit from being awarded 'green credits', rewards or incentives (such as, free time to use bike and scooter sharing services, free access to public car parks outside the major city centres, tickets for cultural events and museums, etc.), as long as they use the public transportation network, instead of their own vehicles (in particular cars)

A great benefit for the users is having all these features and services integrated in a single mobile platform and interface.

Transport and parking services providers will benefit from the increase of available mobility options, an anticipated increase the number of users of their own services, and more efficient use of their resources (parking lots, available bikes, bus occupancy, etc.). In particular, the shared services providers (bike, scooter and car sharing companies), will benefit because the Multimodal Assistant system will make the use of their services very smooth and user-friendly, and thus increasing the number of users and profits.

Since the **ticketing and payment service providers** collect a fee related with their service, the increase of use of public transportation services will provide them more financial gains.

Both providers (transport and parking, ticketing and payment) will benefit from having access to a single mobility platform, where they can provide mobility information and offer new services to the users.

Cities will benefit from offering better transportation services to its citizens and visitors (including tourists), which is expected to increase the number of users of the public transportation network, and thus reducing noise, traffic and air pollution (with direct environmental and cost-saving benefits, and the increase of the city's quality of life). Besides, cities can implement city-scale data-driven mobility policies, and may promote the usage of public transportation, by offering 'green credits', rewards or incentives. The private cars traffic reduction will also provide the city with safer and cleaner areas for citizens' leisure.

3.1.1 Value proposition canvas

The general picture of the Value Proposition Canvas of the Multimodal Assistant use case is provided in Figure 12 and Figure 13.

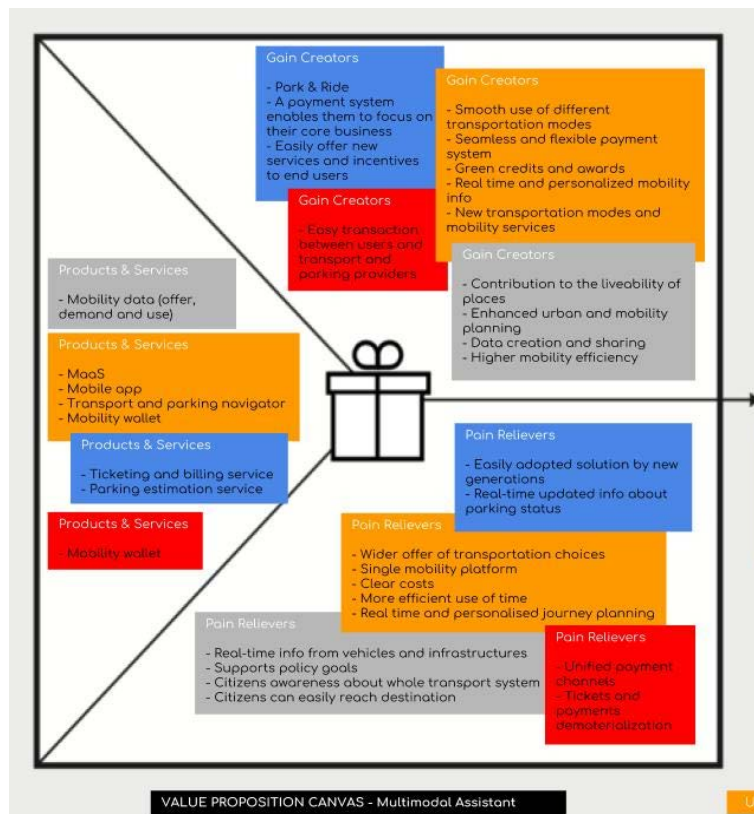


Figure 12: Value proposition canvas of the multimodal assistant use case (1/2)

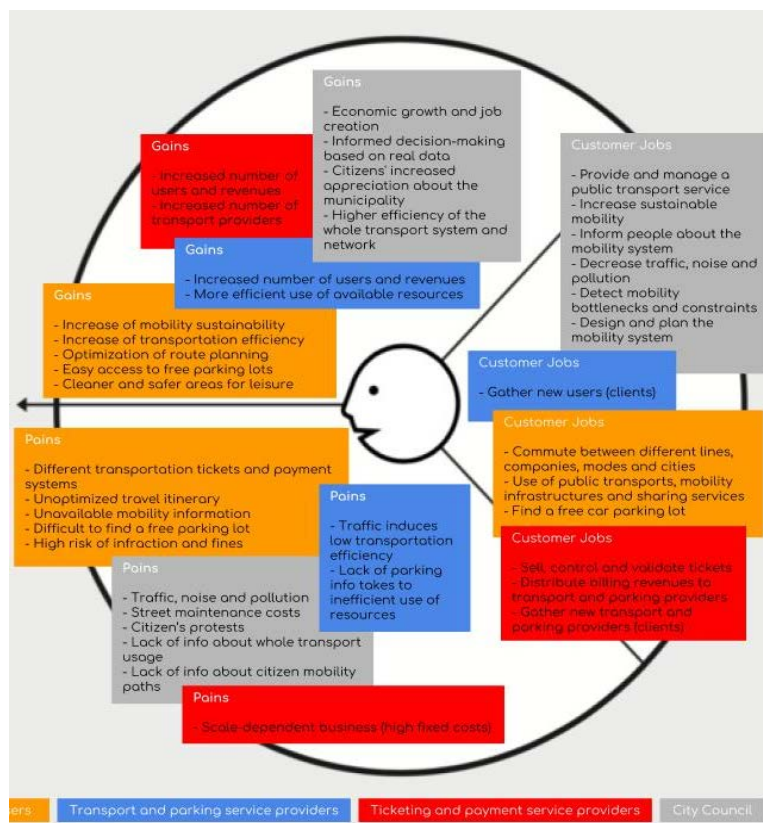


Figure 13: Value proposition canvas of the multimodal assistant use case (2/2)

Customer Jobs

Customer Jobs gather all the customer's needs, the problems that they are trying to solve and the tasks they are trying to perform or complete. The key Customer Jobs that have been identified for the main stakeholders are provided below:

- Users
 - **Commute between different lines, companies, modes and cities:** to go from point A to point B, users need to commute between different lines of the same company providers, between different company providers (public or private), between different modes (in particular, buses, trams, trains, metro and vehicle-sharing) and between different cities (in particular, in metropolitan areas where there is a central city).
 - **Use of public transports, mobility infrastructures and sharing services:** travellers use traditional public and private transportation companies (buses, trams, trains, metro, boats) and sharing services (such as, bike, scooter and car-sharing services).
 - **Find a free car parking lot:** drivers need to find a parking lot to park their cars, either at on-street or off-street parking locations (outdoor and indoor, public and private), including at park & ride locations (close to public transportation hubs and with special tariffs for the users of public transportation).
- Transport and parking service providers
 - **Gather new users:** as any other company (public or private), the transport and parking service providers need to gather new and more users, and have to struggle to combine a good and efficient service offer with a low cost and a sustainable business.
- Ticketing and payment service providers
 - **Sell, control and validate tickets:** all the ticketing and payment service providers need to have a robust ticketing and billing platform, which enables them to sell, control and validate the tickets.
 - **Distribute billing revenues to transport and parking providers:** all the ticketing and payment service providers need to have a fair and reliable way of distributing the revenues among the transport and parking service providers that hired (outsourced) their services.
 - **Gather new transport and parking providers (clients):** as any other company (public or private), the ticketing and payment service providers need to gather new and more users (in this case, more transport and parking service providers), and have to struggle to combine a good and efficient service offer with a low cost and a sustainable business.
- City Council
 - **Provide and manage a public transport service:** each City Council needs to provide a public transport service to its inhabitants and visitors, either directly or through third party institutions and companies (public or private).
 - **Increase sustainable mobility:** the reduction of the use of private vehicles, the use of electrical and gas vehicles (low emissions) and the increase of the use of public

transports, make the city mobility more sustainable (both financially and environmentally).

- **Inform people about the mobility system:** the users demand the City Council to provide greater, more reliable and more integrated information about the city's global transportation system, including public and private services, and both for pedestrians, commuters and vehicles' mobility.
- **Decrease traffic, noise and pollution:** the use of private vehicles (in particular, cars), has a high negative impact on traffic, noise and pollution levels; accordingly, the City Council struggles to reduce those negative impacts on the city.
- **Detect mobility bottlenecks and constraints:** the access and use of more mobility data and information by the City Council, enables it to identify critical mobility points, bottlenecks and constraints, and to take better informed decisions and to design adequate mobility policies to increase the efficiency and quality of the mobility system.
- **Design and plan the mobility system:** the increased access and use of mobility data and information by the City Council, combined with the city growth plans (for example, new housing, public-use buildings and city infrastructures) enables it to plan a better mobility system that will properly respond to the future users' needs.

Pains

- Users
 - **Different transportation tickets and payment systems:** a traveller would have to purchase separate tickets for each individual transport provider
 - **Unoptimized travel itinerary:** a traveller is not always capable of choosing the most advantageous itinerary because of lack of information, leading to unnecessary delays, costs and a struggle to find the information needed to properly plan itineraries (in an efficient and cost/time-saving way).
 - **Difficult to find a free parking space:** when drivers don't have information about parking spaces availability in the city, they waste time (and fuel, money and patience) driving around to find a free space; they feel frustrated when, in the end, they are not successful which contributes to a negative experience for both frequent and occasional visitors of the city
 - **High risk of infraction and fines:** since transportation information is not made available in a clear and integrated way (for example, regarding price and geographic ticket validity), travellers may be inadvertently infringing the rules; besides, travellers tend to choose known itineraries instead of alternatives (unknown, but more adequate to his journey), to avoid infractions and fines.
- Transport and parking service providers
 - **Traffic congestion induces low transportation efficiency:** the main consequences of city traffic are unmet schedules, increase of fuel consumption, degradation of vehicles, reduction of service quality and need of extra vehicles to provide the same quality of service.
 - **Lack of parking info takes to inefficient use of resources:** the lack of parking information decreases the fit between offer and demand, which increases the inefficiency of the available parking resources.
- Ticketing and payment service providers
 - **Scale-dependent business (high fixed costs):** the ticketing and payment service providers have high fixed costs, because they need to deploy more or less the same

infrastructure, regardless of the number of users (for example, one check-in machine per vehicle and per station); accordingly, this is a scale-dependent business.

- **City Council**
 - **Traffic, noise and pollution:** the city authorities (in particular the City Council) have to cope and take measures in order to decrease and mitigate the effect of high levels of traffic, noise and air pollution that citizens traditionally are exposed to in a city.
 - **Street maintenance costs:** high levels of car and truck traffic in the city (in particular in a city that acts as a central hub within a metropolitan area) degrades the streets and its infrastructure, which has significant maintenance costs.
 - **Citizen's complaints/satisfaction:** citizens protest for not having a proper and adequate transportation system, for the high amounts of traffic, for the road conditions and for the taxes they pay. Because of political reasons (e.g. politicians want to be re-elected) dissatisfied citizens are a pain for the city
 - **Lack of info about whole transport usage:** although many municipalities have available data regarding the transportation services' offer (lines, routes, timetables, etc.), they usually lack information about the demand (citizen's needs), and more important, about the actual use, which could enable the City Council to take better informed decisions and to design adequate mobility policies based on real transport usage data.
 - **Lack of info about citizen mobility patterns:** although the transport and parking service providers have some data about mobility paths for each of their own companies, they don't usually share it with the City Council, which causes the City Council to not have a global and top-level view of mobility in the city, and to take better informed decisions and to design adequate mobility policies based on real citizen mobility paths.

Gains

The key Gains that have been identified for the main stakeholders are provided below:

- **Users**
 - **Increase of mobility sustainability:** a better transportation network, combined with richer and more information available to the user, will decrease the need to use private cars; besides, reduced traffic has a positive direct effect on the levels of gas emissions; besides, the use of shared vehicles significantly reduces the need to use private cars, and both enable a sustainable low carbon emissions mobility within the city, both with a direct impact on the users' quality of life.
 - **Increase of transportation efficiency:** a higher use of public transportation will decrease traffic congestion, which, in the end, will save time and money to all the users.
 - **Optimization of route planning:** the Multimodal Assistant enables the user to plan and know the more adequate, less time and money consuming, and more pleasant route according to his profile, preferences and requirements.
 - **Easy access to free parking lots:** information about the location of free (available) parking lots saves time and money to the user, because he will not need to look for a place to park the car by driving around the city.
 - **Cleaner and safer areas for leisure:** due to car traffic reductions and an incentivized use of public transport and city mobility infrastructures, that is reflected into a more friendly, cleaner and safer city model.

- Transport and parking service providers
 - **Increased number of users and revenues:** a simplified and more informed use of the transportation and parking networks increases its use, and thus, increases the revenues of the companies involved.
 - **More efficient use of available resources:** by providing transportation and parking information, the Multimodal Assistant contributes to a better fit between offer and demand, which increases the efficiency of the available resources.
- Ticketing and payment service providers
 - **Increased number of users and revenues:** since the ticketing and payment services are scale-dependent businesses, an increase in the number of public transportation users increases the revenues of the companies involved.
 - **Increased number of transport providers:** an increase in the number of users turns the transportation business into a more profitable market, and so, more companies are willing to operate, which will also benefit the ticketing and payment service providers (which collect a fee by each transaction).
- City Council
 - **Economic growth and job creation:** a more efficient mobility network opens new opportunities for value-adding and business creation and thus contributes to economic growth and job creation; besides, it also contributes to the increase of the economy's overall efficiency, because mobility deficiencies have a negative impact on workers quality of life and working efficiency.
 - **Informed decision-making based on real data:** more mobility data and information enable the City Council to take better informed decisions and to design adequate mobility and environmental policies.
 - **Citizens' increased appreciation of the municipality:** better mobility efficiency and choices increase the citizen's quality of life, and thus increase his appreciation about the work done by the municipality as a whole.
 - **Higher efficiency of the overall transport system and network:** a more efficient transport system saves money to the municipality, which can be better and more adequately used in other areas that benefit the citizens; in the end, more efficiency means less costs needed to provide the same quality of service, or a better quality of service with the same costs, which directly benefits the City Council.
 - **Increase and sustain attractiveness and city image:** for cities it is of utmost importance to have an attractive image. Cities need to be attractive for people to live and work, for business and for tourists to visit.

Pain Relievers

Pain Relievers describe how the proposed solution addresses the challenges needs and the pains of the customer, and how negative emotions, undesired costs or avoidable situations are eliminated. The key pain relievers that have been identified for the main stakeholders are provided below:

- Users
 - **Wider offer of transportation choices:** when the multiple transportation providers (public or private) use a common platform to provide a mobility service to the users,

they benefit by having a wider and complementary offer, and by having more mobility choices; besides, the providers have to compete between themselves to gather users (competition), which increases the quality of each service and decreases its cost.

- **Single mobility platform:** a single mobility platform acts as a one-stop-shop for mobility services, both as an information source (transports, parking and city conditions) and service provider (ticketing, billing, payment), which frees the users from gathering information from multiple sources and to use different and unintegrated services and platforms.
 - **Clear costs:** when the mobility data is combined in a single platform, the mobility costs associated with going from point A to point B, and using several transportation modes and providers, are clear, because the platform details and adds the total costs.
 - **More efficient use of time:** when more transportation information is made available to the users, they take better informed mobility choices, which (among other benefits) enable them to save and to make a more efficient use of their time.
 - **Real-time and personalised journey planning:** real-time data about the transportation network enables the users to plan their journey in a more time and cost efficient way, taking into consideration the real-time status of the network conditions, including unknown, unscheduled and temporary events; besides, the Multimodal Assistant can provide information and services based on the user's own profile, preferences and requirements (for example, for handicap users, for baby carrying and for old people), instead of being treated as a 'standardized' and uniform user.
- Transport and parking service providers
 - **Easily adopted solution by new generations:** since the Multimodal Assistant is based on a smartphone (or any other mobile device) app, it is easily adopted by young people, so transport and parking service providers ease from themselves the process of gathering new users.
 - **Real-time updated info about parking status:** the Multimodal Assistant provides real-time information about the parking availability status, which facilitates the task of finding a free parking lot by the end users.
 - Ticketing and payment service providers
 - **Unified payment channels:** a unified payment platform eases the process and reduces operational costs for the ticketing and payment service providers.
 - **Tickets and payments dematerialization:** the dematerialization of tickets and payments eases the process and reduces operational costs for the ticketing and payment service providers.
 - City Council
 - **Real-time information from vehicles and infrastructures:** the Multimodal Assistant provides valuable mobility data from vehicles and infrastructures, which enables the City Council to take more informed decisions and to design adequate mobility policies.
 - **Supports policy goals:** the Multimodal Assistant provides valuable mobility data, and thus reduces the information gap that City Councils' have when designing mobility policies.
 - **Citizens awareness about full transport system:** when more and better information about the transport system is made available to the users, users tend to have a better opinion about the municipalities, and thus, the City Council faces less protests and

negative opinions from its inhabitants and visitors.

- **Citizens can easily reach their destination:** when users have the possibility to use different transportation modes in a complementary and smooth way (either public or private), this eases the mission of the City Council to provide the needed services by themselves.

Gain Creators

Gain Creators describe how the proposed solution creates customer gain and how it offers an added value to the customer. The key Gain Creators that have been identified for the main stakeholders are provided below:

- Users
 - **Smooth use of different transportation modes:** when the multiple transportation providers (public or private) use a common platform to provide a mobility service to the user, and a multimodal assistant provides mobility information, he benefits by having a wider and complementary offer, by having more mobility choices and by having a user-friendly journey planner.
 - **Seamless and flexible payment system:** a seamless payment system adds value to the user, because he will benefit from a smooth, clear and centralized payment service, instead of complex and multiple services; besides, users will have the possibility of paying their mobility bills in several different ways (such as, pay as you go, monthly bill, monthly subscription, tourist ticket), and will benefit from having different payment systems available (such as, ATM, credit card, pre-payment, post-payment).
 - **Green credits and awards:** users may receive awards, rewards and incentives for using the public transport network and for having more sustainable mobility habits ('green credits').
 - **Real-time and personalized mobility info:** real-time data about the transportation network enables the users to plan their journey in a more time and cost efficient way, taking into consideration the real-time status of the network conditions, including unknown, unscheduled and temporary events; besides, the Multimodal Assistant can provide information and services based on the user's own profile, preferences and requirements (for example, for handicap users, for baby carrying and for old people), instead of being treated as a 'standardized' and uniform user.
 - **New transportation modes and mobility services:** when the mobility system incorporates new modes of transportation, such as, bike-sharing, scooter-sharing and car-sharing services, the user benefits by having a wider and complementary offer and by having more mobility choices (including several private companies providing the same service and competing among each other's).
- Transport and parking service providers
 - **Park & Ride:** transport service providers will benefit from providing integrated Park & Ride car parks, because it will increase the use of their own services.
 - **A payment system enables them to focus on their core business:** the existence of a uniform and centralized payment system enables the transport and parking service providers to focus on their core business (provide a transportation and parking service) and not to worry about these operational issues, which can be better managed and provided by third parties.
 - **Easily offer new services and incentives to end users:** the Multimodal Assistant

is a platform that easily allows the transport and parking service providers to offer and make available new services to the end users, and also to provide incentives and rewards ('green credits').

- Ticketing and payment service providers
 - **Easy transaction between users and transport and parking providers:** a multimodal assistant with ticketing and payment features eases the transaction between users and transport and parking service providers, and thus facilitates the job of the ticketing and payment service providers themselves.
- City Council
 - **Contribution to the liveability of places:** a better mobility system increases its use and decreases the use of private vehicles, and thus contributes to a better city environment and working and living conditions.
 - **Enhanced urban and mobility planning:** the Multimodal Assistant provides valuable mobility data to the City Council for global urban planning.
 - **Data creation and sharing:** the Multimodal Assistant provides valuable mobility data, and is an adequate platform for the different stakeholders to share and make available their own data to the City Council, and to measure mobility parameters that enables the City Council to take more informed decisions; besides, the use of the Multimodal Assistant will generate valuable data about the demand and real use of the transportation system, which will complement the available data about transportation offerings; accordingly, the multimodal assistant is a data supplier and data source.
 - **Higher mobility efficiency:** the reduction of the user's mobility time increases his quality of life, and thus increases his appreciation about the work done by the municipality as a whole, and increases the global living and working conditions in the city; besides, more mobility data and information enable the City Council to take better informed decisions, and to design and plan adequate mobility policies.

Products & Services

The key Products & Services that have been identified for the main stakeholders are provided below:

- Users
 - **MaaS:** users will be able to use several mobility services (public or private, owned or shared), which will be provided by a single ticketing and payment platform embracing the Mobility as a Service (MaaS) paradigm.
 - **Mobile app:** an application that can be installed and used in a smartphone (or other mobile device), which has innovative mobility features and provides differentiated and complementary mobility services to its users.
 - **Transport and parking navigator:** the Multimodal Assistant will act as a virtual *concierge*, in the sense that it will help and inform the user, so that he can take the more adequate mobility decisions, considering his profile, preferences and requirements, and the real-time and scheduled status of the city and the mobility and parking networks.
 - **Mobility wallet:** a virtual (digital) wallet which has 'everything' the user needs to use the mobility network, and can comprise several tickets and payments or a single multimodal ticket with a single payment system.

- Transport and parking service providers
 - **Ticketing and billing service:** the Multimodal Assistant, if embedded with ticketing and billing features, will provide this service to the transport and parking service providers, which will not need to take care of those issues directly.
 - **Parking estimation service:** the Multimodal Assistant will provide information about parking lot availability (based on real-time data) and occupancy estimation (based on historical data).
- Ticketing and payment service providers
 - **Mobility wallet:** the Multimodal Assistant is a platform where ticketing and payment service companies may embed and provide their services, and thus, turning the Multimodal Assistant into a virtual (digital) mobility wallet.
- City Council
 - **Mobility data (offer, demand and use):** the use of the multimodal assistant will generate valuable data about the demand of the transportation system, which will complement the available data about transportation offer; accordingly, the multimodal assistant is a data supplier and data source; besides, the use of the multimodal assistant will generate valuable data about the real use of the transportation system; accordingly, the multimodal assistant is a data supplier and data source.

3.2 Value network and customer interactions

This section provides a general overview of the different stakeholders involved around the Multimodal Transportation theme, depicting their relations through a visual representation. The stakeholders that are considered are not only the four identified in section 3.1, but all key stakeholders that have a significant role in the specific theme (Multimodal Transportation). They are classified in three groups:

1. **Core:** main stakeholders, indeed the final users of the application
2. **Internal:** stakeholders that are directly and/or financially involved in the operational processes and strategies
3. **External** stakeholders that have impact on the theme, such as suppliers, governments, etc.

3.2.1 Description of stakeholder profiles and their roles

Through a series of dialogue discussions with the cities in the reference zones, we were able to identify the key stakeholders that are involved in the service ecosystem, where they come from and what they are looking for in relation to the business. The key stakeholders (core, internal and external) were determined and identified from multiple perspectives across the entire stakeholder spectrum.

The **core stakeholders** have direct participation in the service and they represent the end-user; these are:

- Commuters/travellers
- Visitors

These stakeholders are mainly interested in moving between different cities and within the city. The full journey may comprise walking, switching between different public transport lines, companies and

modes of transport, both public and private (e.g. bus, metro, train, taxi, bike sharing, car sharing, etc.), and finding a free parking lot (which can be considered a thorny task, in particular for commuters that typically are more pressured for time).

Indeed, these stakeholders face different situations, including: buy different types of tickets, use different payment systems, use different platforms to access information about transportation, etc. These problems can be mitigated through an optimized route planning that provides precise, tailored real-time information (e.g. on lines, their location, costs and timetables) and greater choice. This allows for a travel process that is faster, more comfortable and which provides greater control. These stakeholders interact mainly with public and private transport providers, parking providers, ticketing and payment service providers, and mobility agency (they use services provided by these stakeholders and pay for them; information produced by these stakeholders are consumed by commuters/travellers and visitors, also through intermodal information providers).

The core stakeholders are very heterogeneous, and they have specific needs and attitudes that have to be taken into consideration to provide an inclusive solution; in particular, vulnerable-to-exclusion citizens (such as, elderly, low-income, disabled or migrants), in relation to the requirements brought about by the digitised transport system as well as the skills and strategies necessary for all citizens to fully benefit from it.

The **internal stakeholders** (i.e. internal to the city/municipality) are involved in the service process and have a direct influence in the customer experience; these are:

- Public transport providers
 - Provide transport means (such as, bus, train, metro and others), static information (such as, schedules and fares, where the latter are covered by ticketing and payment service providers) and real-time information.
- Private transport providers
 - Provide private transports (such as, shared mobility services that includes bike sharing, car sharing or scooter sharing, and taxis), static information (vehicle information, vehicle driver, availability, vehicle locations and fares, where the latter are covered by ticketing and payment service providers) and real-time information.
- Parking providers
 - Provide static information about public and private parking lot and spaces (such as, location, availability, schedules and fares, where the latter are covered by ticketing and payment service providers) and real-time information.
- Ticketing and payment services providers
 - Provide technology and services for ticketing and payment of mobility services.
 - Responsible for revenues distribution among the transport providers.
- Intermodal information providers
 - Collect real-time information from different stakeholders and provide it in a single platform.
- Municipality and local and regional authorities
 - Manage and organize the public transport in the city and improve its flows.
 - Provide locations of stations and stops of transports.
 - Responsible for transportation and traffic planning and local infrastructures.
 - Responsible for land use planning.
 - Responsible for achieving municipality goals (reduce transport emissions and traffic congestions, etc.)
- Mobility Agency

- An agency that supports planning activities and manages and develops the mobility information system in the field of mobility.

Public and private transport providers, parking providers, ticketing and payment services providers and intermodal information providers interact with infrastructure providers and 3rd party technology and IT system providers (in order to acquire services to monitor their structure, vehicles, premises) and with logistics services operators (in order to acquire goods and materials), which are useful and required to provide services to final users.

The **external stakeholders** influence the service process and ensure the proper functioning of the service; these are:

- National and Regional road authorities and ministries
 - Responsible for higher level road administration, transport legislation and regulation.
 - Responsible for national and regional transport policy and strategies.
 - Provide financial infrastructure and investments.
 - Responsible for long-term and short-term implementation of mobility policy and strategy.
- Policy makers
 - The local policymakers are responsible for analysing and interpreting the data generated from the Multimodal Assistant ecosystem, in order to be able to create informed and data-based policies and regulations for the city.
- Data collection and provider
 - Responsible for collecting and monitoring city datasets (such as, air quality and noise levels), to share real-time data with other stakeholders, and to manage the data generated by the city (sensors and current datasets).
- IoT Infrastructure provider
 - Provides tools and devices that feeds the Multimodal Assistant platform, such as sensors and other IoT devices.
 - Responsible for the installation and integration of data sensors and other IoT devices.
- 3rd party technology and IT system providers
 - Responsible for the development, design and build of the Multimodal Assistant mobile application and user interface.
- Logistics services operators
 - Provide management of goods and materials.

These stakeholders have both a direct and indirect influence on core stakeholders, because they provide services, goods, material, etc. to the internal ones. For instance, national road authorities and ministries and local policymakers regulate and administer transport infrastructures, logistics services operators provide materials and goods that are used by public and private transport providers to operate, etc.

3.2.2 Visual representation of the stakeholder network

To provide a more detailed insight to the Multimodal Assistant service and operator models, this section contributes with a visual representation of the stakeholder ecosystem (Figure 14). This

framework helps identifying how this use case should be implemented and how the different stakeholders contribute to the provision of the Multimodal Assistant service. The ecosystem includes the transport infrastructure and information, transportation modes and service, and ticketing and payment services. By applying this ecosystem structure, the boundaries between the transport system will disappear and will significantly improve the citizens' experience — user-centric mobility services.

Figure 14 gives a holistic view of the mobility sector as a collaborative and interconnected ecosystem that provides services, which reflect the needs of customers and seamlessly combine different transport modes. In this diagram, the main stakeholders were clustered in three groups:

- **Enablers:** This group represents the stakeholders that have the capabilities and resources to administer relevant information, and goods and services, which contribute to the success of the Multimodal Assistant application. As a result, the Enablers improve the end users' (commuters, travellers and visitors) mobility experience.
- **Experience (end-user interface):** This group shows the end-users/customers of the Multimodal Assistant service, which are the commuters, travellers and visitors. The diagram represents the interaction that the internal and external stakeholders must have with their end-user.
- **Multimodal Assistant (Application):** This group represents the stakeholders that have an essential role on the well-functioning of the Multimodal Assistant service. To enable the end-user (commuters, travellers and visitors) to find the most suitable and preferable way to get from a point A to B, these stakeholders (mostly corporate) create a unique business model that provide services that reflect the user needs and seamlessly combines different transport means. The Multimodal Assistant service should combine the existing transport providers in the city into a single mobility platform that acts as a one-stop-shop for mobility services, and most important, provides personalised transport routes adapted to the end-user's needs.

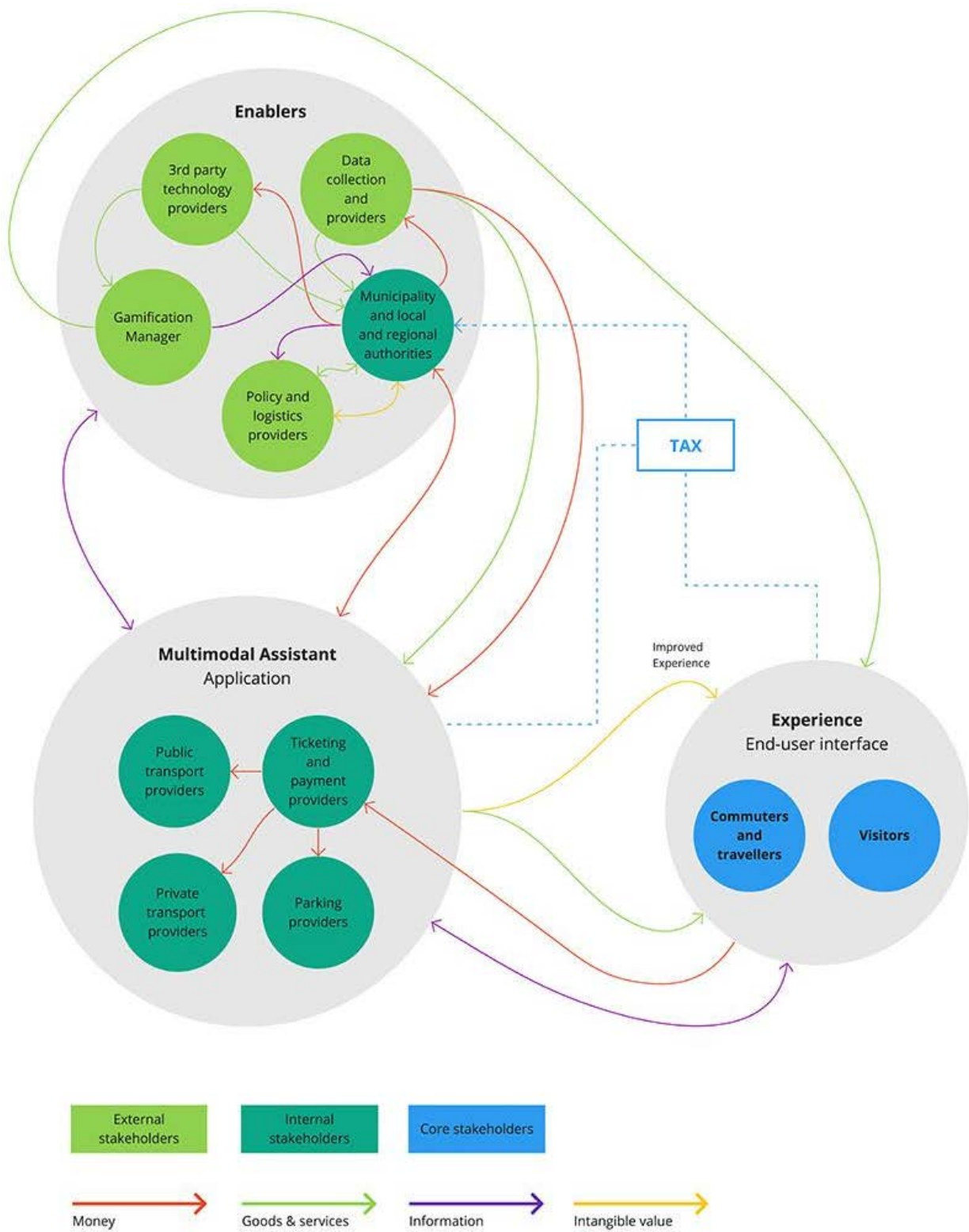


Figure 14: Visual representation of the stakeholder network of the Multimodal assistant use case

3.3 Technological composition of system

This section provides a technical description of the system that will support the Multimodal Assistant application. It presents the high-level system architecture approach (including a mapping of the architecture on the SynchroniCity platform) and the functional and non-functional requirements needed to implement the whole use case

3.3.1 Visual representation of the (high-level) system architecture

A visual representation of the high-level system architecture is provided in Figure 15, which shows the different components and baseline services required to address the target use case and maps upon the SynchroniCity architecture, which is provided in the deliverable D2.1 (SynchroniCity, August 2017). A general description of the layers composing the architecture is also reported below.

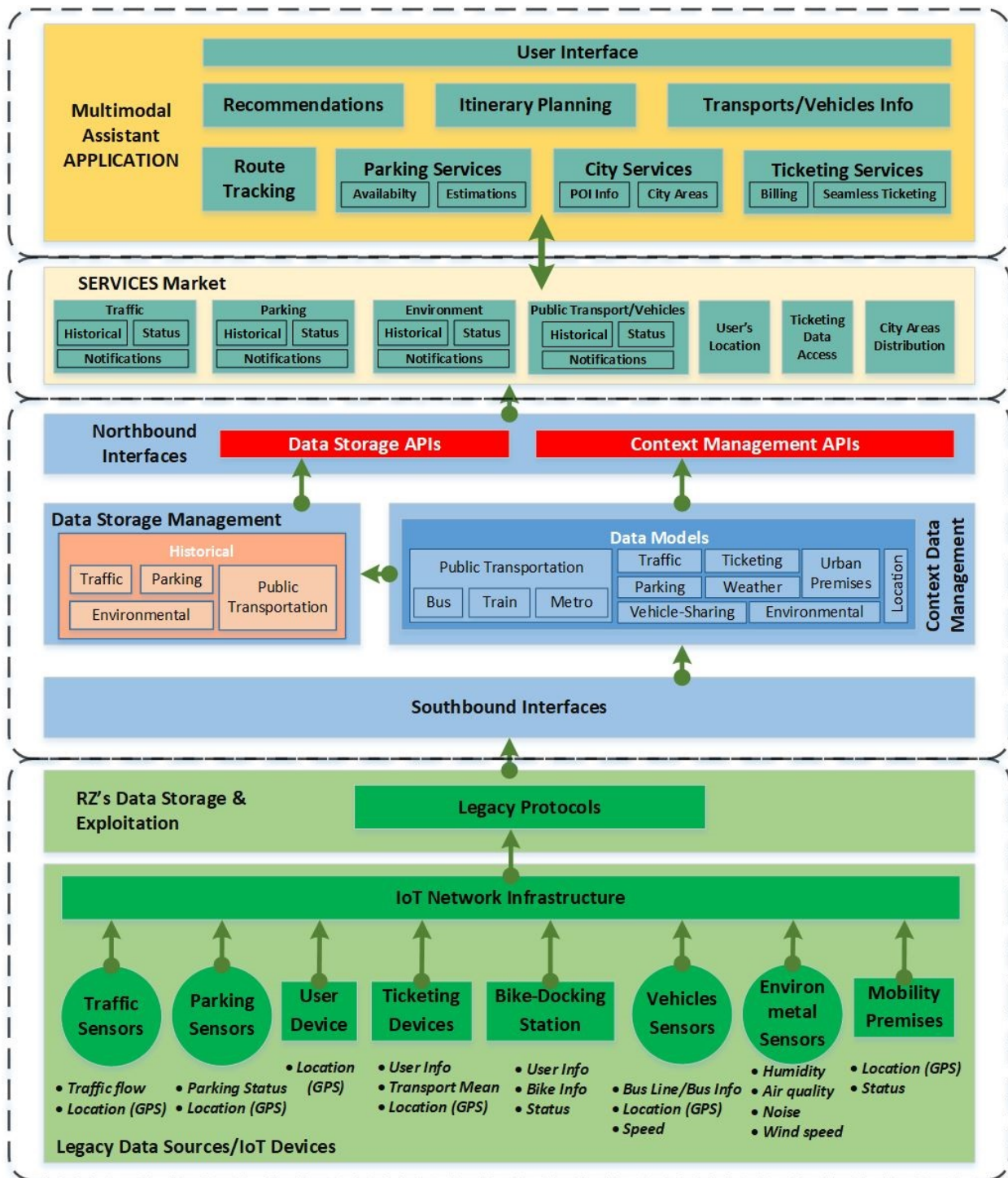


Figure 15: High-level system architecture of the Multimodal assistant use case

The Multimodal Assistant architecture, linked to the reference model of SynchroniCity, is made of four main layers:

- o Multimodal Assistant Application, that implements the specific services and modules of the application
- o Services Market, providing the baseline required services to build the application's core
- o SynchroniCity Architecture Reference Model, as an instance of the general SynchroniCity architecture
- o Legacy data sources/IoT devices, that supply the data to be used by the app.

Multimodal Assistant APPLICATION: this layer includes all the high-level services and components of the final use case application (indeed the navigator); this layer includes the following services/components:

- **User Interface:** this component represents the access point to the services composing the application; it will provide a GUI to the final user to access information about means of transportation, to plan an itinerary, etc.
- **Itinerary Planning:** this service provides combinations of transportation modes and itineraries, considering start location, destinations and journey preferences and requirements.
- **Recommendations:** this service suggests recommendations for itineraries provided to the users based on preferences and requirements of the users themselves.
- **Transports/Vehicles Info:** this service provides information about transport modes (schedules, routes, stations, and in general the information a mobility provider produces to enable the use of its services) and about the availability of vehicles for transportation (e.g. availability of cars and bikes of sharing services, bus and train status, etc.)
- **Route Tracking:** this service keeps track of the transportation means used by the user.
- **Parking Services:** this service provides information about parking lots, such as their availability (if it is free or not), price, location, etc.; furthermore, it is able to provide an estimation about its availability, for instance to indicate to the user if a parking lot is expected to be free or not at the arrival time.
- **City Services:** this service provides geographically contextualized data about the city in terms of environment (pollution, noise, traffic level, etc.) and about Points of Interest (e.g.: location, description, etc.) that can be useful to plan an itinerary. Here, information about city's mobility premises status and availability would be also offered.
- **Ticketing Services:** these services provide an open ticketing system for all the transport provider and billing system to charge the user with the cost of the transports used by month, week, etc.

SERVICES Market: or IoT baseline services, represents the set of services that provides direct access to the information captured in and processed by the SynchroniCity deployed platform, plus the provisioning and access control mechanisms that later will form the digital single market (DSM). In this sense, and in terms of information directly provided by the IoT edge, the Multimodal Assistant use case identifies three main types of core services:

- **Historical** data access: these services provide access to each corresponding historical data sets (traffic, parking, environment, etc.) allowing upper services/applications to build e.g. statistical analysis, forecasting, behaviours, etc. and to provide estimations (e.g. parking probabilities).
- **Status** Query/retrieve: gives last data captured or current status of a concrete sensor/device, plus all directly associated context information. This way, it is easy to know the current

location of a bus or a train, and get the current status of a set of parking lots or know how many available bikes are there in a specified bike docking station.

- **Notifications:** these are the result of a publish/subscribe context management functionality, that allows upper services/applications to subscribe to concrete datasets, devices or sensors, and to automatically receive updates on captured data or in deployment status. This way, an application can e.g. detect new events and inform affected users in real-time.

Aligned to these, the Multimodal Assistant use case defines historical data, status and notifications baseline services for:

- **Traffic** data access,
- **Parking** data access,
- **Environment** and Weather data access,
- Public Transport/Vehicle-Sharing data access.

Besides data directly supplied by city legacy IoT deployments, the system will also provide aggregated information, coming from exploited data also captured by IoT deployments and/or complemented by other information sources. In this line:

- **Ticketing Data Access** services will manage and provide all the datasets related to the common ticketing system, and thus allowing the implementation of the seamless ticketing feature.
- **User's Location:** obeying privacy and data protection, this service is intended to notify the end user, in real-time, about issues, changes or delays that may affect the selected route.
- **City Areas Distribution:** that allows the assignment and mapping of parking lots, bus stops, or bike-dockers according pre-defined areas of the city.

SynchroniCity Architecture Reference Model: this layer directly represents the SynchroniCity architecture defined in the deliverable D2.1 (SynchroniCity, August 2017) that links the required cities' IoT edge with the final Multimodal Assistant application, through the identified IoT baseline services. Here, its main task is to abstract all the heterogeneous IoT deployments provided by the cities in benefit of a common representation of the captured data, virtualized devices and **APIs** to access available information. In this sense, a common set of **Data Models** to manage context information and to store **Historical data** has been identified to support the Multimodal Transportation application:

- **Traffic:** maps the information related to motorised traffic flow (number of vehicles) in monitored loans and streets.
- **Ticketing:** keeps the information captured by the single ticketing deployment, including data of the user involved in the ticketing process.
- **Urban Premises:** used to capture the status of urban escalators, elevators, cables, etc.
- **Environmental:** initially, includes information about air quality (CO, NO, particles, etc.) and noise levels.
- **Parking:** provides information about current status of each sensed parking lot, location, type, etc.
- **Weather:** maps city's weather stations, with data about wind speed, humidity, temperature, luminosity, etc.
- **Location:** of consumers using e.g. the tracking information system.
- **Vehicle-Sharing:** covers the data captured by bike-sharing docking stations, car-sharing vehicles, etc.

- **Public Transportation:** here are included the data models used to map buses, metro, commuter trains, etc., and all related to these information systems (lines, stops, stations, timetables, etc.), plus other available and monitored mobility infrastructures.

Legacy data sources/IoT devices: the lowest layer of the architecture identifies the City IoT infrastructures: IoT networks, IoT devices/deployments and data sources; that will feed the Multimodal Assistant application plus all the add-ons (ticketing, parking, traffic, air quality, noise, etc.) with the required data to build the Multimodal Transportation whole use case. In particular a minimum set of sensors (in term of kinds of information needed by the application) has been identified to cover this concrete use case:

- **Traffic Sensors** (that should provide at least information about the traffic flow and about the relative location).
- **Parking Sensors** (that should provide at least information about the location of the parking and its status, for instance if it is free or not).
- **Vehicles Sensors** (that should provide at least information about the actual position of a vehicle, its speed, and its reference, for instance the bus/metro line).
- **Environmental Sensors** (that should provide at least information about air quality, humidity, noise level, wind speed, etc.).
- **User Device** (that reports current location of the user to notify, on real-time, about incidences that may affect his journey).

Also, a minimum set of required data sources and devices has been identified:

- **Ticketing Devices** (that should provide at least information about their location, available transport means, and about the user/owner of the corresponding ticket).
- **Bike-Docking Stations** (that should provide at least information about their location, status, available bikes, and users hiring bikes).
- **Mobility Premises** (that should provide at least information about their location and their status, e.g. active, stopped, out of service, etc.).

3.3.2 Functional and non-functional requirements for the system architecture

This section reports the more relevant functional and non-functional requirements that have been identified in relation to the Multimodal Transportation Application, derived from the proposed scenarios in section 3.1; in particular section 3.3.2.1 reports high-level functional requirements, whereas 3.3.2.2 reports on high-level non-functional requirements.

3.3.2.1 Functional Requirements

Table 3: Functional requirements of multimodal assistant application.

ID	Subsystem	Description	Actors involved
application			
FR-1	General App	The application must provide user identification and access control at least by a username/email address and password basic security (log-in).	Users
FR-2	General App	The application may provide basic features that can be accessed in an unregistered way.	Users

FR-3	General App	User must register an account and log-in to access features of the application that cannot be used in an unregistered way.	Users
FR-4	Planner-Navigator	The user should be able to enter (or provide by the GPS sensor embedded in his mobile device) the departure point, destination point and optionally other intermediates points of an itinerary on a map.	Users
FR-5	Planner-Navigator	The user should be able to enter the departure point, destination point and optionally other intermediates points of an itinerary writing their addresses, GPS coordinates or Point of Interest (PoI).	Users
FR-6	Planner-Navigator	The user should be able to select among different traveller profiles (e.g.: by walk, drive a car, drive a bike, use public transportation, etc.).	Users
FR-7	Planner-Navigator	The user must be able to combine multiple transportation modes and mobility infrastructures (e.g.: metro + bike sharing for last mile instead of bus).	Users
FR-8	Planner-Navigator	The application must permit to plan routes by considering user preferences (panoramic itinerary, air quality, lowest cost, lowest time, etc.) and requirements	Users
FR-9	Planner-Navigator	The user should be able to view on a map alternative routes and select the one he/she wants to use.	Users
FR-10	Planner-Navigator	The user should receive the amount/estimation of the cost (e.g. total ticket price) and arrival time (when possible) of each alternative route.	Users, Transport and Parking service providers
FR-11	Planner-Navigator	The user should be able to select the preferred route he/she want to use.	Users
FR-12	Planner-Navigator	The user should be able to view on a map the points of interest located in an area near to the route.	Users, City Council
FR-13	Planner-Navigator	The application may consider real-time information (deleted rides, delays, etc.) to better plan and update the journey.	Users, Transport service providers, City Council
FR-14	Planner-Navigator	The app should notify the user in real-time about issues that affect selected route.	Users, Transport service providers, City Council
FR-15	Planner-Navigator	The application should be able to consider user related information to suggest routes based on his/her preferences.	Users
FR-16	Parking	The application must provide users with a georeferenced search of parking areas.	Users, Parking service providers
FR-17	Parking	The application must permit to search for car parks by considering user preferences (proximity of stations, bus stop, destination address, secured park, Park & Ride features, etc.)	Users, Transport and Parking service providers, City Council
FR-18	Parking	The application must be able to indicate which transport possibilities are currently available near the selected parking area (e.g. estimated arrival times for nearby bus lines).	Users, Transport and Parking service providers, City

			Council
FR-19	Parking	The application should be able to indicate in real-time where free parking lots are available and at which cost/minute.	Users, Parking service providers
FR-20	Parking	The application may be able to estimate when and where it will be possible to find a free parking lot.	Users, Parking service providers
FR-21	Parking	The application may indicate alternative parking lots/areas nearby when there's no parking availability (or the parking availability estimated probability is too low) on the user-selected area.	Users, Parking providers
FR-22	Ticketing	The application must be able to receive and track the routes, means, check-ins and check-outs by the users, to share the revenue among the different transport providers.	Users, Transport service providers, Ticketing and payment service providers
FR-23	Ticketing	The application must be able to handle different subscription forms and tariffs decided by the transport providers.	Users, Transport service providers
FR-24	Ticketing	The application may allow the user to pay a single periodic bill for all transportation services providers.	Users, Ticketing and payment service providers
FR-25	Ticketing	The application may provide the user with a report of all routes and their relative costs, and the total cost.	Users, Ticketing and payment service providers
FR-26	IoT Edge	Traffic sensors must at least provide their GPS location and the traffic flow intensity.	City Council
FR-27	IoT Edge	Parking sensors must at least provide their GPS location and their status.	Parking service providers
FR-28	IoT Edge	Ticketing devices must at least provide User information, transport mean and their GPS location.	Ticketing and payment service providers
FR-29	IoT Edge	Vehicle docking stations must at least provide User information, Vehicle info, Status and their GPS location.	Transport service providers
FR-30	IoT Edge	Vehicle sensors must at least provide Vehicle/transportation line info, Speed and their GPS location.	Transport service providers
FR-31	IoT Edge	Environmental sensors must at least provide humidity, Air quality, noise and wind speed.	City Council
FR-32	IoT Edge	Mobility premises must at least provide their GPS location and their status.	City Council, Transport service providers
FR-33	IoT Edge	User devices must at least provide their GPS location.	Users

3.3.2.2 Non-Functional Requirements

Table 4: Non-functional requirements of multimodal assistant application.

ID	Subsystem application	Description
NFR-1	General App	The application should have a low footprint on energy consumption.
NFR-2	General App	The application must support most of the screen resolutions and screen form factors (responsive).
NFR-3	General App	The application must be able to run on mobile devices.
NFR-4	General App	The application must provide information in a user-friendly way.
NFR-5	General App	The application must use standard data models.
NFR-6	General App	The application's interface should be accessible by people with disabilities (ease of access).
NFR-7	General App	The application should minimize the amount of data exchange between the servers and the user's device (to minimize data traffic consumption).
NFR-8	General App	The application must support language localization of the user interface.
NFR-9	Privacy	The application must allow the user to manage (delete, restrict, modify, download...) his/her personal/private data and to eliminate his/her account at any moment.
NFR-10	Privacy	The application must provide the user with the privacy policy.
NFR-11	Privacy	The application must be compliant with the EU GDPR (General Data Protection Regulation - Official Journal of the European Union, L 119, 4 May 2016) and national regulations.

3.4 Service specification for target use case

3.4.1 Service blueprint

To provide a more detailed insight of the Multimodal Assistant use case, this chapter contributes with two different visual representations of the service use case. The first representation, the experience cycle, gives a bird's eye view of service experience. The second representation, the service blueprint, provides a detailed visualisation of service components of the service.

The **experience cycle** (Figure 16) maps an example of a user (commuter, traveller or visitor) journey with the Multimodal Assistant application. In this example, the application suggests the user to drive his personal car until the available parking lot/space, then take a bus to a bike docking station, and finally ride until his final destination. Along the journey, the Multimodal Assistant application provides him several notifications: time to arrive, check-out locations, bike availability at the docking station. At the end, the app notifies the user of the total mobility cost and number of green credits won.

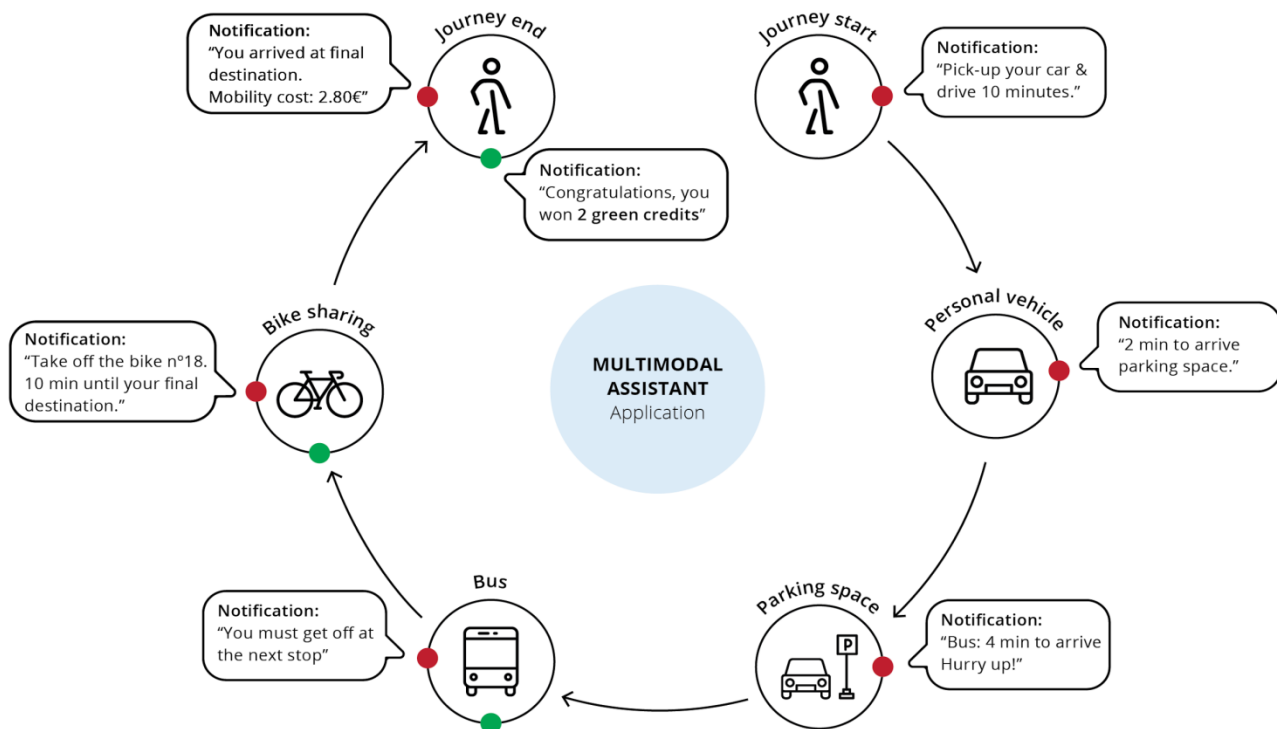


Figure 16: Example of experience cycle of the Multimodal assistant use case

Four practical scenarios are described below.

Manuel uses a seamless payment despite various operators (1)

Manuel lives in City A and works in City B (the bigger one). He leaves home in the morning and picks up a private bus (first check-in) to the train station; then, he picks up a public train (second check-in) to City B's central train station; finally, he picks up the metro (third check-in) to his final destination. At the end of the day, he does the same in reverse.

Since all the transportation modes and companies are integrated in the Multimodal Assistant system, he just needs to check-in at the start of each journey (three times in each direction). Manuel is a Multimodal Assistant user so he will receive a monthly bill, which he can pay by credit card or at an ATM machine. Also, he receives 'green credits' and rewards, such as 30 minutes for free each time he uses a bike or scooter sharing service, free tickets for cultural events, and vouchers for museums. Furthermore, as a registered user the system knows his preferred public means of transport, so it automatically notifies Manuel in real-time, about any change, delay or issue that may affect his journey, and offer him alternatives.

Roberto browses and compares possible bike/scooter sharing services and their availability information (2)

Roberto lives in City A and works in the centre of City B. Once a week, he plays indoor football with his friends at the end of the day. The football field is located far away from the centre; it has no public transports service; therefore, he always picks up a taxi before and after the game (which is quite expensive), the latter until the central train station. He then reaches home by using a train to City A, and a bus from City A's train station. He recently realised that the City B is offering new mobility services bike and scooter sharing services, which are provided by multiple private vendors.

By using the Multimodal Assistant app, he can choose any bike or scooter sharing company which is available close to his work office to rent a bike (when he leaves office on time) or a scooter (when he leaves office close to the start of the football match) to reach the football field, and the reverse way at the end of the game. To do that, he simply checks-in with his mobile phone at any bike or scooter sharing station, or simply picks up a free one if free-floating bike or scooter sharing services is available. Since he has multiple choices (multiple vendors), he can choose the one which has the best tariffs and service or he picks the vendor with the most suitable locations of docking stations or of free vehicles; besides, he can check the number of available vehicles at each docking station in real-time. Roberto gets back and leaves the vehicle at an available docking station close to the City B's central train station, and then reaches home the usual way (train and bus).

Sarah ensures accessibility of her planned route (3)

Sarah lives in City A; she is a disabled person who requires a wheelchair, but she often uses her car for transportation. She is planning a visit to City B. She finds that City B provides an application for multimodal transportation and planning. Through this application, she discovers parking areas locations, real-time availability of parking lots for disabled people and estimation of parking probabilities, linked to hours of the day and days of the week.

By introducing her preferences (e.g. tourist tour), the application suggests different interesting areas of the city and provides the most suitable parking options as well as different adapted route possibilities, including public transport connections and urban mobility infrastructures to reach them (e.g. bus, metro, train, escalators, etc.).

Alice plans her route according to environmental conditions (4)

Alice has a 6 months old baby, so she usually moves across the city with her pram. She enjoys walking through the big park on the other side of the city with her baby. If the weather is fine, she usually walks part of the way to the park. If there is a possibility of rain, she may take a bus and walk.

The Multimodal Assistant app offers her all the possible combinations, including bus lines, metro and urban mobility infrastructures like elevators, so Alice can configure her path before leaving home. It also includes current information about noise and air quality, weather conditions (real-time and forecast) and street occupancy, which allows her to avoid crowded, noisy and polluted streets, and to avoid walking when the weather conditions are not appropriate for her and her baby.

To enable the above scenarios, a series of basic features and data are needed. The main features that we have identified include: multimodal itinerary planner and navigator, multimodal ticketing and payment, and smart parking. The main data sources are: transportation (real-time and scheduled); noise and air quality (real-time); weather (real-time and forecast); pedestrian and traffic flow and restrictions (real-time); parking (real-time); and points of interest (static). The Multimodal Assistant service blueprint is visualized in Figure 17 through Figure 19; it is divided in three main service stages: **acquisition**, **usage** and **post-usage**. The six main swim lanes (each lane is assigned to a specific category) that are represented in the Multimodal Assistant service blueprint are the following:

- **Phases of the journey:** represents the journey steps of the service.
- **Physical evidences:** everything that the user can see, hear or touch— touchpoints.
- **User actions:** the actions that the user has to take to experience the service.
- **Frontstage interactions:** the activities that the user can see while going through the service.
- **Backstage interactions:** the activities required to produce the service that the user does not see or interact with.
- **Support:** the actions that support the service.

In the Multimodal Assistant service blueprint there are **three primary lines** that separate swim lanes of information, they are:

- **Line of interaction:** the points at which customer and the service provider interact.
- **Line of visibility:** beyond this line, the customer can no longer see into the service.
- **Line of internal interaction:** the point where the service provider interacts with 3rd party partners and processes.

The **experience cycle** that is represented in the stages *Real-time info* and *Multimodal mobility* (indicated in the *Phase of the journey* swim lane) of the service blueprint, describes the steps that the user can do repeatedly during the service usage main stage.

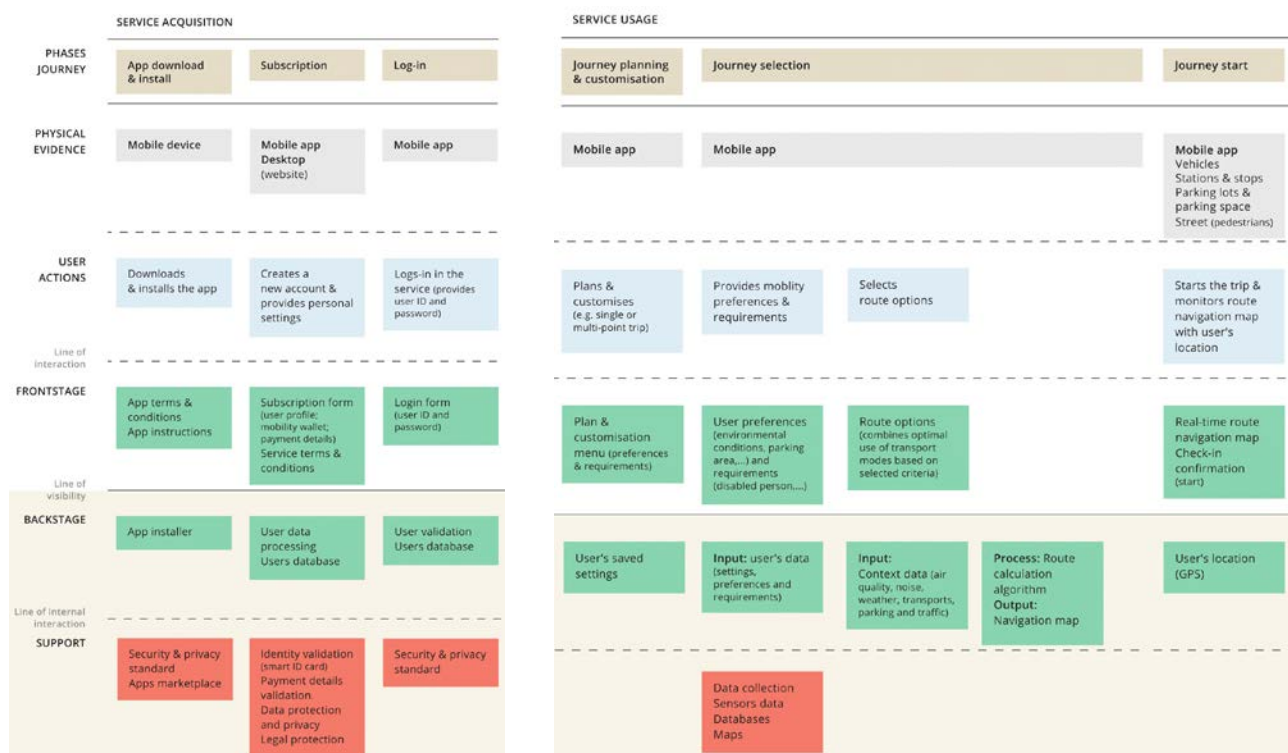


Figure 17: Service blueprint structure of the Multimodal assistant use case – part 1 of 3

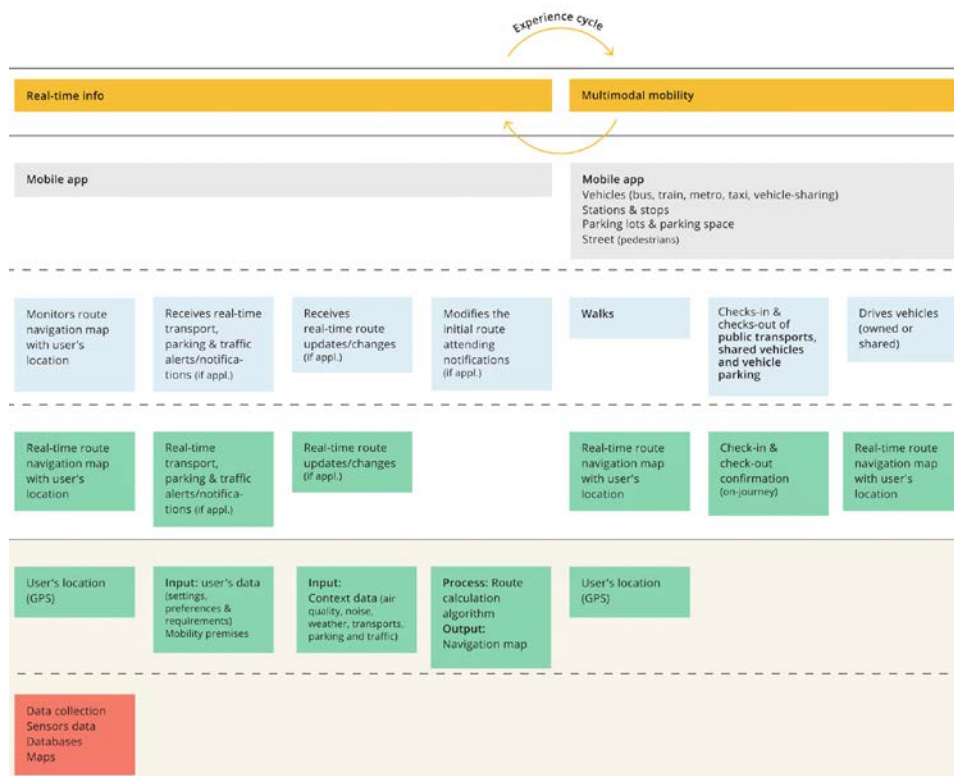


Figure 18: Service blueprint structure of the Multimodal assistant use case – part 2 of 3

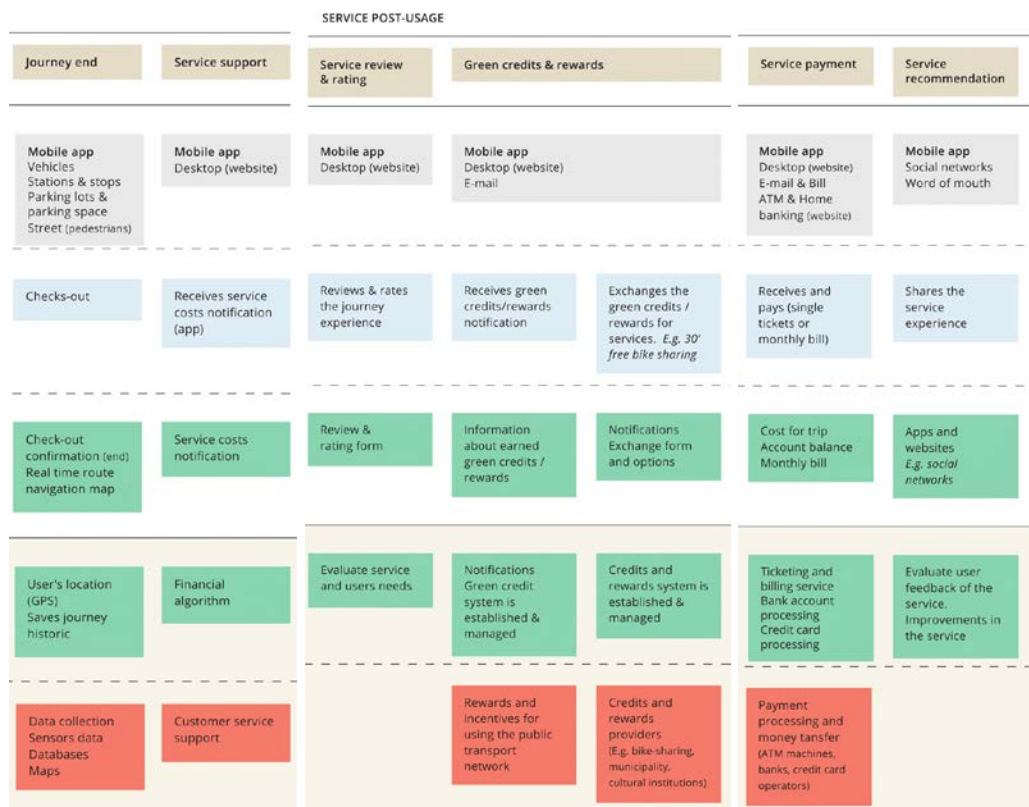


Figure 19: Service blueprint structure of the Multimodal assistant use case – part 3 of 3

3.4.2 Value proposition description

Why: Urbanization is an increasing global trend and cities and citizens are facing different kinds of challenges; one of the most important challenge is mobility. The use of private cars in cities is having and increasing and high negative impact on mobility, sustainability, quality of life, noise, air pollution, incidents, etc., in particular in big cities. To alleviate these impacts, it is necessary to improve the quality and efficiency of mobility means, for instance, by providing citizens with appropriate tools that can support them when moving between cities and within the cities: accessing correct information and facilitating them in the use of both public and private transports available in the cities (such as metro, bus, car and bike sharing, etc.) in a seamless way.

What: Citizens will be able to plan and use public and/or private transports such as bus, metro, bike-scooter-car sharing, etc., including mobility premises like public escalators, elevators or cables, without the need to make new registrations on each service/companies platforms and accessing information about those different means of transportation and about their premises (e.g.: about parking areas and parking lots), in order to provide an easier way to access the transportation infrastructures available in the cities, to save time and to reduce traffic. Users will be able to plan their itineraries considering different variables, to receive notifications of disruptions/incidents/changed conditions along their route, based on their location and to pay for all the mobility services used in a seamless way. This will improve efficiency of transportation in the cities.

With: A dedicated application (e.g. for user devices) that provides mobility information about different means of transportation and mobility premises (e.g. time tables, prices, parking lots, car sharing availability, escalators, etc.).

Who: Inhabitants, commuters, travellers, city visitors and tourists.

When: Moving for different means: jobs, vacation, shopping, etc. This implies commuting between different lines, companies and modes (urban areas) and different cities (suburban areas) and using of public/private transports & sharing services and finding free car parking lots.

Where: Throughout cities and their suburbs.

User requirements:

- Obtain accurate and optimized travel itinerary based on real-time and updated mobility data, and user's preferences and requirements.
- Access to wider and complementary offer of transportation modes.
- Easy combination of public and private (owned or shared) transportation modes.
- Easy find of free parking lots.
- Avoid infractions and fines.
- Understand clearly the total cost of transportation and ticket validity.
- More efficient use of mobility time.
- Use a multimodal and single ticket.
- Access to a seamless and flexible payment system.
- Use a single one-stop-shop mobility platform

4 Application theme: community policy suite

City governance and development of policy is often dependent on historical data, and strategies are developed over a long timescale. Within cities, the adoption and implementation of new policies takes place either within existing services or through the creation of new teams, often dependent on external factors (regulation, funding, political priorities) or being reactive to problems (homelessness, air pollution). IoT provides cities with real-time data that is often used for day-to-day operational functions, but is not currently being utilized for service management or strategy development.

Both traditional hierarchical structures (service “silos”) and cross-departmental working are in use within the city, often in an ad hoc way. To better inform the city’s governance, it is critical to provide a mechanism where IoT data can be combined with historical and static data to better inform: (a) management decisions (b) strategic decisions. To provide an initial proof of concept we will look at how environmental conditions, namely poor air quality and noise levels have a damaging effect on delivery of a better city.

The aim of the community policy suite (WP3.1) is to design and implement an approach to developing innovative IoT-based solutions that leverage the SynchroniCity digital single market. The objective is to enable local authorities to become more agile in their management and policy making processes (Agile Governance).

Because IoT provides real-time information, this can not only be used in a pre-defined way for operational day-to-day management but can provide an information and intelligence layer for city governance which is currently not being utilised to its full extent. As cities identify new problems or initiatives, the use of accurate, timely data sources, and their combination to provide intelligence for complex challenges, can accentuate innovation.

The cost of implementation of IoT solutions and their need to be specifically designed for the environment (e.g. placement of sensors, regularity of data collection, integration with legacy systems), provides a series of separate hardware and software solutions across the city, often only connected through some shared infrastructure. By looking at how the data from these solutions can be re-utilised for a range of problem statements, and repurposed for different stakeholder groups beyond operational managers (e.g. strategic managers, data analysts, developers, citizens), we can identify a range of different tools that need to be used to maximise the use of this data.

Within this document we look at the stakeholder work that has been undertaken in two target cities, Porto and Manchester, and synthesize the findings towards a common use case. With analysis of the datasets available currently and during the course of the baseline applications, we have identified a genuine commonality between two cities which will utilise some of the same software tools to manage and share data, within the wider context of the developing Synchronicity technical architecture.

4.1 Description target use case (initial application)

Working with Porto and Manchester, who have different IoT infrastructures, governance structures and levels of smart city maturity, we used the following approach:

- Each City identified their internal priority themes;
- From these discussions 2 themes were chosen, and these were validated within the cities to identify the commonalities of the use case.

What

City councils will have access to a service which provides a data based situational awareness to support the definition, implementation and evaluation of policies. A suite of tools to analyse and display streaming data from many sensors and devices, to present issues, in a tangible way, by

providing a searchable interactive map to explore pain points in the city in real-time, will be available to:

- Provide hierarchical access to consolidated, siloed data sets, giving real-time insights;
- Alerts for peaks in unwanted activities (CO2 levels, noise);
- Utilise people and vehicle tracking to identify and respond to pressure points in city activity e.g. around public events;
- Enable intelligent job tasking across these teams;
- Facilitate a more efficient way of responding to the cities' needs;
- Creates recommendations for policy makers;
- Support the implementation, test and validation the implemented policies;
- Promote data based decision making.
- Provide better management of city resources.
- Providing customised views of city data for different stakeholders.

One aspect is an open interactive map that offers a bird-eye view of current conditions of the city—with information on noise and air quality levels, street works, green areas, waste management, mobility and pedestrian volume amongst others. From the city hall's perspective this interactive map can be adopted as a helpful working tool to monitor different locations and real-time conditions of the city. This map is designed to be dynamic and have a user-friendly interface to:

- Improve cross-department work;
- Promote quick and effective actions: placing scarce resources where they are most needed; improving the urban experience for visitors, resident and workers;
- Enable the redesign of services and policies to better reflect the needs of the city;
- Reduce environmental impact – namely of vehicle's emissions;
- Promote more efficient routes for pedestrians, public transportation and municipal vehicles;
- Promote an effective control of the impact of traffic and construction;
- Augment the efficacy of response to specific events - alert authorities for high noise or Co2 emission levels;
- Bring a richer experience of the city to both stakeholders, the citizen and city council members;
- Improve situational awareness during events by sending alerts to city council members (traffic, construction, cultural events, etc.);
- Define filters and location-based analytics that automatically refine and focus real-time data on specific events or locations.

Noise and poor air quality can be caused by traffic, construction or people gatherings. In the case of traffic it is often a symptom of a city's large incoming working population (or visitors) which leads to increased congestion, slower journey times, and poor health outcomes in the affected areas. This initial application aims to mitigate these problems through more extensive monitoring, developing policies for example for restrictions on polluting vehicles and better movement of people leading to new solutions that can enhance the experience of city living and working through targeting the most affected areas of the city and groups of people. As such, the target application explores how IoT data can inform and influence policy at a strategic, managerial and operational level as well as validate that same policy.

As more IoT data becomes available during the course of the initial application development (e.g. people counting, bike journeys), the deployment of the application can be extended to other areas and domains of the liveable city.

As well as an information tool, this interactive map can be used as a communication and cross information channel between city hall and citizens through a common visual language, to gather relevant information about users (citizens and visitors), needs and interests in real-time; can increase civic engagement and transparency; and helps optimize interventions processes. The introduction of gamification—the application of game-design elements and game principles in non-game contexts such as citizen participation platforms— instruments aims at building a citizen's participation programme. By bringing a more competitive and playful character the commitment rate can be significantly higher. People are driven to contribute to something from which they will benefit from a personal and community point of view. To enhance the challenge impact, the project plans to integrate an innovative rewards mechanism, such as green-credits which can be exchanged for city merchandising or public transport tickets. By introducing these features, the project can influence citizens behaviour and motivate them as “players” to do eco-friendly actions.

Datasets: noise; air quality; mobility; street works; green areas (urban gardens, parks); Possibly also: pedestrian volume, waste management, culture events, commercial spaces;

Who

The Primary stakeholders of this use case are Municipalities and municipal companies aiming to promote a data based decision making process through monitoring and validation tools for policy making. Main Stakeholders:

- City councils: City officers, operational managers
- Municipal companies
- Citizens that can be engaged in the monitoring and validation process as well as in the behavioural transformation.

Manchester: The main stakeholders in Manchester are city officers. The reason we are targeting this group, is that the improvement in governance is focused on enabling better understanding of the city's problems, so we can look to develop better overall responses. This focus has come out of considerable work identifying key leaders and teams within the city council, those that currently use data to inform their work, and those who provide this service to front line managers and staff. 14 operational and strategic managers who work with data have attended stakeholder workshops where we have validated the agile governance approach, outcomes include:

- Identification of city needs
- Data availability
- Decision-making flows
- Deployment of ad-hoc teams

The primary geographic focus will be within our smart city reference zone on Oxford Road Corridor, and the adjacent city centre area. Key departments involved in the stakeholder workshops have included Performance and Intelligence; Data Governance; Reform and Innovation; Policy, Partnership and Research; and Public Health.

Porto: The Primary stakeholders of this use case are the municipality and municipal companies aiming at promoting a data based decision making process through monitoring and validation tools

for policy making. In the case of Porto, the main stakeholders are: Porto Municipality, Porto Digital, EMAP (Empresa Municipal de Ambiente do Porto) and CGI (Integrated Management Centre). Another main stakeholder which is as well the target end-user is the citizen which we aim at engaging in the monitoring and validation process as well as in the behavioural transformation.

4.1.1 Value proposition canvas

Customer jobs

City council:

- Policy-making based on “guesswork”;
- Problem centred approach on decision making process;
- Build and implement a policy;
- Policy developed within functional and hierarchical silos;
- Collect citizens claims and suggestions;
- Municipality strategy development;
- Leading environmental projects;
- Improve citizens quality of life.

Citizen:

- Live their lives in the city (working, living, traveling, leisure, sports);
- Search for green public urban areas;
- Discover healthy spots and points of interest in the city;
- Enjoy the city during free times;
- Search about sustainable and environmental choices;
- Improve health;
- Develop sustainable skills and knowledge;
- Contact municipality for city issues;
- Create engagement in the community.

Pains

City council:

- Ineffective and unsuccessful policy implementation
- Uncertainty about the impact of new policies
- Policies developed within functional and hierarchical silos
- Unnecessary financial costs
- Time consuming to build and implement a policy
- Scattered, insufficient and uncontextualized city data
- Lack of data driven tools
- Communication barrier between municipality departments
- Negative citizen perceptions
- Regulations & legislation barrier

Citizens:

- Communication barrier between citizen and the municipality;
- Lack of communication about sustainability and environmental actions;
- Lack of time to search and apply to environmental initiatives.

EXAMPLE: Requests and information from Councillors and Citizens can come in via a number of ad hoc channels. In most cases, the answers to the challenges will not be easily gathered, particularly where a comprehensive or highly specific request is required. Even where the information is readily available, it will only be accessed via certain departments and certain people within those departments. This process can sometimes take weeks, and can lead to a poor level of service, as well as involving a wide range of officers across multiple departments taking them away from their current work. The system works best when officers work together and know who to go to with information. It is essential to work in new cross-department processes and workflows promoting a sustainable response despite the possible staff changes and people moving jobs.

Gains

City council:

- Have a more efficient and effective policy decision making process;
- Access to information that reduces guesswork;
- Improve citizens quality of life;
- Access to city data;
- Get to know city interactions and environment in real-time;
- Have an open communication channel with citizen (if applicable);
- Data measurement and mapping;
- Accelerated policy approval process.

Citizens:

- Centralized and contextual city information;
- Access to information that reduces guesswork;
- Have an open communication channel with city council (if applicable).

EXAMPLE: Understanding that ad hoc requests for information are difficult to turn into a regular service, a new approach is adopted - bringing data closer to the individuals requesting it so they can immediately get an answer to more common questions, or can more easily find the officers in other departments who are also on city. By combining with other data sets, which are linked through the system, a quicker and more bespoke response is possible. It becomes easier to identify which ad hoc requests require new teams or workflows, which we can then quickly implement as demand increases.

Pain Relievers

City council:

- Have a single visual platform with all the city datasets;
- Encourages cross-silo working through involving officers across many teams;
- Improve cross-department work;
- Monitor alert about noise and CO2 emission levels in real-time;

- Cleaning up city air and reduce noise levels;
- Open communication channel;
- More effective use of city resources management to reduce financial costs;
- Enhance citizens engagement;
- Identify valuable information and patterns to support policy decision making;
- City datasets that helps identify patterns and pain-points.

Citizen:

- Facilitating issue reporting;
- Receiving feedback;
- Analyse and identify areas of the city;
- Be able to monitor noise and air quality levels;
- Influence on citizen and community health levels;
- Have a more green and pleasant public urban areas;
- Make the city more attractive and sustainable;
- Promote more efficient and green routes;
- Cleaning up city air and reduce noise level.

Gain creators

City council:

- Collaborative approach to problem solving, internal and external the organization;
- Insure policy viability and feasibility;
- Create truly valuable policies and services;
- Increase of interoperability between data sensors and with citizen;
- Contextual and real-time working tool;
- Implement a citizen-centred approach on decision making process;
- Accelerated policy approval process;
- Encourages cross-silo working through involving officers across many teams;
- Build relationships with external stakeholders.

Citizens:

- Increase trust and transparency for the municipality;
- Decreases barrier between citizen and municipality;
- Improves knowledge about the city by integrating data;
- Follow city growth and improvement;
- Be an active voice and be part of the development of the city;
- Have a healthy impact in their life;
- Build a relationship with the municipality;
- Be rewarded, with green credits, for an actively participate in sustainable actions.

Product & Services

City council:

- Open interactive city map with data visualization in real-time;
- Methodology for agile governance that can “stress test” any software solutions;
- Air quality and noise level awareness;
- Filter and location-based analytics;
- Software that makes it easier to get and interpret city data;
- User friendly experience;
- Develop sustainable products, services and policies;
- Web and mobile based solutions;
- Incentives for citizens involvement;
- Customisation view of city data.

Citizens:

- Software that makes it easier to get and interpret city data;
- Web and mobile based solutions for example around incident reporting including potential ways of incentivizing;
- Air quality and noise level location-based awareness;
- Centralized and contextual city information;
- Gamification instruments.

The Value Proposition Canvas of the target use case brings together all the above sections in an infographic and synthesized way, and is provided in Figure 20 and Figure 21.

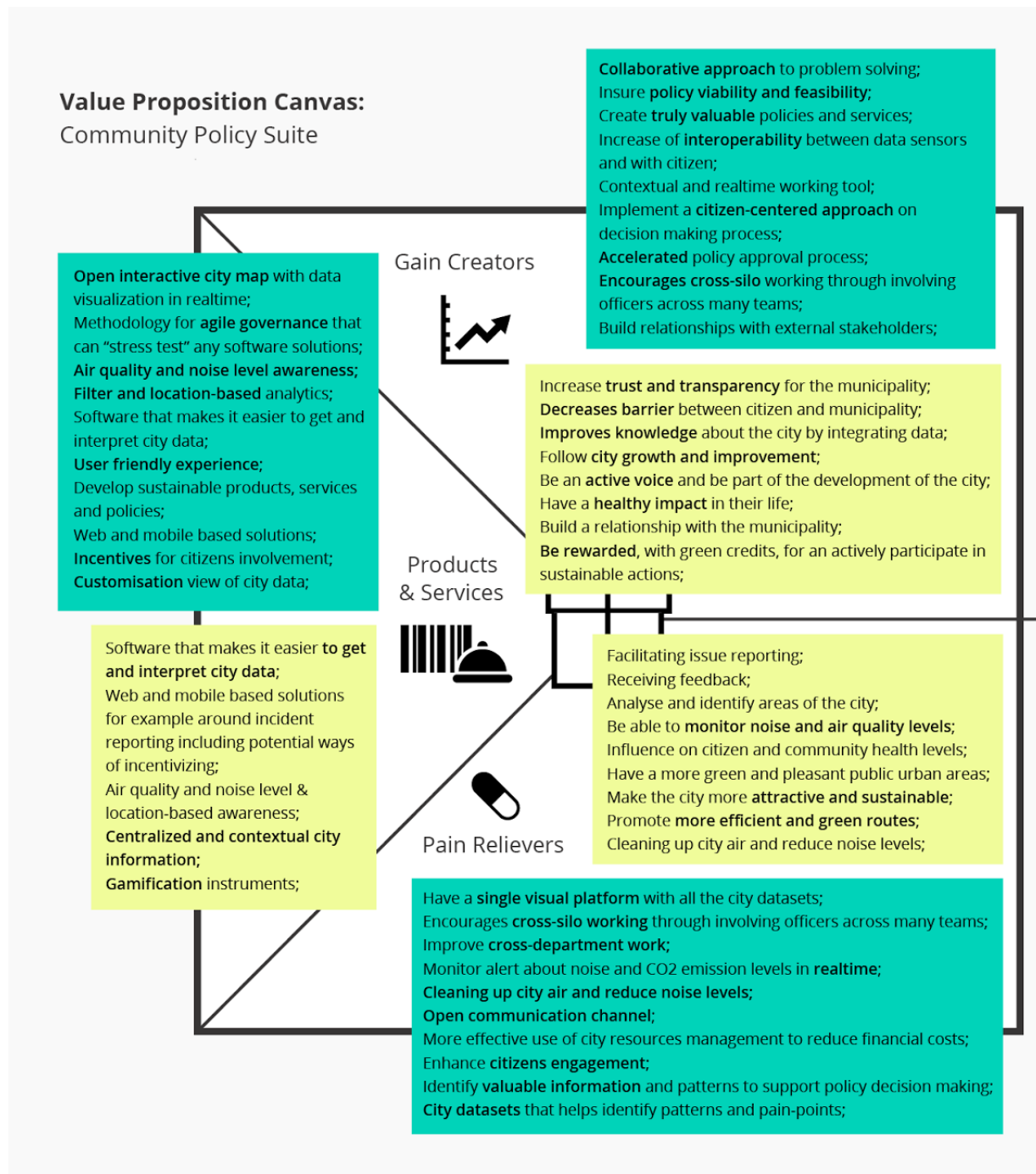


Figure 20: Value proposition canvas of the agile governance use case (1/2)

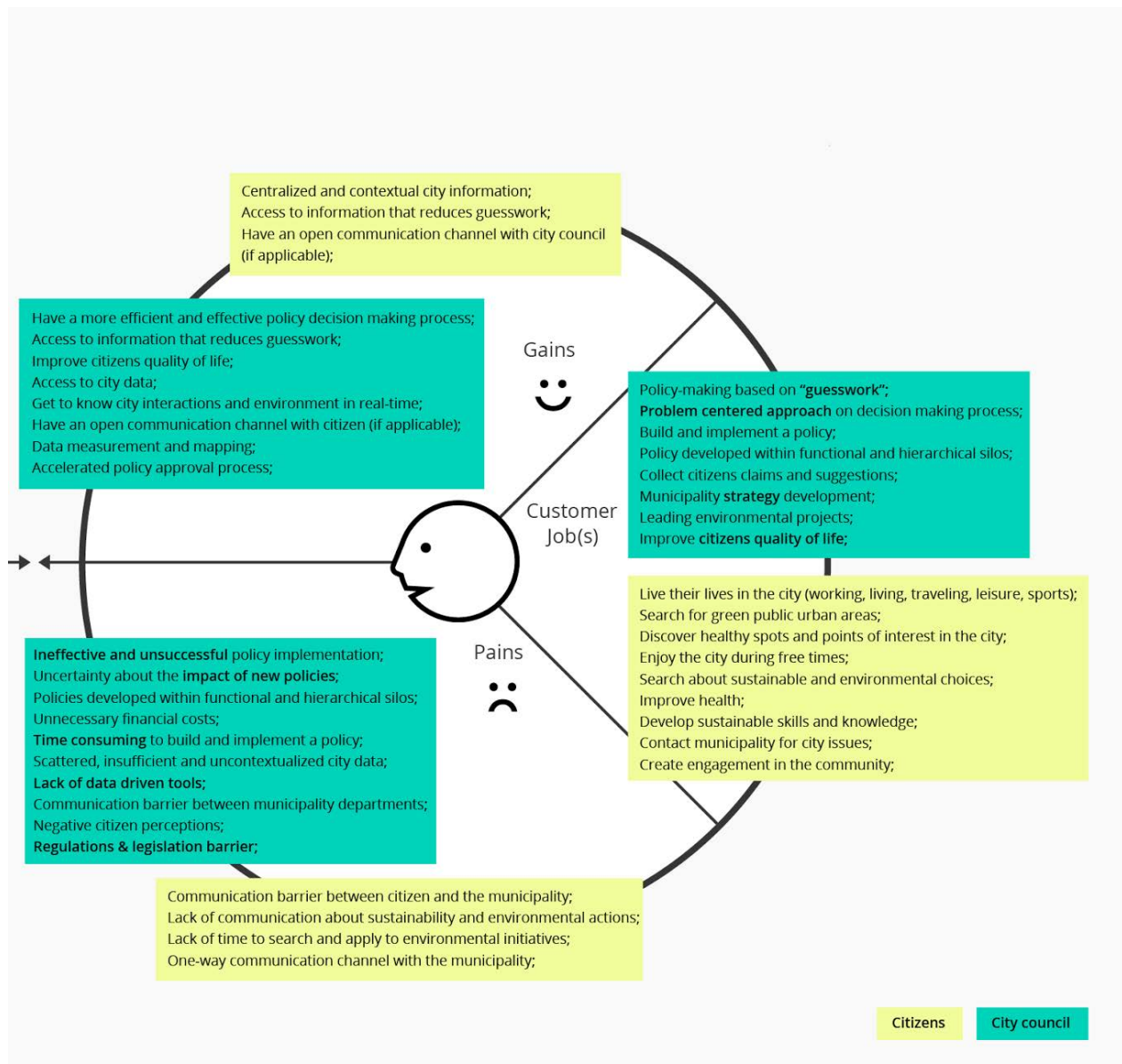


Figure 21: Value proposition canvas of the agile governance use case (2/2)

4.2 Value network and customer interactions

4.2.1 Descriptions of stakeholder profiles and their roles

The stakeholders and their roles around the target audience are identified in Figure 22. They are divided in three main categories: the **core stakeholders** (target audience)— that have direct participation in the service and an open interaction with the end-user— the **internal stakeholders**— that are involved in the service process and have a direct influence in the customer experience— and finally, the **external stakeholders**— that influence the service process and ensures the proper functioning of the service. The list below provides more detailed information about the different stakeholders and their roles in the cities.

Core stakeholders

Citizens:

- The citizens represent end-users within the Agile Governance ecosystem. Citizens can have two roles at each end of the service design:
 - Citizens with a more collaborative and active role with the interactive map and throughout the policymaking process. The aim is to involve citizens during the phases of exploration, design and implementation of a new and innovative policy solution by inviting them to co-create with the city council.
 - Citizens as recipients of the service with a participatory role by actively interacting with interactive map. The aim is to understand citizen behaviour and capture their needs and frustrations across the data generated and visualised in the interactive map. This interaction will reinforce a data based decision making process through monitoring and validation tools for policy making.
- Besides their relevant role in the service design, Citizens are the beneficiaries of the services. Being the end-users, they are also part of the validation process of the implemented policy either with a direct communication (e.g. direct feedback) or indirect information (e.g. data collected on the quality of life).

Strategic managers & administration:

- The strategic managers & administration have as main role the identification and exploration of needs or problems captured in the city interactive map. Furthermore, these stakeholders— these usually are in the senior management team or a wider leadership team— should have the capability to implement and lead on the development of a response to a new service proposal.

City council staff & local policymakers:

- The city council and local policymakers are essential for the implementation and maintenance of the interactive map.
 - The city council is responsible for receiving and coordinate information between internal and external stakeholders.
 - The local policymakers are responsible for analysing and interpret the data visualisation in the interactive map to be able to develop data-based policy with or without the citizens participation. In a more macro view, this stakeholder is responsible for developing policy and regulations for the city.
 - Example of the stakeholder interaction: the strategic manager should appoint a project manager who will then (with support from strategic manager) construct a virtual team which will look at developing and implementing a new service or solution.

Business Owners:

- This stakeholder has an important role in the Agile Governance service; they have an indirect and direct participation on the service application. Through an indirect approach this stakeholder contributes with data generation which feeds the interactive map. Furthermore, the business owners have a direct participation with the interactive map to be informed and updated about the city current status.

Internal stakeholders

Council & Service Manager:

- These stakeholders are usually responsible for a team of operational staff and will be involved in implementation of new services including the involvement of their staff.

Data collectors & providers:

- The data collectors and providers should become city council partners for the collection and monitoring of city datasets. These stakeholders have the responsibility to share real-time data with other stakeholders and manage the data generated by the city (sensors and current datasets). The aim is to provide information for data users such as the city council (policymakers, strategy managers and administration) as well as the citizen (drivers, pedestrians and business owners).

Gamification Manager:

- The gamification manager is responsible for the application of game-design elements and principles in the service with the aim to increase citizens engagement and create an open communication channel between end-users and the city council. Applying the gamification functionality into the solution it can be a very helpful trigger and driver for behaviour change.

Communication Team:

- The communication team is responsible for the development of a communication and marketing strategy of the service, with short-term and long-term activities. The main goal of this stakeholder is to reach maximum number of citizens and turning them into users of the service.

Interface developer:

- This stakeholder is responsible to develop, design and build an interactive user interface. During the service lifetime the interface developer should provide support and maintenance to the service platform (interactive map).

External stakeholders

Municipality:

The municipality plays an important role in the Agile Governance ecosystem. The communication and cross information between internal and external stakeholders is the main role of the municipality. Furthermore, other responsibilities are incorporated in municipality role such as:

- Responsible for the financing and payment systems between different service providers (data collectors, gamification managers, infrastructure and software provider).
- Responsible for the control and maintenance of data sensors devices and infrastructure planning.
- Responsible for passing on information to Data & Information and Communication Technology Analyst to support and feed different infrastructures and software.
- Responsible for regulation and support of policy development and implementation.
- Responsible for the communication and marketing strategy of the use case through the communication department.
- Responsible for look after the interests of the entire city. The municipality stakeholder should

minister to the comfort and health of its citizens, and may educate, instruct, please and amuse its inhabitants by understanding their tangible and intangible needs.

- Responsible for achieving goals of sustainability and city liveability.

Data management:

- This stakeholder should be responsible for passing on valuable information of insights identified in the interactive map to each department. E.g. the current traffic problems, increased noise level and low air quality.

Software Provider:

- This stakeholder is responsible to build a technologic infrastructure of the service interface to provide support to other internal and external stakeholders of the Agile Governance ecosystem.

Politician:

- This stakeholder has the responsibility to interpret and analyse the data generated and transform into policy solutions. Just like the policymaker stakeholder, the politician has an important role of capture valuable information from the interactive map that might be helpful in policy making.

IoT infrastructure & Optical Fiber infrastructure (sensors & IoT devices):

- These stakeholders are essential tools to provide support to all the service infrastructure. Responsible for the installation and integration of data sensors & IoT devices.

4.2.2 Visual representation of stakeholder network

To provide a more detailed insight of the Agile Governance use case, this chapter contributes with a visual representation of the stakeholder ecosystem as visualized in Figure 22.

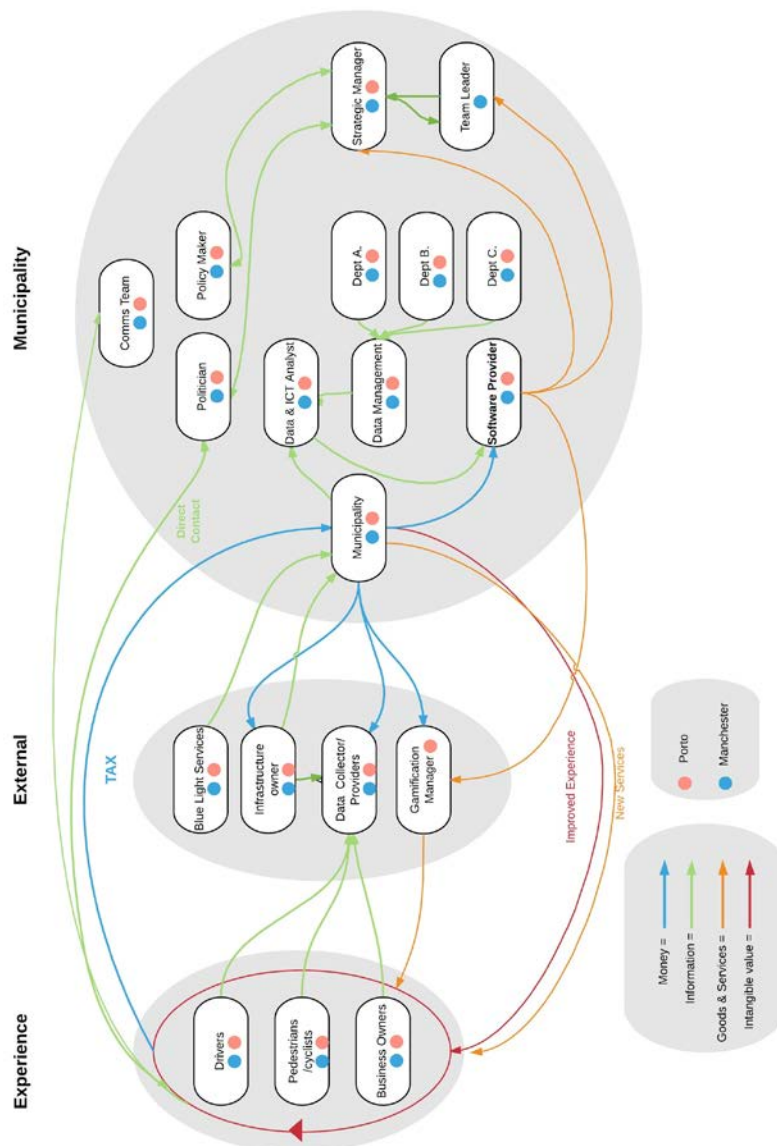


Figure 22: Value network for agile governance use case

This framework helps identify how this use case should be implemented and how different stakeholder contribute to the provision of Agile Governance service. The visual representation of the stakeholder network represents the relations and interactions between the different stakeholders and shows the type of value that is being exchange. It was identified four types of value: money, information, goods & services and intangible value. The direction of the arrows indicates the direction of the value exchange.

4.3 Technological composition of system

4.3.1 Visual representation of the (high-level) system architecture

The Agile Governance system shall be providing a platform for different levels of local authorities to interact with incoming datasets over the SynchroniCity framework and expose data to 3rd parties over the digital single marketplace.

The system will accept datasets from multiple, disparate sources / silos and provide a consolidation platform for visualization of the data and to provide insights. It will allow the use of historical / legacy data and will also be able to push back to these systems.

It will also allow the creation of teams to deal with city issues and facilitate interaction with the citizen. Live policy documents will be made available and using customisable workflows interaction with the system will be by exception for many users as processes and interaction with other systems are automated.

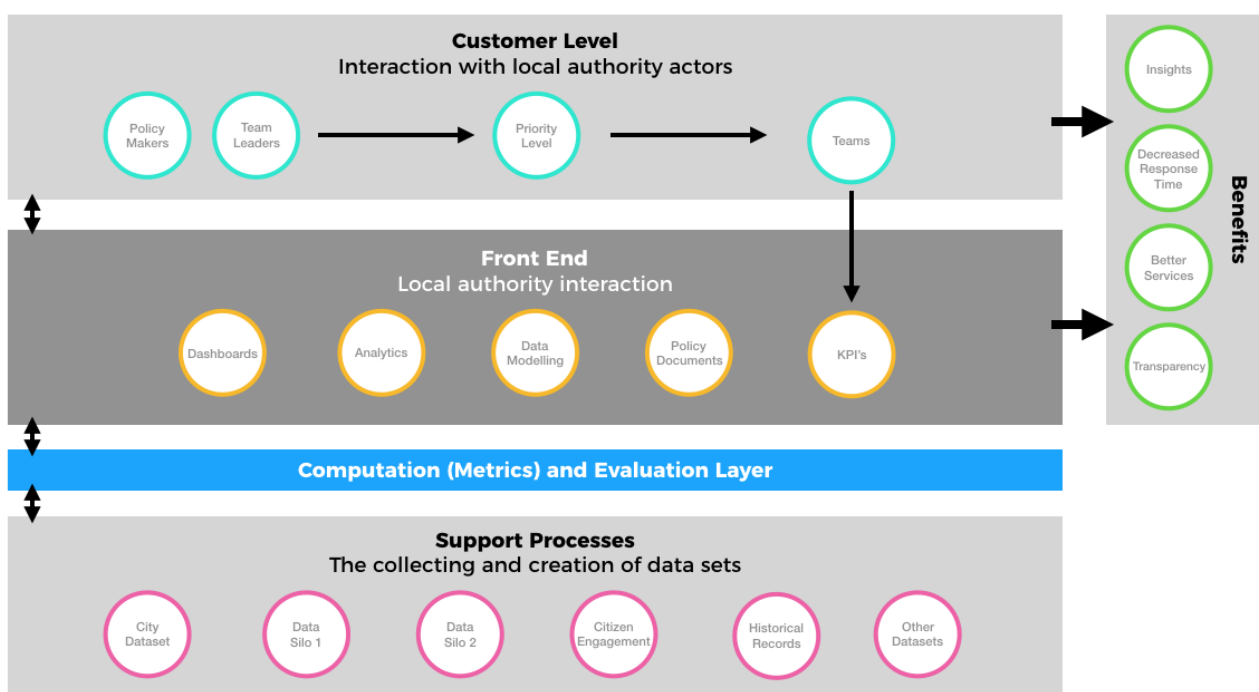


Figure 23: Visual representation of technical composition for agile governance use case

The below diagram represents the Community Policy Suite mapped to the SynchroniCity architecture. The digital single marketplace shall be used to pull data for local authority use and push insights that can be utilised, possibly as case studies for other cities.

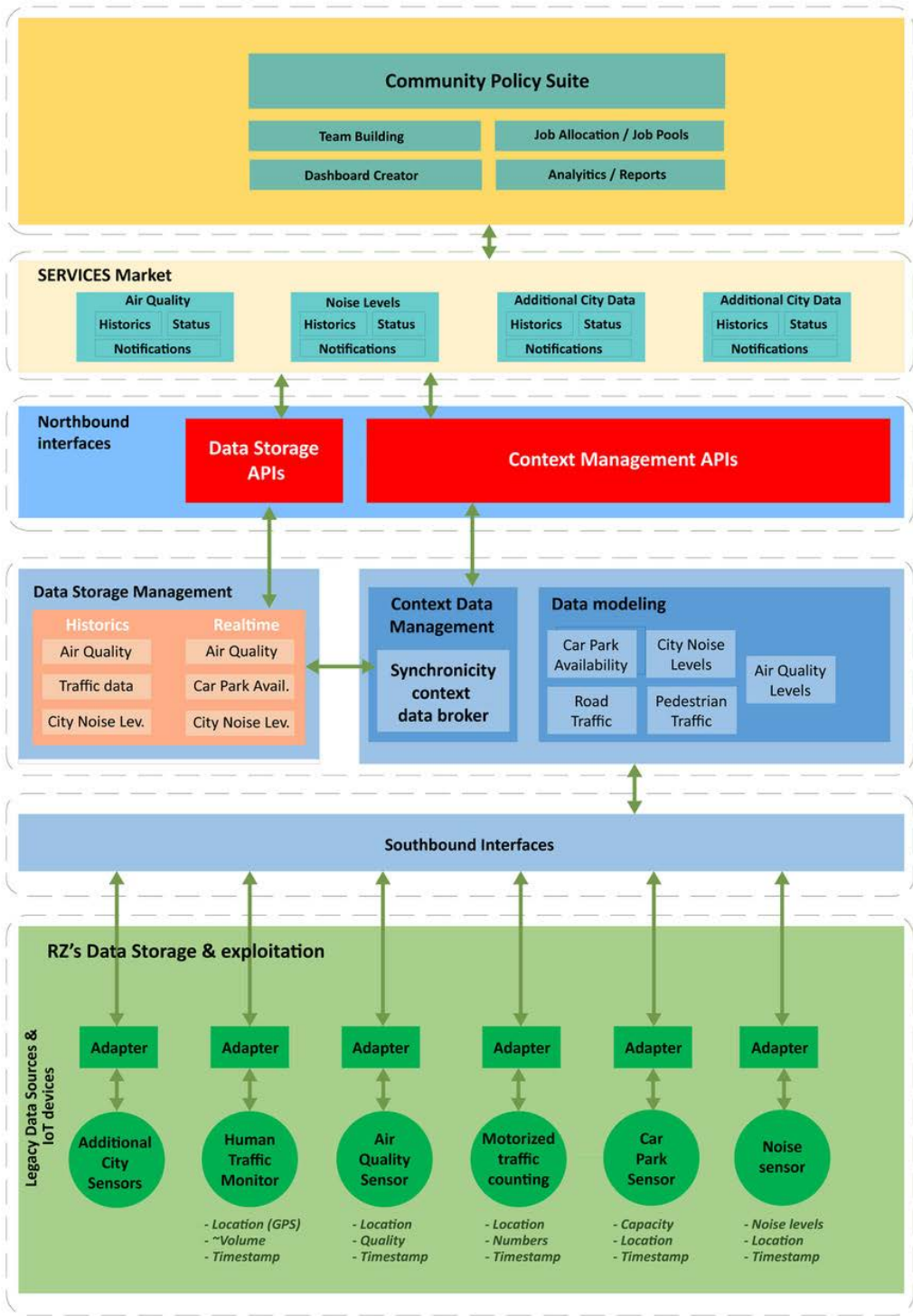


Figure 24: Technical composition mapped upon Synchronicity digital single market

4.3.2 Functional and non-functional requirements for the system architecture

The below two sections highlight important, top level functional and non-functional requirements from the system for the SynchroniCity framework, Porto and Manchester.

4.3.2.1 Functional Requirements

Table 5: Functional requirements of agile governance

ID	Description
FR-1	Hierarchical login; system should cater for login and access to different dashboards / datasets based on the hierarchy of the local authority
FR-2	Editable dashboards; based on city / team requirements user should be able to amend and lock (based on hierarchy) the dashboard “widgets”
FR-3	Data management; system should be able to take custody of the data and edit for visualisation
FR-4	UI requirements; system should be intuitive and easy to use
FR-5	User admin; authorities should be able to control their own teams / users via admin panels
FR-6	System should be able to connect to legacy systems available in cities for data acquisition
FR-7	Connection to SynchroniCity digital marketplace; for north and south bound data purposes
FR-8	Meta reporting; for statistics on data and user interactions with the system
FR-9	Workflows; for emailing up of reports and creating a level of autonomy between other systems

4.3.2.2 Non-Functional Requirements

Table 6: Non-functional requirements of agile governance

ID	Description	Related to
NFR-1	System should be available on the most recent browsers and sensibly back a few versions	Accessibility
NFR-2	System should be backed up at an agreed level (most likely daily)	Backups
NFR-3	Security certificates should be in place at all times	Certification
NFR-4	Code base should comply with the most recent standards at time of development	Compliance
NFR-5	System should be flexible to be deployed via either a cloud based service or an on-premise solution	Deployment
NFR-6	System should consume the minimum amount of resource as is reasonable	Efficiency

NFR-7	System should have a response time that is convenient to users	Performance
NFR-8	System must adhere to privacy laws	Privacy
NFR-9	High up-time is to be expected (>99.5%)	Reliability
NFR-10	System should demonstrate a high level of security and include latest data encryption methods	Security
NFR-11	System interfaces should be easy, enjoyable and intuitive to use	Usability

4.4 Service specification for target use case

4.4.1 Service blueprint

Below paragraphs provide use case scenarios that are visually represented in the service blueprints that are provided in Figure 25 and Figure 26.

A typical use case scenario for the city council (1):

Councillors have approached senior management because of an increase of complaints from residents about city centre issues affecting the environment outside of their apartments. City managers are currently only able to provide the elected members with general statistics on waste collection, pollution, visitor numbers, and car park occupancy and the information doesn't address the specific resident needs. It is agreed that the responsible officers will provide accurate, more timely data in a map that is accessible to each councillor according to their ward. Existing systems are not able to provide this information and will require considerable development time and cost to provide the necessary integration. With the involvement of the team working on Synchronicity, we can identify the specific nature of the problem identified, pull in a number of datasets that we have already identified as providing key information, and by combining them and outputting to a specified map are able to provide a quick "birds eye view" of the problem which we can quickly assign to managers across different departments who may not otherwise have access or experience with particular systems. The council officers are therefore able to link up residents' problems with operational patterns and identify ways of improvement. In one scenario we identify that building works have been taking place in the same area where waste disposal takes place and that this has led to several weeks of missed or irregular collections. We can use this information to improve future provision and lead to quickly and more efficiently improving services.

A typical use case scenario for the city council (2):

During the winter months there have been increasingly poor figures for respiratory health in a specific part of the city leading to delays in getting to a doctor and increased waiting times in A&E departments within hospital leading to budget shortfalls. Analysis of the figures sees that there is some correlation between days when air quality readings are poor and the difficulties for public health. Public Health messages about air quality are not reaching the people who need them most leading to increased problems and costs. By using this information, and sharing across a range of different departments in the city, we can develop a targeted local neighbourhood plan for "better breathing" which is supported by text alerts, emails and posters; and health and community visitors are given access to information via a special dashboard on their phones where they are able to link these alerts with their list of vulnerable clients. When visiting clients, they can look at mitigating poor respiratory health. Over time, this is expected to result in a considerable drop of the number of

emergency referrals in the area.

A typical use case scenario for the city council (3):

The environmental department of the city has been receiving complaints from the citizens communication platform about the noise levels in a specific area of the city. To measure the local noise level, the city council members use the open interactive map to analyse and measure the level of noise creating valuable insights about the area. Through that they can determine the main sources; to what extent should noise be reduced; the level at which action should be taken; and facilitate the policy making process to a more efficient and co-created approach based on data. After analysing the detected noise level problem, the council members can interact directly with the citizens and other main stakeholders— such as bars and restaurants— to co-create, test and validate a future policy implementation. To enhance the policy impact and have a more effective and active involvement of the main stakeholders, the city council will give green-credits— a rewards mechanism that offers benefits for both citizens and bars and restaurants that actively participate in the creation and maintenance of an eco-friendly environment.

A typical use case scenario for the city council (4):

A couple of buildings in the historic part of the city are being renovated. The environmental department detected in the open interactive map that, in areas of construction sites there has been a growth of traffic jam during the rush hours and noise levels were exceeding the recommended level during the day time. By analysing data on the interactive map, the council members could establish the location of the main sources of noise and congestion and also by how much traffic and noise should be reduced to maintain a comfortable environment to the citizens. After the initial analysis, a policy making process is initiated, with a co-created approach based on data and citizens participation. In a very effective way, council members decide to implement a new policy that limit noise level by reducing the working hours in construction sites and limit the hours for loading or unloading of goods in that same areas. By implementing this policy, the noise and traffic jams levels had a significant reduction.

A typical use case scenario for the citizen:

Through an awareness-raising and information campaign in the central areas of the city; citizens will be invited to participate.

For example: Joana, a citizen of Porto, is walking by Aliados and notices a new awareness-raising campaign in the city that invites citizens to explore and discover pain-points of the city that need support or maintenance. In exchange for her participation, the city council will reward green-credits that can be exchanged for city merchandising or public transport tickets. After reading this information, Joana gets excited about this project and immediately scans the QR code and starts to explore a bit more about the project. Later that night, Joana is having a beer with some friends in the “movida” area of the city, and realizes there is too much noise in the street because of a nearby bar that is having a concert. She quickly acts and reports the noise in the city council platform. The next day she is rewarded by the city council with green-credits. A few days later, Joana is walking to work and notices that the garbage can nearby her office is full and littler is starting to pile up next to it. She doesn't think twice, quickly reports the issue to the city council platform. In a few hours the street is finally clean, and she collects a few more green-points.

SERVICE BLUEPRINT	1. DISCOVER			2. ANALYTICS		
	1. Sign-up to Service	2. Data Collection	3. Explore Interactive Map	4. Notifications	5. Policy Identification	6. Prototype Solution
AGILE GOVERNANCE JOURNEY STAGES						
CONTEXT						
FRONT END INTERACTIONS  CITY COUNCIL  CITIZEN	- Creates a user profile - Adds team details, skills - <i>Creates a citizen profile</i>	- User selects data-sets to personalised view - Suggests data that needs to be collected through the dashboard	- User explores personalised view of the city with prioritized list of issues - User requests frequency and types of alerts - <i>Citizen explores view of submit and submits requests</i>	- Updates would be provided by activities and workflows, created by each city - <i>Update is sent in from citizen, this could trigger workflows</i>	- User searches live policy document to address issues in city - User suggests new/adaption of policy to tackle issue	- User prototypes solution and models data - <i>Citizen is engaged in testing solution</i> - <i>Citizen receives green credits for participation in prototype</i>
PHASE 2 : FRONT END INTERACTIONS LINE OF VISIBILITY		- Uploads data-sets and insights from their department		- Mobile council worker add unwanted activities or update on a solution		- User can compare solutions from DSM cities
BACK END & SUPPORT PROCESSES 	- Identity management - Data protection and privacy - Users are geo-located	- Sensor data collected - Data prepared by the city council and providers and stored in data models - Retrieve and input historical data	- City Data is added to Synchronicity platform - Data analysis in data engine	- Sensor sends notification to interactive map	- Policies are digitised and tagged against challenges - Search engine retrieves the relevant policies	- Hypothetical data is generated to visualise scenarios - This data is created by human input

Figure 25: Service blueprint for agile governance (1/2)

 3. ACTION			 4. PARTICIPATION			 5. EVALUATION		
7. Choose Solution	8. Organise and Delegate	9. Manage Solution	10. Gather Citizen needs	11. Citizen Participation	12. Suggest Better Options	13. Policy Evaluation	14. Share Benefits of Approach	15. Provide Intelligence
								
- User creates job for job pool to be passed to teams - User plans activities and views availability of resources	- User assigns tasks and mobilises team	- Teams identify missing data sets - City council request businesses for solutions and data sets	- City council creates information campaign in the city - Citizen uploads useful updates - Citizen receives green credits for updates	- Citizens participate in policy testing	- Promote better options to citizens - Citizen use better option and receives credits	- Teams inputs learning to database - Teams make recommendation for new IoT - Citizens feed-back on the policy - Citizen receives green-credits	- Data-driven teams share learnings in the city council - Teams feedback to the software teams improvements to the software	- Policy proposals are updated and shared - Policy makers are able to access strategic view of policy implementation
	- Online space channel created for team members to share (dependent on budget)	- Businesses submit proposals to supply data		- Notifications are received in real-time during events				- Policy makers can view the KPIs of implementation
- Task library is updated - Team members sent notifications - Dashboard integrates with council resource management or can be used as standalone tool	- Dashboard connects with online sharing channel	- System automatically updates completed tasks	- Citizen profile connected to 'interactive map' - Citizen loads app/webapp - There are data rules on what can be shared publicly	- Integration with Green credit system - Awards are collected from businesses and the city	- Platform creates unique recommendations for each user depending on there use of the city	- New data is cleaned and managed	- Software is updated every 2-4 weeks	- Newsletter is produced manually from dashboard highlights

Figure 26: Service blueprint for agile governance (2/2)

4.4.2 Value proposition description

The following description is a summary of the proceeding chapters and encapsulates the core purpose of the Agile Governance software.

Why:

- City Councils are not using data driven tools to inform city challenge solutions
- The policy process is not transparent, and citizens are unable to understand policy deployment
- We need to support behavioural change for both council staff and citizens to use data more effectively
- There's a mismatch between strategies which may be longer term, operational work which might be real-time and reactive, and the agile governance that a modern service needs.

What:

City councils will have access to a service which provides a data based situational awareness to support the definition, implementation and evaluation of policies. A suite of tools to analyze and display streaming data from many sensors and devices to present issues in a tangible way, by providing a searchable interactive map to explore pain points in the city in real-time, will be available to:

- Provide hierarchical access to consolidated, siloed data sets, giving real-time insights;
- Alerts for peaks in unwanted activities (CO2 levels, noise)
- Enable intelligent job tasking across these teams;
- Facilitate a more efficient way of responding to the city's needs;
- Creates recommendations for policy makers
- Support the implementation, test and validation the implemented policies;
- Promote data based decision making.
- Provide better management of city resources.
- Provide customised views of city data for different stakeholders

Who:

Core stakeholders

- Citizens (pedestrians, commuters, drivers, cyclists)
- City managers & administration
- City council staff & local policymakers
- Business Owners

Internal stakeholders:

- Data Analyst
- Council / Service Manager
- Civil society organizations
- Team Member
- Data Collector / Providers
- Gamification Manager
- Communication Team
- Interface developer

External stakeholders:

- Municipality
- Sensors & IoT devices
- Software Provider
- Municipal vehicles
- Infrastructure Owner
- Politician
- Department of innovation and environmental
- IoT infrastructure
- Optical Fiber infrastructure
- Department of communication (marketing)

Where:

- City council offices
- Reference zones of Porto and Manchester
- Citizen's neighbourhoods

User Requirements:

In developing user requirements in Manchester, we have undertaken a range of activities:

- Citizen forums have taken place through our existing Smart Cities programme identifying key needs and concerns around broad themes: transport, environment, health
- Manchester is lead on Smart Impact, an EU funded URBACT network developing Integrated Action Plans for 10 European cities (Eindhoven and Porto are also part of this network)
- Stakeholder meetings take place every 2-3 months to update on the progress of CityVerve, the Manchester IoT demonstrator, and identify synergies and opportunities
- One-to-ones have taken place with key staff in support departments including City Policy, Reform and Innovation, and Performance, Research and Intelligence
- Manchester Metropolitan University School of Architecture have worked with the City Council to identify current formal and informal agile governance processes
- 2 stakeholder workshops were undertaken to validate these findings and identify needs

Higher Level Needs identified:

- Better sharing of data between departments
- Access to real-time data to better inform management decisions and to inform strategic managers and politicians
- Improved ICT systems to enable “self-service” of information across the council
- Mapping of data at ward and neighbourhood levels
- Working with external data sources and other city partners (e.g. Transport, Health) to create integrated services
- Simplification of processes (e.g. responding to Freedom of Information Requests) through developing knowledge base of issues and challenges
- Need for real-time information to improve city centre services (e.g. environmental sensors, people counting)