



Deliverable 5.2

Initial methodologies and tools for Visual Analytics and Decision

Support system

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1 Summary

Deliverable D5.2 firstly presents an introduction to the activities in Work Package 5, Methodologies and Technologies for Visual Analytics, Data Exploration and Decision Support System. The document presents how the technologies were designed and developed following a user-centred design paradigm and the living lab approach presented in D7.1.

2 Glossary of Terms

<i>DoW</i>	<i>Description of Work</i>
<i>D</i>	<i>Deliverable</i>
<i>DSS</i>	<i>Decision Support System</i>
<i>UI</i>	<i>User Interface</i>
<i>VA</i>	<i>Visual Analytics</i>
<i>WP</i>	<i>Work Package</i>
<i>iOS</i>	<i>Mobile operating system developed by Apple Inc. and used on their proprietary hardware – iPhones and iPads</i>
<i>Android</i>	<i>Mobile operating system developed by Google aimed at devices with a touch screen.</i>
<i>OD</i>	<i>Origin destination</i>
<i>HTML</i>	<i>Hypertext Markup Language (HTML) is the standard markup language for creating web pages and web applications.</i>
<i>CSS</i>	<i>Cascading Style Sheets (CSS) is a style sheet language used for describing the presentation of a document written in a markup language.</i>
<i>CSV</i>	<i>In computing, a comma-separated values (CSV) file stores tabular data (numbers and text) in plain text.</i>
<i>UI</i>	<i>User interface</i>
<i>3D</i>	<i>Three-dimensional</i>
<i>TSS</i>	<i>Transport Simulation System</i>

3 Introduction

The SETA project is aimed at developing and deploying a technology and methodology to change the way mobility is organised, monitored and planned in large metropolitan areas. The goal is transforming the role of citizens into active players in the mobility process and provide services for citizens and decision-makers to better manage their own mobility and through this contribute to achieve better mobility in an area.

To this extent, the project designed and developed, using a user-centred design approach, novel methodologies for:

- supporting citizens' participation through a system that is centered around the user's context for supporting mobility based tasks;
- supporting decision-making by using the acquired and manipulated data to provide evidence for decisions;
- providing visualisation of distributed, high variety, high velocity and high volume data, through intuitive exploration along facets of interest.

This deliverable outlines the solutions designed and developed within the first phase of development of the SETA to provide visual analytics solutions for cross-dimensional exploration of the information space, with particular reference to citizens' and authorities' dashboards.

This deliverable starts with the presentation of the updated requirements from D5.1 (Section 3.2) the design and development of technologies that support citizens (Section 4) and Decision-Makers (Section 5): input from WP1 was taken into account to contextualise the visual analytics design and development into the case studies scenarios and requirements. This work allowed us to create a set of applications that WP5 will be evaluating in the next project phase. Finally, this deliverable concludes with plans of future activities within the Work Package.

3.1 A user-centred design approach

User-centred design is a framework used in software development which focuses on usability goals, user characteristics and workflow of a product. The framework uses a series of iterative processes which SETA implemented in two phases of design, development and evaluation, as illustrated in the table below.

	Requirements Analysis	Design and Development	Deployment	Evaluation
Phase 1	M1-M6	M6-M15	M15-M16	M16-M18
Phase 2	M19-20	M20-M33	M33-M34	M34-M36

Table 1 - Iterative project plan

The process follows the user-centred design approach (exemplified in Table 1):

In the Requirements Analysis phase, we used user-centred design techniques to elicit requirements from stakeholders (i.e. members of the public, city council members and other decision-makers – described in more detail in D1.1) and inform the technology development (see Figure 1). In the design and development phase WP5 implemented the initial core of applications that create value out of the SETA ecosystem for citizens, business and authorities. These applications will be deployed in the case studies, in cooperation with WP1, WP6 and WP7, to test the solutions in three metropolitan areas. At the end of Phase 1 the outcome of the evaluation will be used to re-analyse and refine the requirements for Phase 2.

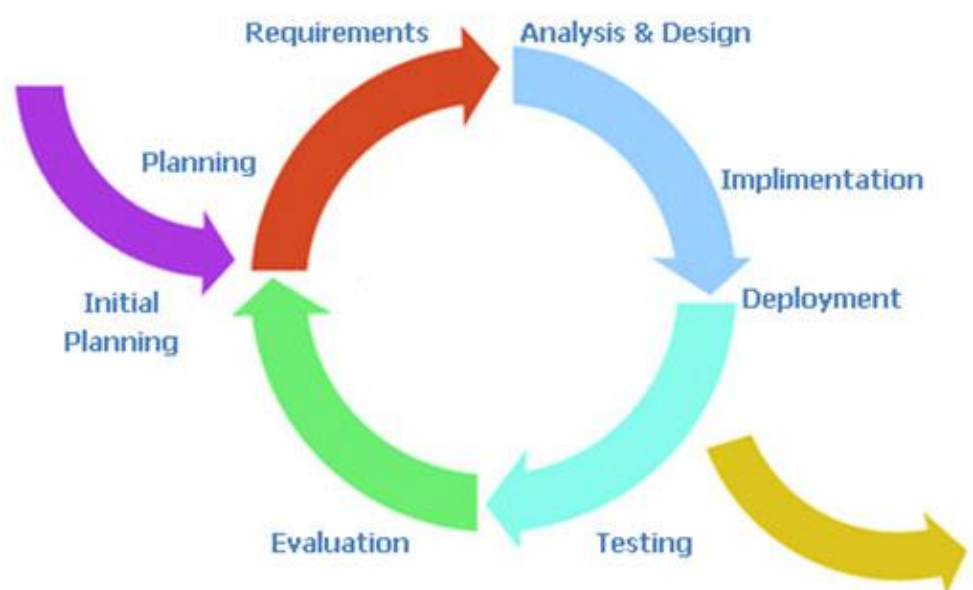


Figure 1 - User-centred design diagram

3.2 Decision Support and Visual Analytics Requirements

In D5.1 we have identified a set of requirements for citizen participation, decision support and administrative management: in order to contextualise the activities of WP5, we are reporting

¹ Source: [Development methodologies](#), Arctern, 2011

here the requirements of D5.1 adding a column that will specify which requirements have been addressed in Phase 1 and which requirements will be addressed in phase 2.

3.2.1 Decision Makers Requirements

ID	Functionality	Requirements	Phase
DM1	Login	Logging of personnel - load personal schedules / plans/ context	1
DM2	Dashboard interface	Give decision makers an immediate picture of issues/priorities through multiple visualization widgets	1
DM3	Search	Allow people to search information in different ways, exploiting the richness of the information available (models, data, predictions): <ul style="list-style-type: none"> • hierarchy of categories browsing • faceted browsing • full text search • search based on tags that are aimed to classify information according to different dimensions 	2
DM4	Geographic Map	Traffic and highlight hotspots Heatmap of mobility data (e.g. static users/locations of high running activities) Historic data of static points / trajectories / paths Trajectories for Origin-Destination data of different modes Overlay with data other than mobility (e.g. pollution) Static points such as sensors	1
DM5	Calendar View	Planned events Schedules (personal/group)	2
DM6	Modelling View	Impact of events on routes Impact of routes on pollution	2
DM7	Graphs	Compare traffic levels of different modalities over daily/weekly/monthly/yearly trends Compare traffic levels over hourly (rush hours) intervals	1
DM8	Contextual Menu	To enable different layers of data presentation <ul style="list-style-type: none"> - Truck routes - Cycle routes - Pollution - Public transport - Private vehicles 	1
DM9	Zooming and Filters	Zoom-in to different regions/zones of interest	1

		Filters for visualising different temporal resolutions	
DM10	Annotations	Virtually add infrastructure components (e.g. lanes / routes / roundabouts)	2
DM11	Exploitation of information implicitly provided by citizens	Social networks monitoring (Facebook, Twitter, Flickr) Social Network predictions Visualization through charts/timelines	2
DM12	Capture additional information on-demand	Geospatial localization map about cooperating citizens registered in the system Support for sending requests to citizens	1
DM13	Content validation	Verification of information provided by citizens, their veracity and reliability Visual display of veracity and reliability	2
DM14	Planning and Interaction with predictive tools	New schedules (e.g. garbage pickups) New routes and roundabouts	2
DM15	Support strategic decision-making	Visualization of: <ul style="list-style-type: none"> • Mobility predictions • Probability of traffic/congestion in some areas • Consequences of decisions 	2
DM16	Notifications	Provide push updates to teams via mobile apps Provide updates when simulations/processes complete execution	1
DM17	Reporting	Capture Screenshots and Graphs to create reports	1

3.2.2 Public/Citizens Requirements

ID	Functionality	Requirements	Phase
P1	Logging to user account	Preserve historical route interests or preferences (e.g. modality/price)	1
P2	Geographical Map	Weather prediction Heatmap for point data Pollution map Traffic overlay Warnings and alerts on the map (e.g. road incidents) Multiple routes and directions Historic route data Route map (cycling/walking routes)	1
P3	Generic Interface visualisation	Data from external source (e.g. webcam live streams)	1

		Citizen Observatory data (e.g. citizen generated data) Location-based services	
P4	Journey Assistant / Planning	Connection with Calendar Origin-destination Select preferences (e.g. modes) Present multiple routes/modes Display characteristics of routes (e.g. costs, miles to destination, car emissions, connections, pollution exposure, weather on the way)	2
P5	Multimodal data capture and access (e.g. smartwatch or mobile app)	Monitoring activities/steps Present / query possible alternative routes Push information	1
P6	Reporting	Report issues/concerns via Citizen Observatory Report reasons for choosing alternative routes Submit reports/data seamlessly across multiple devices Geolocalization of reports Support for uploading text, images, and video/audio Content tagging/categorization. Implicit and explicit sharing (e.g. reporting activity through sensors)	1
P7	Alerts and notifications	Reminders and display incidents Registration to news/alert/report categories Support for choosing the location to receive alerts about, and the size of the area Support for mail, SMS, RSS notification	1
P8	Make the access to the platform and the data as open as possible	Data API Dedicated apps and interfaces	1

3.2.3 Administration/Management Functionalities

In addition to the specific requirements identified for Decision-Makers and Public/Citizens we have identified a set of requirements that address admin and management needs.

	Need	Functionality	Phase
A1	Build up the SETA community	User registration	1
A2	Get the wider citizens involvement	<ul style="list-style-type: none"> Anonymous access to some resources/functionalities 	1

		<ul style="list-style-type: none"> Language localization (to offer the platform in the native language) 	
A3	Support user interaction through different devices	Interface customization according to the set of allowed devices, at least for web and mobile.	1
A4	Provide different functionalities to different users (e.g. authorities vs. citizens)	Support different roles, with associated sets of access privileges to resources/functionalities	1

4 Methodologies and tools for supporting self-awareness, participation and feedback

In order to support citizens' participation and interaction with the SETA platform, both in terms of providing and consuming content, we have opted to provide a mobile app for iOS and Android platform.



The choice of the mobile app was motivated by the need of having easy access and interaction: during the first focus groups and interviews that we ran with the end users it became clear how the user groups targeted were digitally active and almost all in possession of a smartphone. A thorough discussion on the focus group and interviews is presented in D1.1.

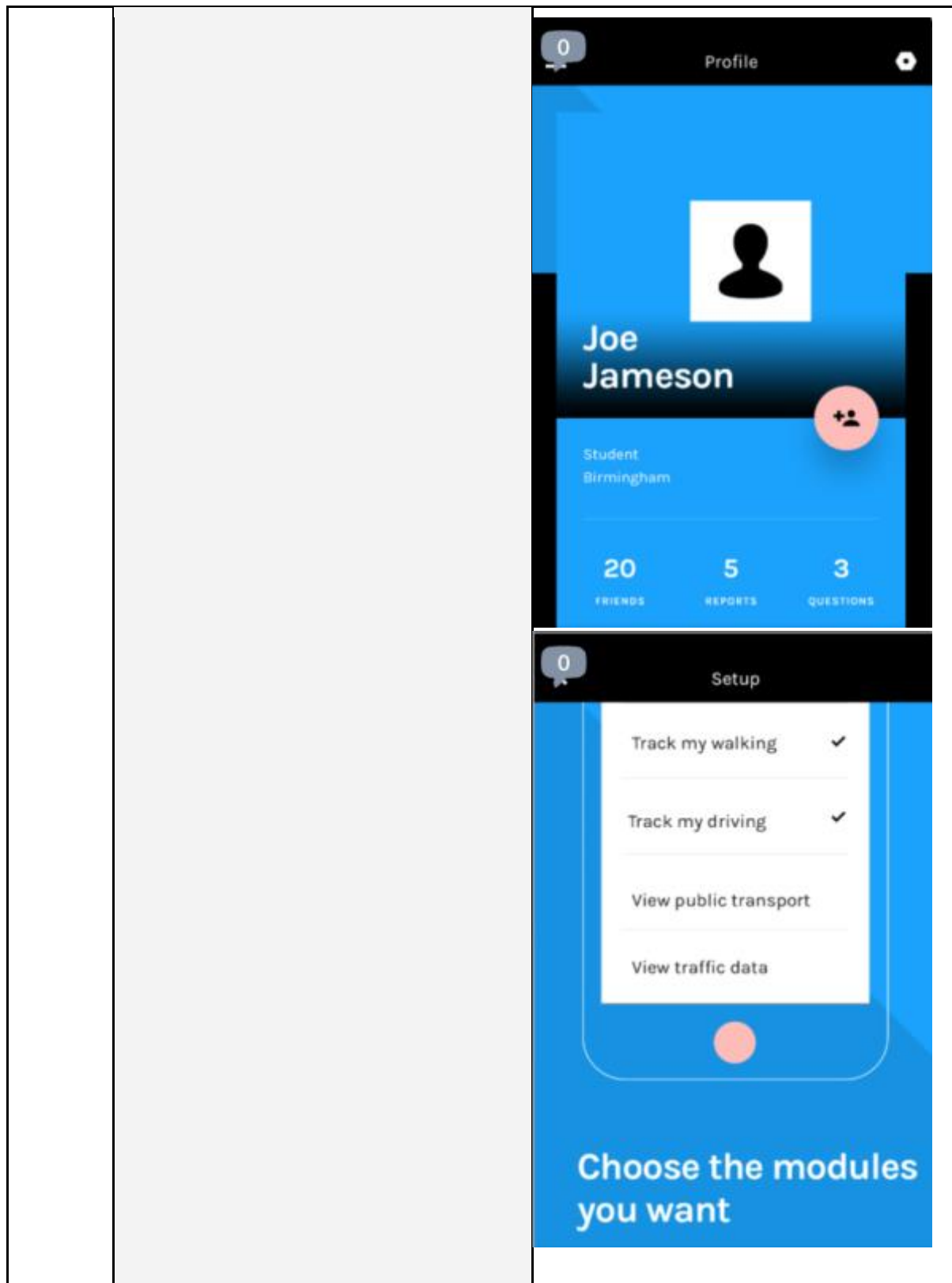
4.1 Design

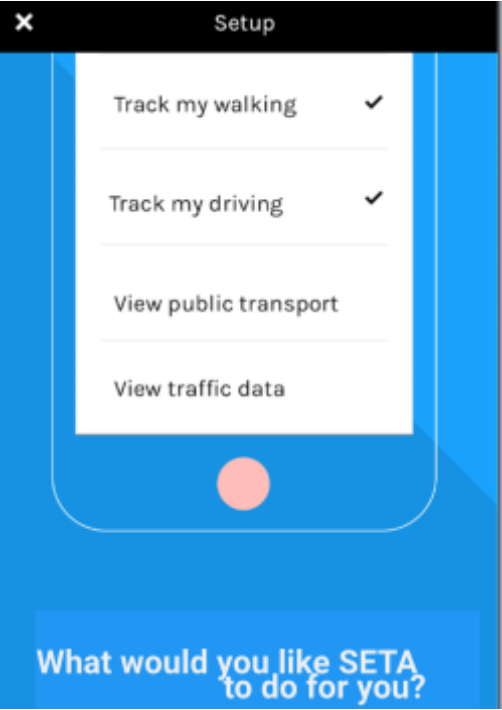
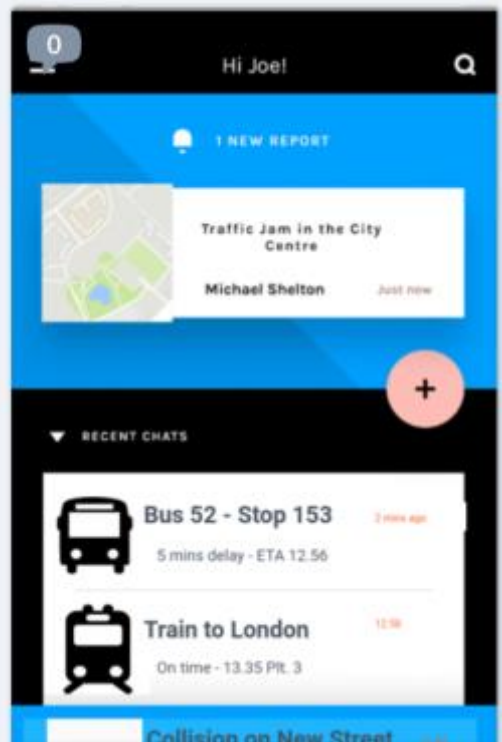
The mobile app was designed following an iterative user-centred design approach, starting from the requirements presented above to draw some initial low fidelity user interface mockups. The low fidelity mock-ups were refined during several meetings with end users after which we reached an agreement on the basic functionalities and message of the app. At this point a high-fidelity prototype was designed and distributed to the other project partners and to the end users for comments. Feedback from this validation stage was used to refine the design and to start the development phase.

4.1.1 Low fidelity mock-ups

The first low-fidelity mockups were based on the scenarios presented in D1.1. Using the described scenarios presented in D1.1, a series of mockups describing various screens and stages in the application have been designed. The table below outlines the scenarios used to create the initial mockups along with the resulting mockup for each screen.

N	Narration	WP Interaction
1	<p>Joe wakes up at 7:30 and eats breakfast with his housemates, whilst eating they catch up on Instagram on their tablet computers.</p> <p>Joe has to be at a lecture at 9, it is normally only 25 minutes' walk, or a 15-minute bike ride. Joe logs in to the Birmingham Real-Time Mobility Portal to check his journey before setting off.</p>	<p>WP6 Login Support</p> <p>WP5 - Login interface</p>  <p>Screen Shot 2016-09-20 at ... 550x918</p> 



		
2	<p>Zooming-in on the city-centre Joe can see that there is an 85% chance of rain between 3 and 4 pm, the time he would be cycling home, so he decides to walk instead.</p>	<p>WP5 Zoomable Dashboards for different data sources.</p> 

The screenshot shows a mobile application interface. At the top, there's a status bar with a notification icon (0), the text "Hi Joe!", and a search icon. Below this is a section titled "My City" featuring a map of Birmingham. The map displays major roads (M54, M6 Toll, M42, M5) and a red dot indicating the current location. Below the map, there's a "Pollution levels" section with a green dot indicating "Low" levels and a "Click for More" link. At the bottom, a "Weather forecast" section is partially visible.

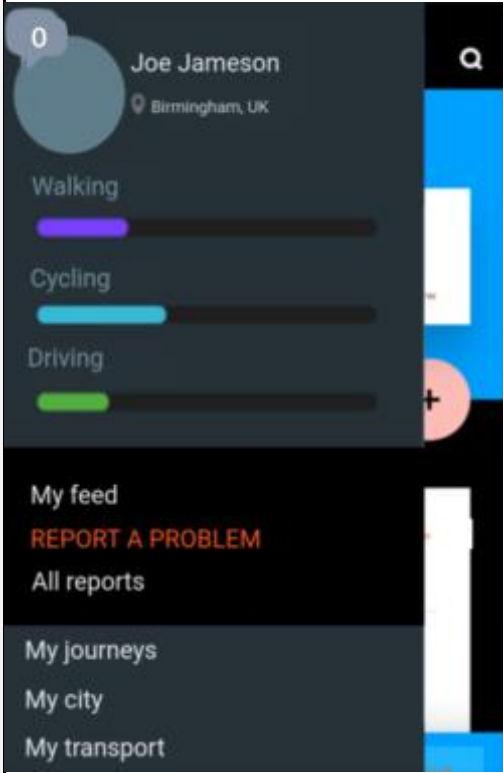
WP2 weather data collection

This screenshot shows the "Weather forecast" section of the mobile application. It displays a 7-day forecast with icons for each day, high and low temperatures, and a detailed summary for the current day. The summary includes sunrise and sunset times, chance of rain, humidity, wind speed, feels like temperature, precipitation, and pressure.


Day	Icon	High	Low
Monday	Cloudy with sun	16°	11°
Tuesday	Cloudy with sun	17°	13°
Wednesday	Cloudy with sun	16°	11°
Thursday	Cloudy with sun	16°	10°

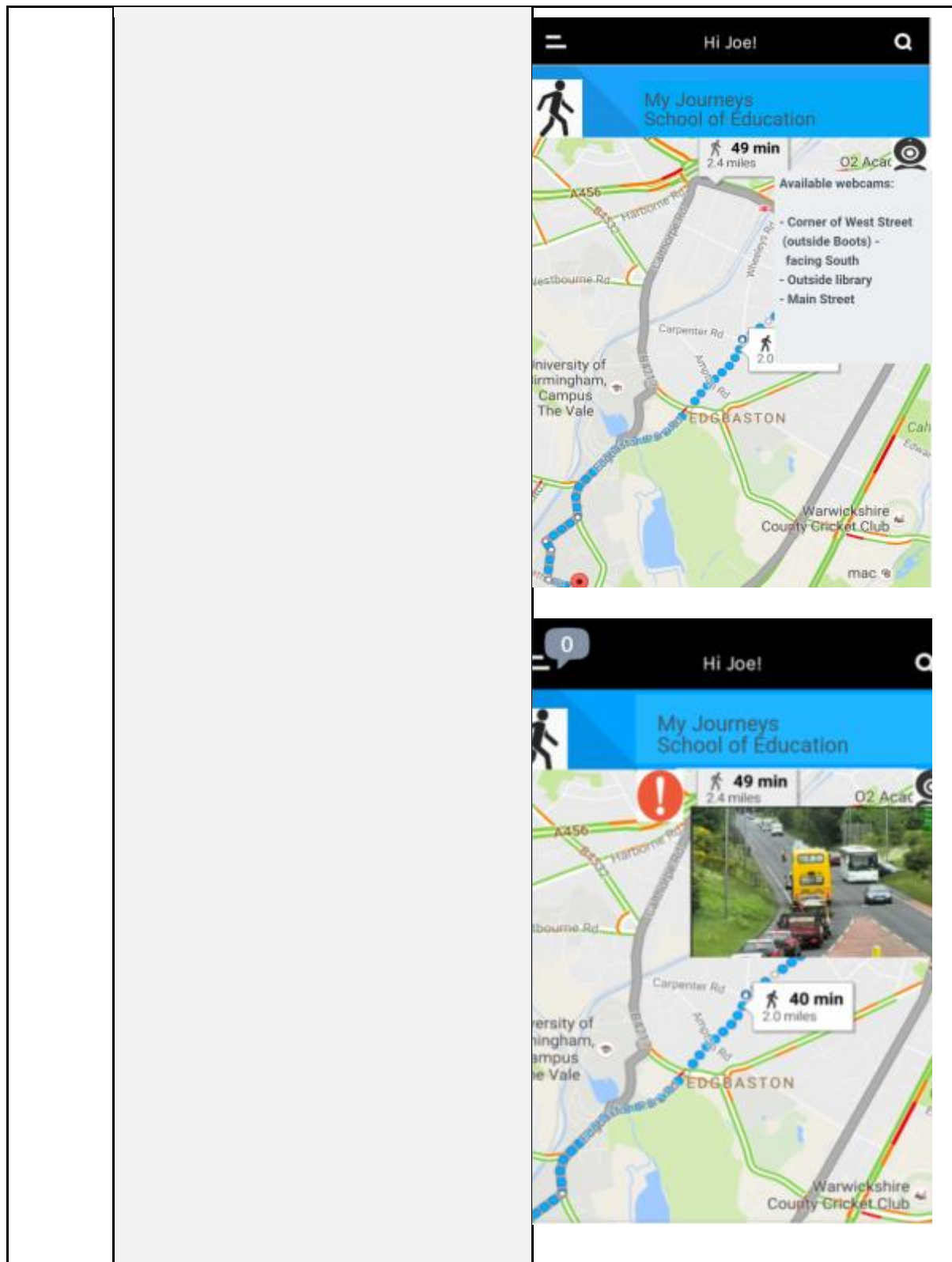
Today: Mostly cloudy currently. The high will be 19°. Mostly cloudy tonight with a low of 10°.

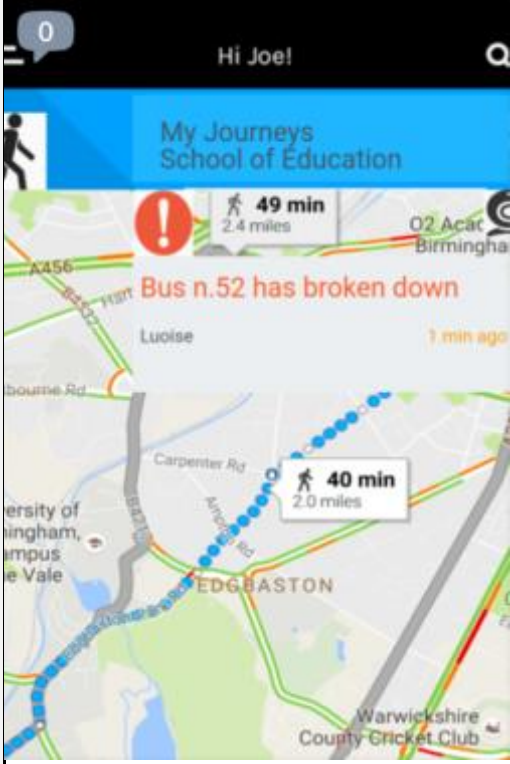
Sunrise: 06:50
Sunset: 19:08
Chance of Rain: 20%
Humidity: 67%
Wind: wnw 4 mph
Feels Like: 18°
Precipitation: 0 cm
Pressure: 1019 hPa

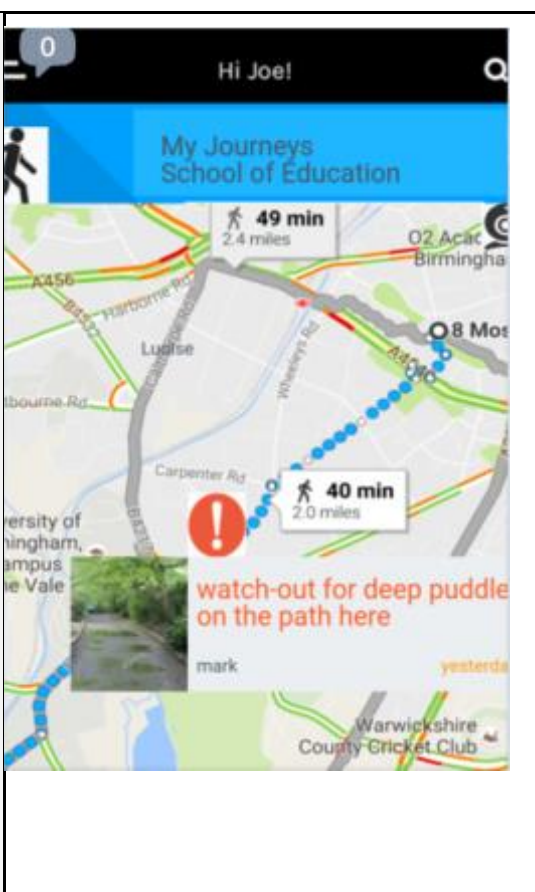
3	He selects one of his saved journeys, a walk between home and the University.	<p>WP5 - Historic journeys WP2 - Non motorised transport data collection</p> 

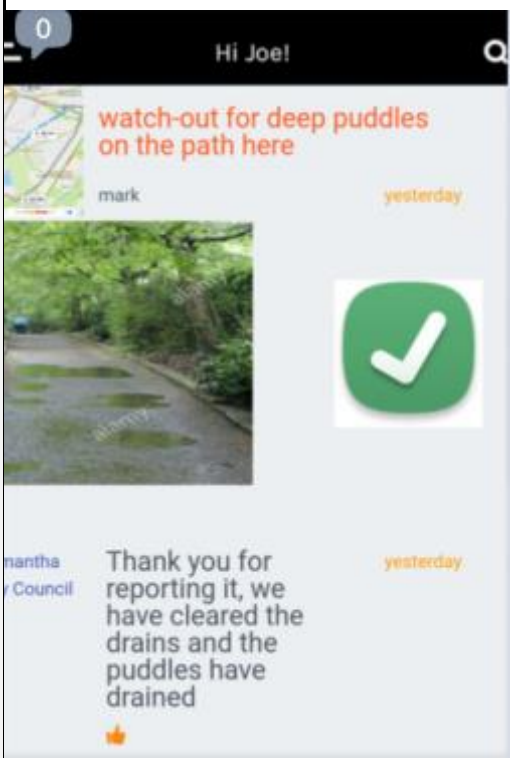
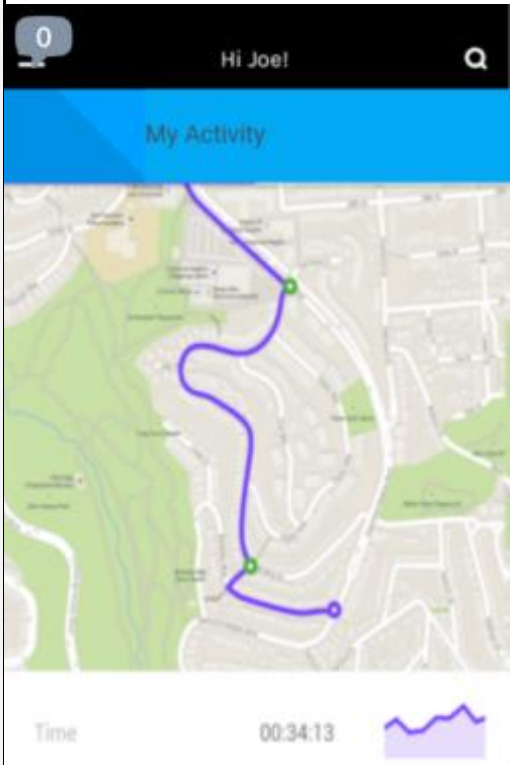
4	Looking at the colour-coded pollution map for the route, he can see that pollution levels	WP5 - Heat maps and overlays WP2 - Environmental data collection


	<p>are quite high, the traffic overlay shows slow-moving traffic.</p>	<p>WP3&4 traffic estimates</p> <p>WP2 - Motorised data collection</p> 
5	<p>He clicks on a webcam icon and opens a live stream; he can see that a bus has broken down. Warning icons start appearing on the map, he clicks one which says 'number 52 bus has broken down on Church Street, nothing moving!'.</p>	<p>WP5 - Link to live-streams feeds.</p> <p>WP5 - Real-time alerts and notifications</p> <p>WP2 - Webcam data</p> <p>WP2 - Citizens observatory data</p> <p>WP5 - Citizens data collection and visualisation interface</p>

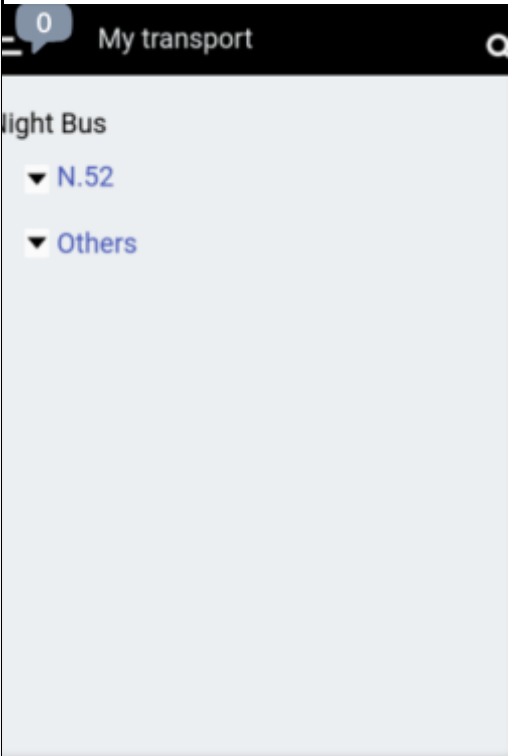
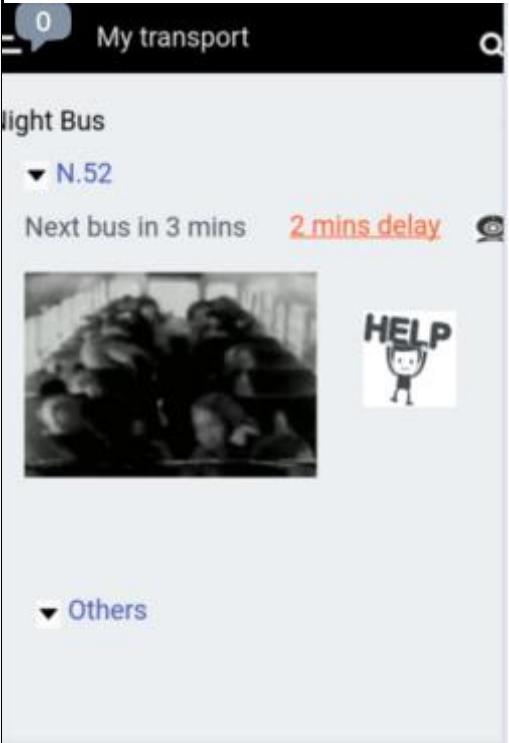



		
6	<p>Joe would rather avoid the pollution so he selects an alternative route via the park; there is one alert on this route dated 4 pm yesterday: 'watch-out for deep puddles on the path here'.</p>	<p>WP5 - Map-based routing WP5 - Real-time alerts and notifications WP2 - Citizens observatory data WP5 - Citizens data collection and visualisation interface</p>


		
7	<p>A member of the council parks department has marked the message 'resolved' and commented 47 minutes ago 'thank you for reporting it, we have cleared the drains and the puddles have drained'.</p>	<p>WP5 - Citizens observatory - commenting and feedback -></p>

		
8	<p>Remembering his umbrella, Joe leaves the house at 8:25, giving himself plenty of time to detour via the park. On the way, his smart-watch monitors his walking and congratulates him on achieving his 30-minute daily exercise target.</p>	<p>WP2 - - Non motorised data collection WP5 - app WP5 - feedback</p> 

		
9	<p>Joe meets his girlfriend after lectures are finished, and along with some friends they visit a new bar that they have seen is offering a student promotion via Facebook. They decide to leave around 11:30 pm, and as it is now raining, Joe gets-out his smartphone and checks the night-bus schedule via the portal.</p>	<p>WP5 - Dashboard/mobile interface</p> <p>WP2 - Public transport data</p>

		
10	There is one due at 11:50, the portal tells him that it is 2 minutes behind schedule.	<div>WP2 - Real-time public transport data WP5 - alerts</div> 

11	<p>Joe checks the webcam on the bus, the images of individuals are deliberately blurred so he can't recognise anyone, but he can see that there are several spare seats upstairs.</p>	<p>WP2 - live video data collection WP6 - privacy and ethics WP5 - live data streams display</p> 
12	<p>Joe and his girlfriend share his umbrella and walk to the bus-stop. Unfortunately, someone has vandalised the bus-stop and there is broken glass on the ground. Joe reports this via the portal, taking a photo as evidence. Avoiding the glass, they wait for only a few minutes until the bus arrives on time.</p>	<p>WP5 - Citizens observatory app for reporting</p>


		<div><div>0 REPORT</div><div>Is your location correct <input type="radio"/> YES <input type="radio"/> NO</div><div></div><div>Are you at bus stop n. 1362? <input type="radio"/> YES <input type="radio"/> NO</div></div>
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REPORT

Summarise the problem

10 inch pothole on Example St, near post box

Photos



Take a photo now!

✔ For best results include a close-up and a wide shot

✘ Avoid personal information and vehicle number plates

Explain what's wrong


This pothole has been here for two months and...


REPORT

Summarise the problem

Bus stop 1361 vandalised

Photos



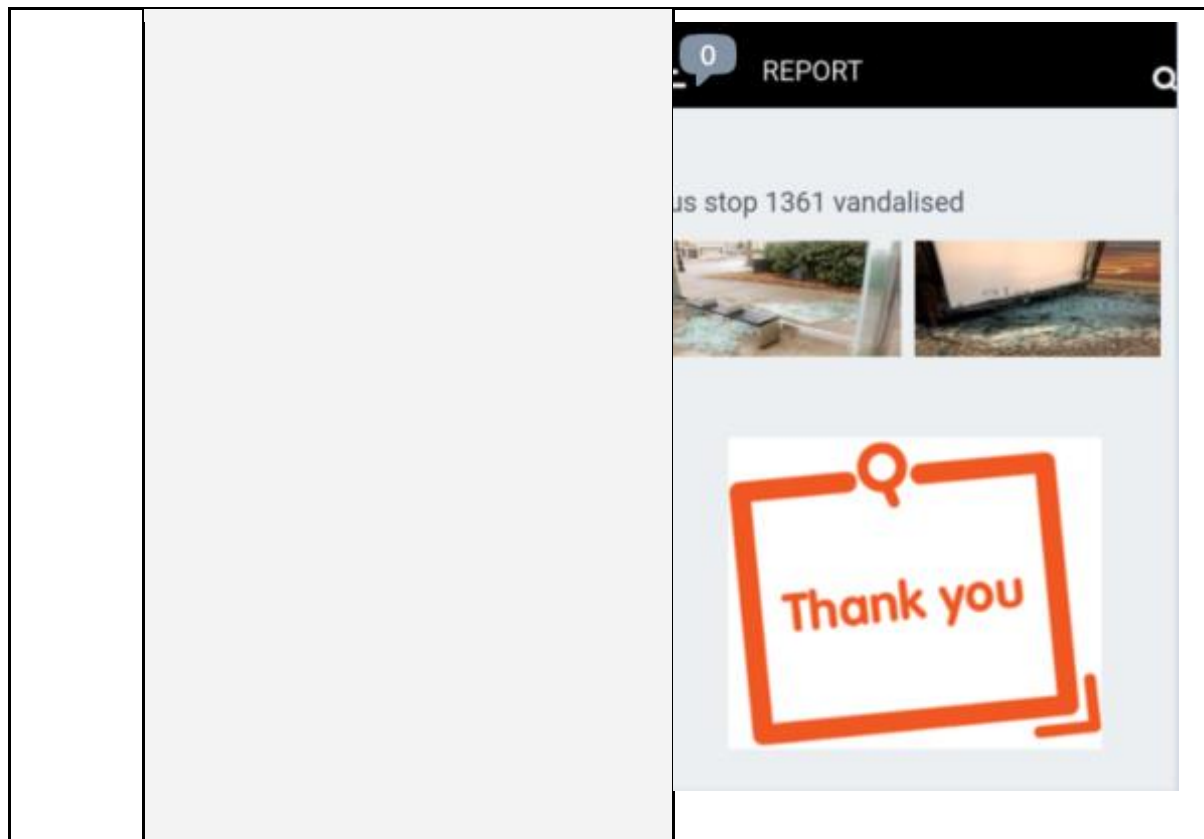


✓ For best results include a close-up and a wide shot

✗ Avoid personal information and vehicle number plates

Explain what's wrong

Someone vandalised the bus stop, there is broken glass on floor



This scenario and the associated mockups were evaluated during a focus group with several decision makers from Birmingham City Council (held in Sheffield, UK) and during several telephone calls with other case study owners.

The feedback from other partners and from end users was positive but it was argued that the app was aiming to achieve too many things and risked to be too confusing for a user. Moreover, the capabilities of the app seem to be too in-line with what is already offered by other major mobility providers (i.e. Google) and it was agreed that we should try to focus on a subset of the capabilities to achieve an app that had a very clear message and aim.

The next steps were:

- agree on the main focus of the app
- create a short list of features the app should support, based on the initial requirements and the feedback from the focus groups.

Internal brainstorming meetings and a new set of focus groups with the end users were held to agree to a basic message the app should deliver. For the first phase, amongst the factors that could influence a behaviour shift towards sustainable mobility, we decided to focus on designing a feedback/self-monitoring app, that addresses behavioural factors such as:

- Calories / steps / distance / active time
- Other people's behaviour
- Exposure to pollutants
- CO2 saving

but also, financial factors (i.e. Saving in travel costs).

Starting from this we created a revised list of functionalities the app should provide:

1. Login (email and password)
2. Terms and conditions
3. Setup
 - a. notifications (cycling, public transport, car, walking) -> adaptive (second phase)
 - b. additional info (e.g. type of car - wizard)
 - c. permissions
4. Dashboard
 - a. summary of activity done respect to 4 dimensions
 - i. time
 - ii. calories
 - iii. emissions
 - iv. money
 - b. daily/weekly/monthly summaries of the user's daily activity
5. Notifications
 - a. location-based (zoom level or all)
 - b. map/list
6. Proactive activity/location based pop-up
7. Reporting something (geolocated).
 - a. Drop down menu (type of report)
 - b. Text content
 - c. image
8. Help section
 - a. (FAQ)
 - i. about the app (version number)
 - ii. what does the app do?
 - iii. what's in it for you?
 - b. application settings
 - i. notifications (cycling, public transport, car, walking) additional info (e.g. type of car - wizard)

The functionalities were then translated in low fidelity app wireframes (a few examples are in Figure 2 whilst the complete wireframes (a visual guide that represents the skeletal framework) are available in Appendix A) that were discussed again during focus groups and revised until an accepted version was finalised.

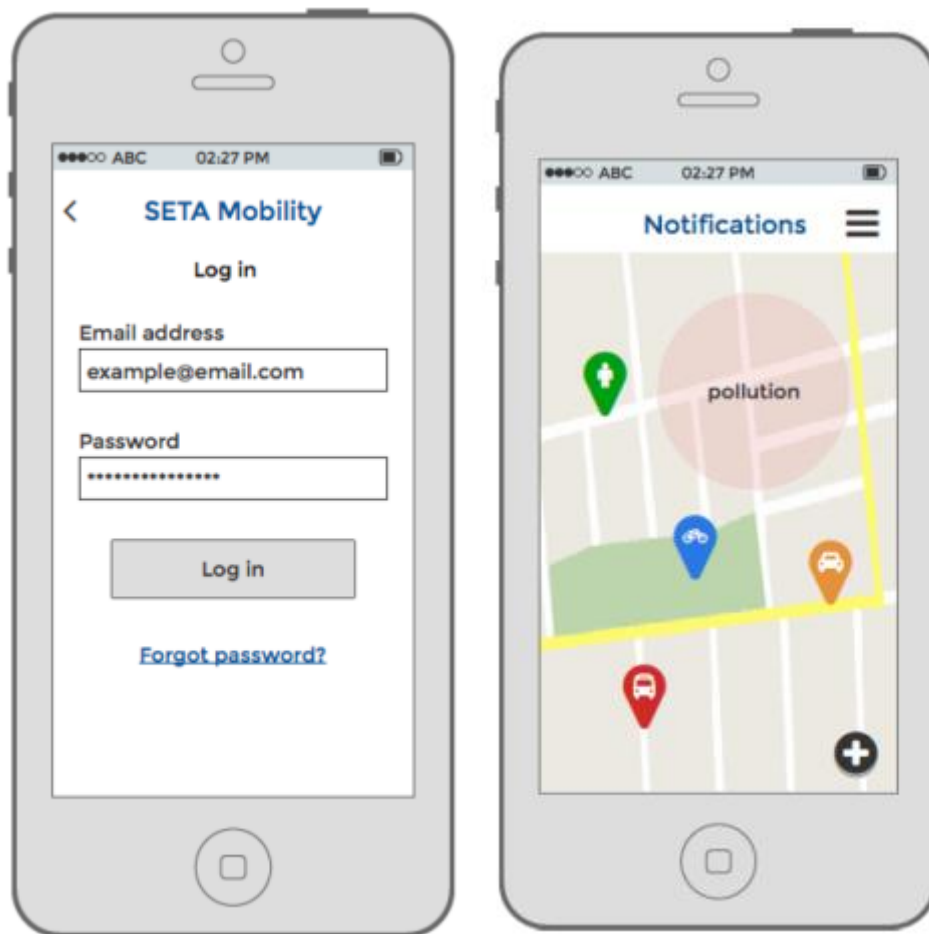


Figure 2 - SETA App wireframes

The accepted version was then translated into designs for implementation (a few examples are in Figure 3 whilst the complete designs are available in Appendix B): the designs were presented and discussed one more time with the end users to finalise all details before implementation started.

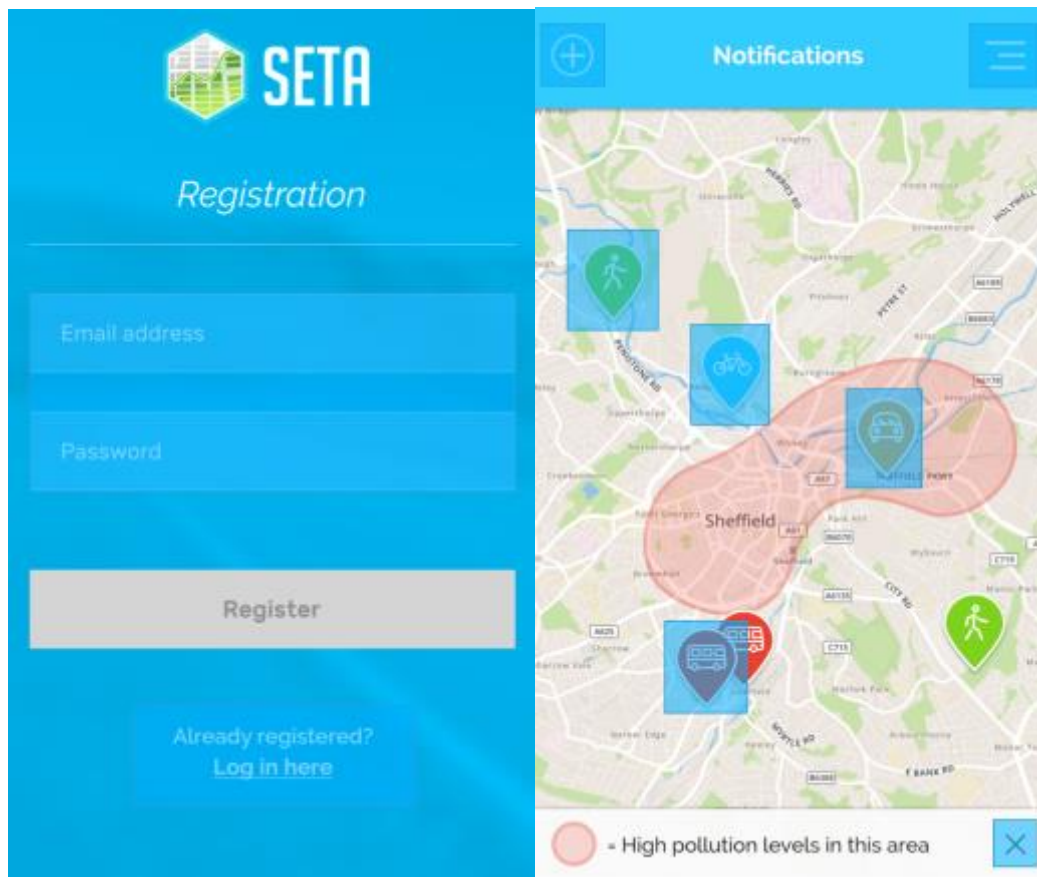


Figure 3 - SETA App Design

4.2 Development

Based on the designs, two mobile apps were developed, respectively for iOS and Android devices.

The app supports awareness and self-monitoring of mobility behaviours by providing a daily snapshot of the movements of a user, distinguishing them between: walking, cycling, driving and public transport.

In order to achieve this, the app monitors the users' movements using technologies developed in WP2 and presented in D2.2.

When the user logs into the app, he is presented with a dashboard showing the different types of mobility and a summary of their behavior for each mobility category (see Figure 4):

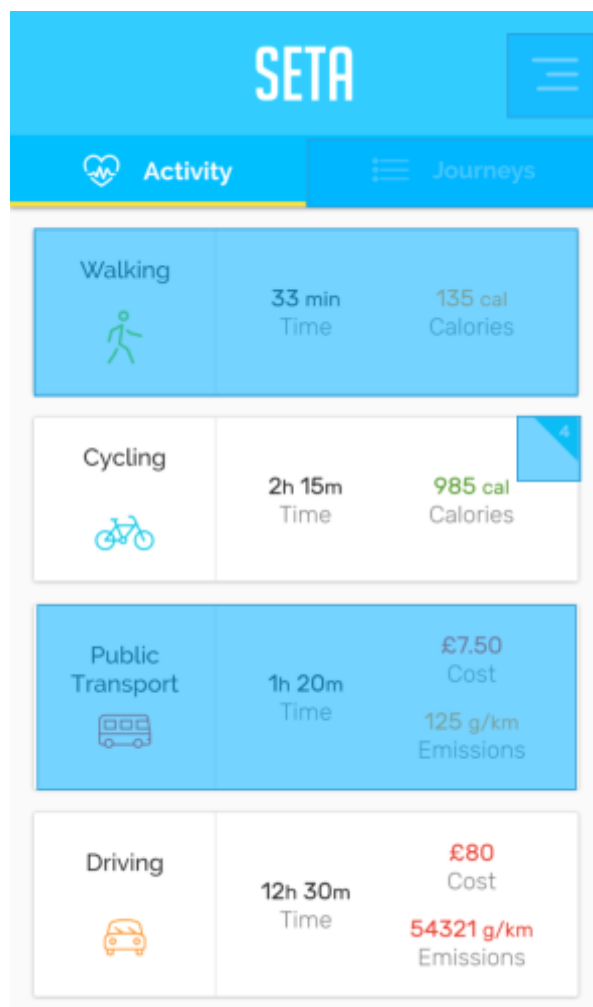


Figure 4 - SETA App: dashboard

The app supports self-awareness by displaying for each mode of transport, the total amount of time that mode has been adopted (for a given day), the number of calories consumed (if relevant), the cost (saved or spent) and the emissions (caused or saved).

Drilling into each category, the user can see more details for each (see Figure 5):

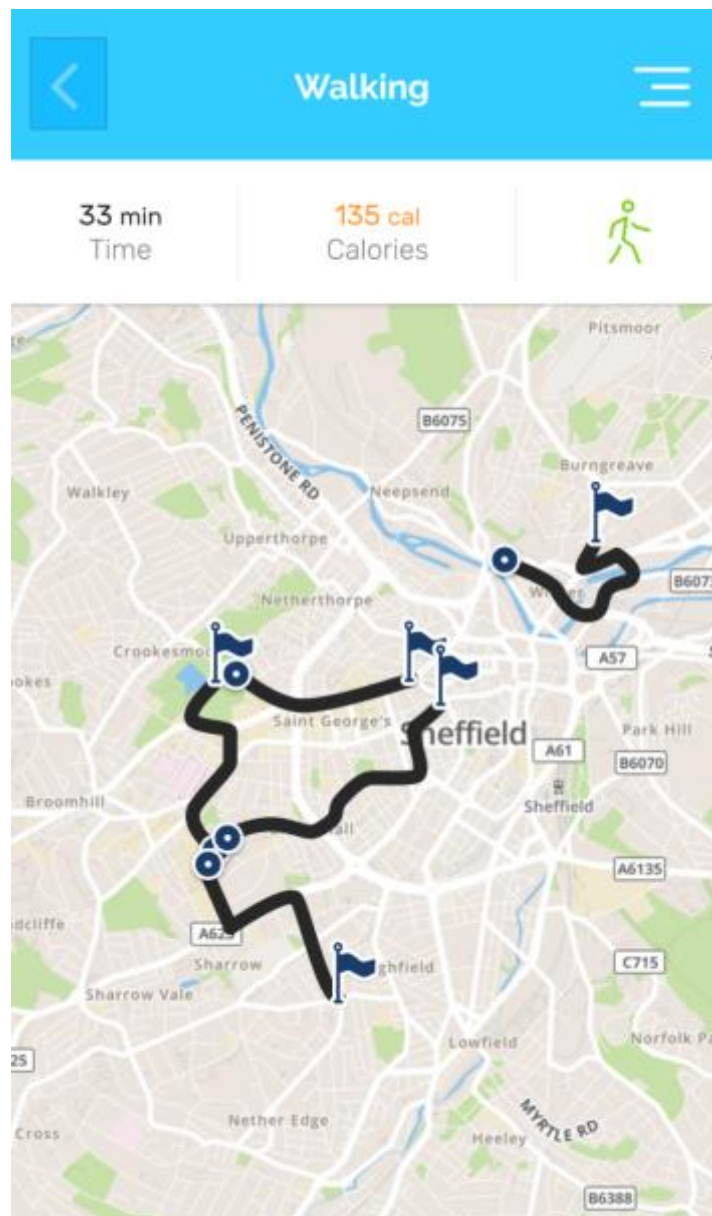


Figure 5 - SETA App: journeys details

The app supports also citizens' participation, allowing them to share:

- Mobility information: the citizens – but also the city councils – can raise awareness about emergencies or troublesome situations, by sending reports. All the reports are geo-located and can contain attached evidence (e.g. photos or videos). The reports are then distributed as location-based notifications for all the users of the app.
- Information about occupancy: location-based notifications invite users to report on occupancy of spaces (i.e. availability of parking spaces)
- Sensor data: the app allows citizens to be aware of the mobility conditions by making sensor data (e.g. traffic information or pollution information) available as geolocated data on a map (e.g. a heat map layer to display pollution information).

Collected data will be sent and stored in the Seta Data Platform using the third-party API provided. This includes, sensor readings, reports sent by citizens and activity tracking information. The Seta Data Platform will also be responsible for sending out mobility notifications to the mobile application users.

In essence, the platform is a Big Data system that stores and analyses any flow of data between citizens and decision makers. The platform has been designed with scalability in mind to accommodate large amounts of data and a high number of requests (made via the API).

4.3 Load/Unload Bays application (Turin only)

The current section will discuss the entire process of analysing a need identified during requirements gathering meetings with the Turin City. As this was a very specific feature, it has been agreed on developing a separate application to tackle this issue.

One of the goals set out in the SETA project is to transform the role of citizens into active players when it comes to mobility decisions. By providing services for citizens to contribute and for decision-makers to better understand the actual problems faced, cities can make more informed decisions regarding mobility changes and improvements.

4.3.1 Scenarios and objectives

Throughout Turin (Italy), a large number of private parking bays are used for loading and unloading, couriers being primary users. As these bays are sometimes illegally occupied by other road users, one of Turin City Council's requirements was to provide a means of monitoring and tracking their usage. The solution provided by SETA is to develop a mobile application that will allow couriers to select a parking bay and change its state from free to occupied and vice-versa. The solution will also allow its users to report any misuse of those parking bays.



The final goal of the mobile application is to provide the City of Turin with a tool which will monitor the usage frequency of the load/unload bays, through a data crowdsourcing mechanism provided to citizens.



As smartphones are very common nowadays, and also come with the necessary tools – i.e. GPS tracking, camera functionality and internet connectivity, a mobile application was the obvious solution to tackling the problem of tracking load/unload bays as Big Data. This need was identified during the first meeting with Turin City Council which then led to the design of an Android and iOS application fulfilling these requirements.


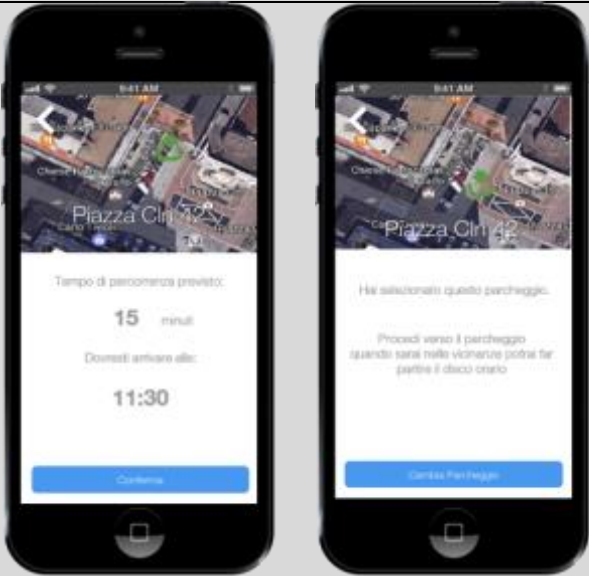
The mobile application was designed following a continuous discussion with the City of Turin, starting from the initial requirements, and going forward with determining the use-cases. The process has looked at both functional and non-functional requirements.



Figure 22 in appendix C a simple app user flow is described.

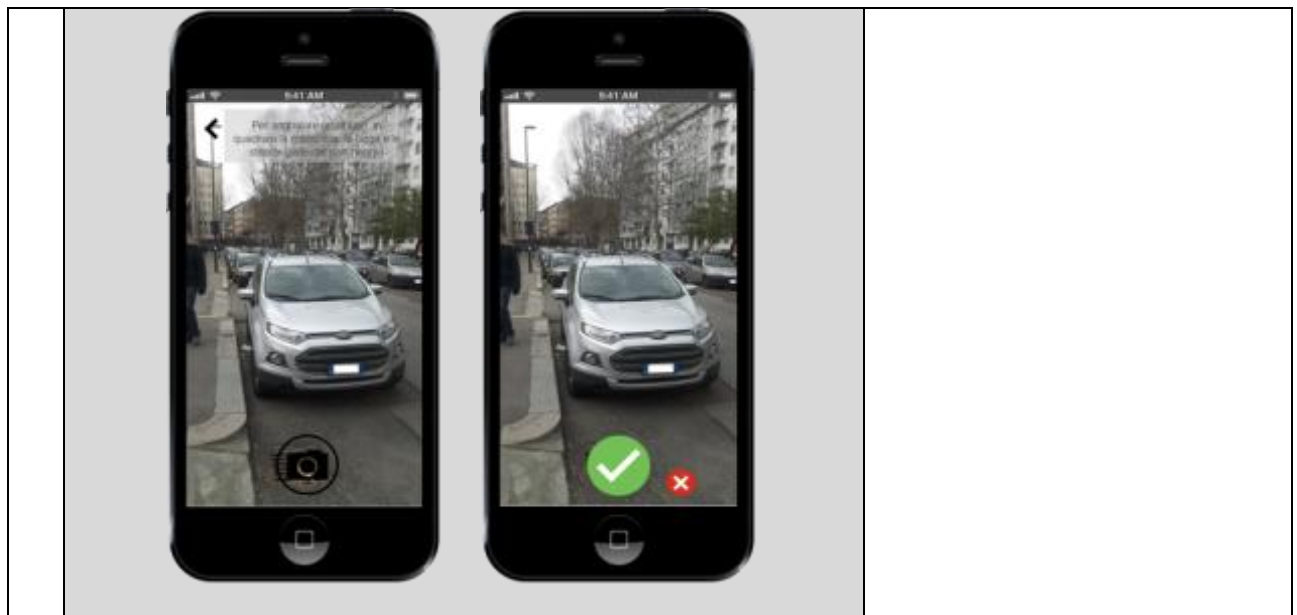
Figure 6 shows an overview of the user's flow through the application as decided with the City of Turin during the several meetings and teleconference calls that have been held. Using this diagram, a series of wireframes have been developed which can be seen below:

	Wireframe	Description
1		Opening the app, the user has the possibility to log in or to register in the application.
2		The user could be a Professional User (belonging to a company) or a Private user (Citizen)

3		Registration form both for Professional and Private user
4		User will insert the destination in the search bar
5		A map with the load/unload parking bays nearby to the selected destination will be displayed on the screen

		
6		<p>Once the user selects a parking bay, a new screen with the estimated time of arrival will appear.</p> <p>The user will then need to confirm the selected parking bay.</p>
7		<p>Once the user is within 50 meters of the chosen parking bay, a screen with a parking disk will appear automatically. Once the user has parked, they will be able to start the timer, report an illegal use of the bay or cancel.</p>

		
8		This screen will appear once the user taps on the “Start timer” button.
9		If the user notices that the bay is illegally occupied they can tap on the “Report misuse” button, take a picture of the vehicle and send it to the council.



4.4 Testing Plans

Plans for testing the mobile app in the three case studies are described in Deliverable D1.2, 1.3, 1.4.

5 Methodologies and technologies for Decision Support

One of the main requirements of SETA is to provide tools and methodologies for analysing mobility in urban areas, for example understanding strengths and weaknesses of the existing road infrastructure, and opportunities to improve it.

To achieve this, we have created a set of tools that allow visualising mobility information according to different dimensions to support multiple levels of decision-making in micro-level areas:

- Origin Destination analysis
- SETA Citizens Observatory - a web app for viewing all the reports submitted by Citizens using the SETA app and for sending notifications to all citizens using the app.
- a web app for analysing and visualising data gathered using the Active10 app (described in D2.2) visualisation methodologies that build a picture of the relationships within the data, through intuitive exploration along each facet of interest, and by tracing the links between facets.

In the next sections, we will discuss the design and development of each technology.

5.1 Origin Destination Analysis

The Origin-Destination (OD) analysis is primarily designed to provide decision makers the ability to refine/select areas of interest. The interface will then provide details on how users travelled to and from the regions selected and specific details about their journeys. The OD tool provides various interaction mechanisms for decision makers to filter and sift through large volumes of data. Furthermore, it provides the ability to visualise data in different representations to communicate different aspects of the data. The following text summarises the requirements addressed in Phase 1 of Visual Analytics. These requirements were collected from decision makers via workshops and discussions.

The requirements (as discussed in Deliverable 1.1 and Deliverable 5.1) were aligned further with a use case of understanding where users travel to, what journeys they make and what means are used to make the journeys. The OD tool satisfies several of the requirements from decision maker's tools (DM), in particular:

DM1 (Dashboard interface): Give decision makers an immediate picture of issues/priorities through multiple visualization widgets.

The OD tool provides multiple visualisations in a dashboard metaphor, where all visualisations are laid out in a single page, providing interactive means for setting queries that drills-down to specific subsets within the underlying data.

DM2 (Search): Allow people to search information in different ways, exploiting the richness of the information available

The filters provide interactive means for decision makers to quickly focus on a subset of data, essentially allowing complex queries to be created. Several queries can be currently created for e.g. querying for journeys starting and ending between specific hours of the day, or

journeys occurring in weekends/weekdays or specific types of journeys and so on.

DM3 (Geographic Map): Traffic and highlight hotspots

Heatmap of mobility data (e.g. static users/locations of high running activities)

Historic data of static points / trajectories / paths

Trajectories for Origin-Destination data of different modes

The geographic map is the primary point of interaction in the OD tool, providing a variety of information - postcodes are represented as points, colored by the number of journeys originating and terminating, effectively providing users with an interactive heatmap. This provides a quick summary of all the journeys made within the region. Selecting postcode combinations provides a view of the trajectories of the journeys made between the two postcodes, as well as the specific roads tagged with the activity points.

DM4 (Graphs): Compare traffic levels of different modalities over daily/weekly/monthly/yearly trends; Compare traffic levels over hourly (rush hours) intervals

The geographic map, in addition to presenting the postcodes as heatmaps displays the route network, color coded by the number of activities on the road. This is also connected to the filters provided on the dashboard.

DM5 (Contextual Menu): To enable different layers of data presentation

A variety of information is presented via the geographical map (postcodes, road network, journey trajectories). This, while presenting several different types of information, can get confusing for users. Hence, the visibility of each layer can be toggled based on the interest of the user.

DM6 (Zooming and filters)

Filters provide the means for users to drill-down into specific subsets of the dataset. The geographical map provided in the OD tool enables users to visualise the data in multiple zoom levels.

5.1.1 Data Preparation

Data received from the Seta application is stored in a table as individual records of timestamped locations, along with user ID and further information. A separate table stores timestamped activities along with other pieces of information such as accuracy, user IDs etc. The two processes of activity recognition and location pings are asynchronous and hence, need a further process of alignment to ensure locations can be tagged with an activity. This is further analysed in three steps, the first to provide temporal categorisation. This process takes timestamped data and tags it by the hour of day or day of week, while the second process tags the location data by the postcode the geo-coordinates originate from. The final process tags the timestamped geolocated activities with the OpenStreetMap road (line) segment they originate from. This further enables querying and filtering the data based on hour of the day or weekend/weekday combinations. Activity data (timestamped, geo-located) collected via the Seta app is currently stored at secured USFD servers, as per the necessary privacy and security requirements – summaries and interpretations of the data will be made available to

the Seta Data Platform developed in WP6 during the next phase of development.

5.1.2 OD Interface and Interactions

The OD tool is presented in three different sections: filters, geographical map, graphs/charts. Figure 6 shows the developed tool for analysing journeys users have made. The three sections are presented as follows: in the top, the filters provide means for users to select a particular subset of the data. The initialisation process presents the users with all the data available in the database. Selecting a particular journey time/day of the week refreshes the visualisations to reflect the new selection.



Figure 6 - The OD tool provided to decision makers for analysing origin destinations.

The charts are simple representations of the distribution of the data points within the selected journeys. The charts summarise all the data points that have been recorded - for example, two journeys may be selected, containing 20 activity-location points. The charts would present category visualisations of the 40 points. The first pie chart presents a summary of the number of times different activities have been observed in all the journeys. The second chart is a stacked bar chart which presents a distribution of the different activities, over different days of the week. The third chart provides a distribution of the activities in different times of the day.

For example, Figure 7 presents the charts being refreshed with a new set of filters

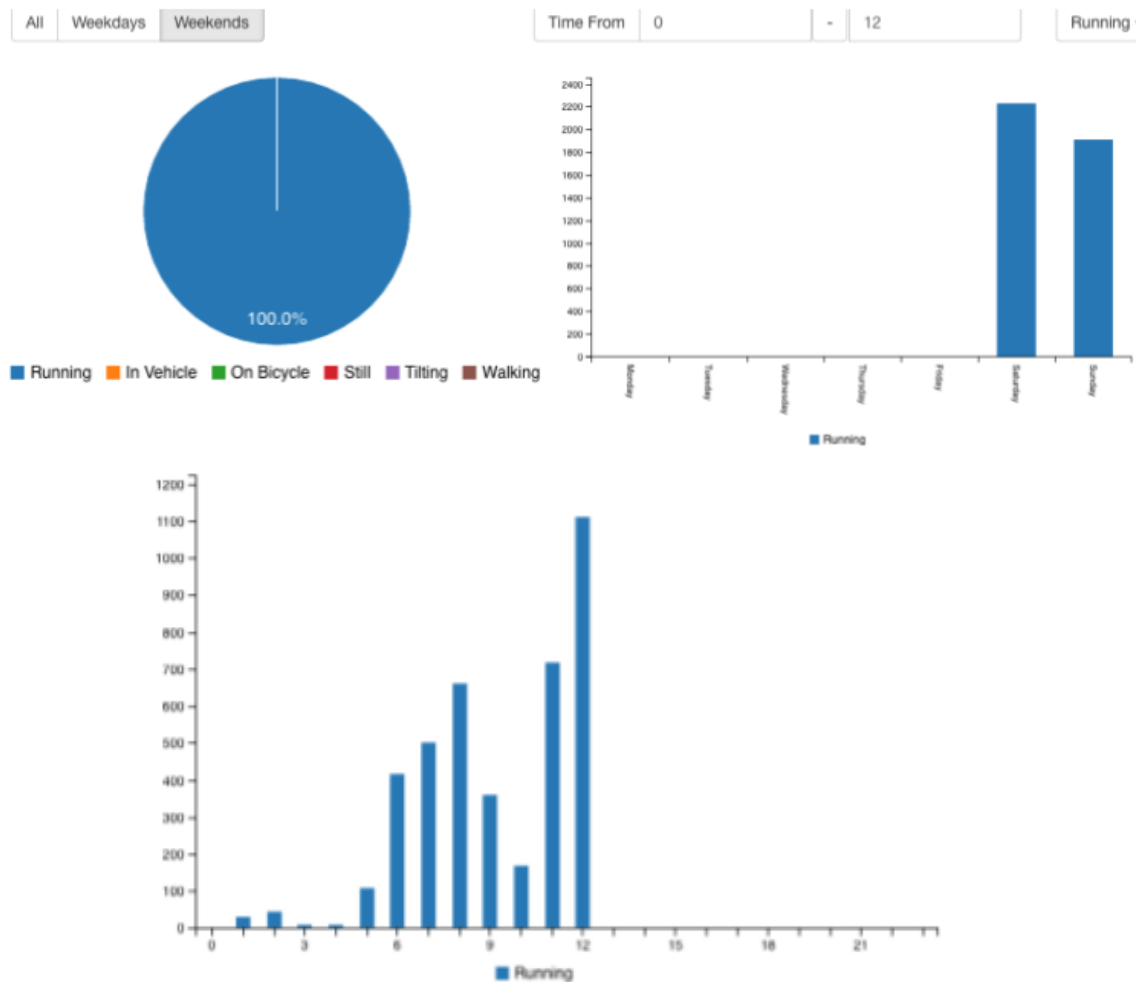


Figure 7 - Filters select subsets of the data. Here, all the running journeys made by all users on weekends, between midnight and noon.

The geographical map is the most complex section of the OD tool and is aimed at being the primary point of interaction for the decision maker. The geographical map also provides multiple layers for interaction, as discussed previously - these are mainly the postcode layer (which also presents information as heat maps), the road segments and the trajectory data points. Figure 8 illustrates the different layers in the map. Roads display a vector layer of the road network, based on the number of times an activity observation has been recorded on the road. Postcodes are the main points of interaction for origin destination analysis, and support mouse-over gestures and clicks. Clicking on a postcode highlights the relevant postcodes which have journeys connected to the selected postcode. Selecting an associated postcode to the selected postcode presents the geo-coordinates of the journey (in 'JourneyPoints' layer – the layer that plots individual points that comprise a journey), as well as highlights the corresponding road segments in the road network vector, color coded by the number of occurrences (bottom-right).



Figure 8 - Multiple layers for geographic maps presenting different types of information.

The initialisation process loads all the activity data points, categorised by the postcode and road segment - as presented in Figure 9. Clicking on the postcode highlights the origin/destinations of the relevant journeys. Orange indicates the postcodes where journeys (that had originated from the clicked postcode) terminated. Green indicates the postcodes where journeys originated from (terminating in the clicked postcode). Magenta postcodes are postcodes that have both origins as well as destinations in relation to journeys originating to/terminating at the selected postcode.



Figure 9 - Geographical map - hovering over postcodes present the details of the postcode and how many journeys have been recorded from and to the postcode. Selecting postcodes show related postcodes, while losing focus on the other postcodes.

5.2 SETA Citizens Observatory

Citizen observatories allow the general public to become an active part of the decision-making process via different means such as problem reporting, contribution to a knowledge base or just by enabling communication within the community. In SETA, they are employed to gather and distribute mobility data from/to the general public with the aim to help decision makers get a broader and clearer overview of what their communities need in their daily commutes.

The citizens' observatory in SETA is integrated in both the mobile app described above and in the decision-maker web application – see Section 4.



5.2.1 Integration of Citizens Observatories functionalities in the SETA mobile app

The mobile app offers an environment to empower users and allow them to contribute to the knowledge base of mobility. The application will offer its users the possibility to send structured location based reports to describe any problems they have seen in their day-to-day travels.

The user can send reports about mobility issues or generic reports, attaching images or videos as evidence (see Figure 11). Their reports will be visible to decision-makers using the web interface and to other citizens as location-based notifications in the app.

Figure 10 – SETA Citizens Observatory: reporting interface

5.2.2 Citizens Observatory for Decision-makers

The citizens observatory's decision makers' platform offers the possibility to users to:

- view the data submitted by citizens
- distribute news/information to citizens on the mobile app via notifications

When a report is submitted, it is automatically displayed in the decision-makers' dashboard, where data can be visualised using different means such as tabular data or charts or maps. The system allows a high range of visualisations in order to allow decision makers to extract the most relevant information from the available data.

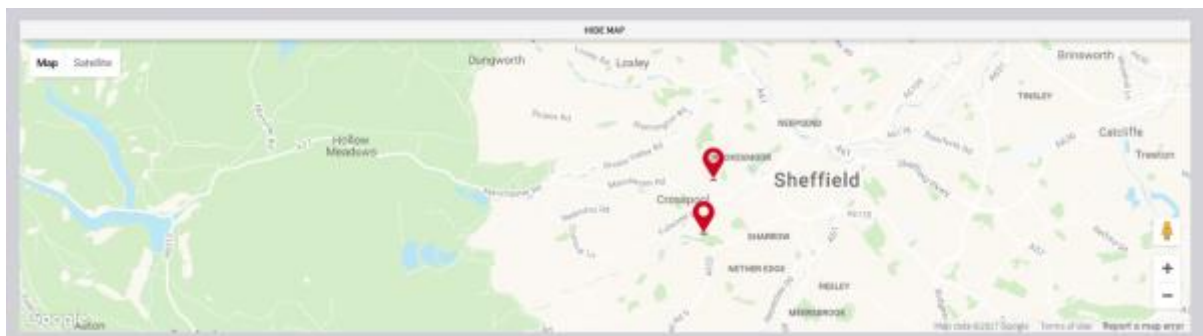


Figure 11 – Citizens' Observatory: The map based interface

Any submitted data that has been geolocalized can be visualised on a map (see Figure 11), the relevant submission being highlighted, as shown in the example below (Figure 13):














Results				DELETE ALL
Incident	Visibility	Delay (mins)		
 two cars collided	Good	45		
Road is full of smog	Poor	10		
	Poor	10		
Smog has cleared	Good	0		
	Good			

Figure 12 – Citizens' observatory: view submitted data

Using the collected data, decision makers can then create custom dashboards on the visual analytics platform to better understand mobility issues in the local area. (The figure shows only three points as no delays have been recorded between 29th of January and 19th of March.)



Figure 13 – Citizens' Observatory: example of delays chart

The citizens' observatory's decision makers' platform also enables decision-makers to send notifications to all user using the mobile app: the notifications are sent in the form of reports

(see Figure 14) and will be received by users only when they are in a relevant area, to avoid information overload.

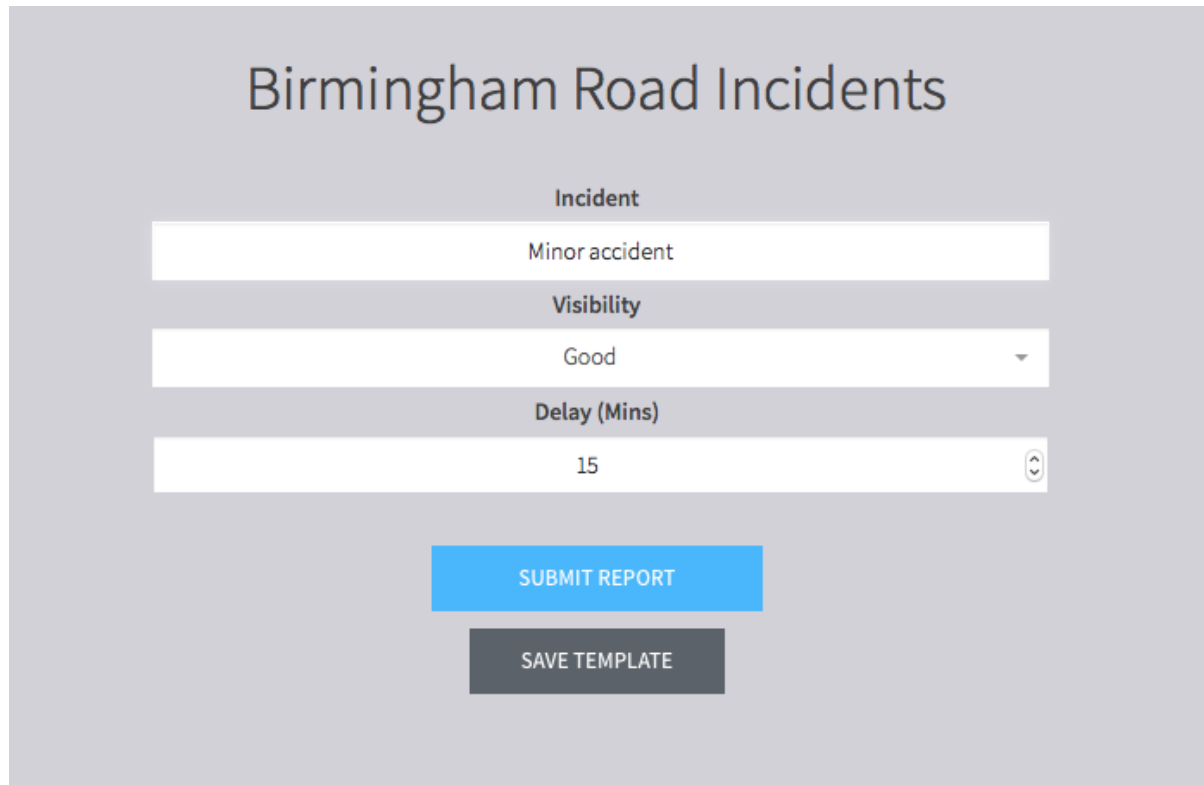
The image shows a web interface titled "Birmingham Road Incidents". It features three input fields: "Incident" with the value "Minor accident", "Visibility" with the value "Good", and "Delay (Mins)" with the value "15". Below these fields are two buttons: a blue "SUBMIT REPORT" button and a grey "SAVE TEMPLATE" button. The interface is clean and modern, with a light grey background and white input fields.

Figure 14 – Citizens' Observatory: web interface for submitting a report

5.2.2.1 Technical implementation

The citizens' observatory's decision makers' platform is a responsive web application developed using HTML5, CSS3 and the latest versions of open-source mapping and charting JavaScript libraries. The platform is running on a Ruby on Rails server which operates the collection of data but also any data processing required. Any processed data is stored in SOLR which is a scalable and high availability data store that can work with very complex queries.

Any received data is processed automatically using custom modules which are triggered with every new piece of data inserted in the system. A use case of this implementation is the Seta Platform API. Any reports submitted by citizens will be processed by the decision makers' platform and added to the Seta Platform API so that other components can access it. This is a modular way of allowing further development and introduction of new features.

To achieve the data management, security and privacy requirements, the platform offers multiple access levels to different features and data. Users can be grouped based on permission levels that allow them to see only specific parts of the system or only certain data. Any secure areas of the platform will require an account to be accessed – for example: data

alteration.

Communication between the mobile application and the citizen observatory's decision makers platform is made through a RESTful API that operates using secure tokens to avoid unauthorised third parties from submitting data. The secure token is provided once the user has logged in and it is used for any communications between the app and the server thereafter.

Any data flowing between the citizens and the decision makers' platform will be transmitted through the Seta Platform API. The Seta Platform API also provides secure communication using unique tokens, similarly to the decision makers' platform API.

5.3 Active10 Mobility Analysis

The main aim of the Active10 Mobility Analysis ² platform is to provide decision makers with temporal and location views over the current mobility choices. The design of the Active10 Mobility Analysis platform was carried out as exploitation of SETA in an external project (funded by Public Health England) in which government decision makers identified requirements for visualising the data collected using the Active10 app ³.

5.3.1 Requirements

The following table presents specific requirements for the visual analytics platform. The requirements have been identified by project partners in collaboration with Public Health England decision makers.

ID	General Requirement
G – 1	The user will be able to login in the system using username and password.
G – 2	The user will be able to set up automated queries execution for pre-defined timeframes (choice between daily, weekly and monthly)
G – 3	The user will interact with a dashboard interface with interconnected widgets (summary, spatial and trend analysis). For example, when selecting a specific

² **Please note:** the data collection method via the app was designed by the University of Sheffield. The concept of Active 10 and the requirements for the visual analytics was provided by Public Health England. The copyright of the concept is theirs. The visual analytics platform was implemented by K-Now in collaboration with USFD. The activity was funded externally by PHE. The information about Active 10 is **highly confidential and must not be disclosed outside the consortium**. USFD as main contractor and K-Now as subcontractor have a binding contract with PHE that strictly regulates any public disclosure.

³ Please refer to D1.2 for further details.

	location (e.g. postcode) or a specific timeframe, also the rest of the visualisation will focus on that area only.
G – 4	The user will be presented with a summary of: <ul style="list-style-type: none"> · total number and percentage of days the Active 10 target was achieved by users · average number of instances when 10 minute chunks of brisk walking was achieved · how many times goals were set in the past week · adherence to individual goals
G – 5	The user will be able to interact with the map by selecting areas (grouped at postcode level using the first 2 letters). Clicking on an individual section highlights the section on the map, and queries for the relevant data to be populated on the other two components – summary and trend analysis.
G – 6	The user will be able to zoom in and out on the map.
G – 7	The map of postcode areas is overlaid on a standard geographical map to provide users with a reference of the area they are focused on.
G – 8	By default, a distribution of the total number of users is presented, which can be changed to show the distribution of daily and weekly minutes walking or brisk walking.
G – 9	The user will be able to use bar charts to see trends of different characteristics
G – 10	The user will be able to interact with the bar charts, selecting a specific timeframe or an activity for visualization.
G – 11	The location used in all visualizations will be determined by <ul style="list-style-type: none"> • Deriving a default postcode based on a user's activity (e.g. collect the most frequent postcode registered during the first 6 nights of use) • Generalising the postcode to the first two letters.

The following table presents specific requirements for the data analytics.

ID	Requirement
D – 1	Visualise for every day, all users achieving at least an active ten, using a table and/or a graph
D – 2	Visualise the total minutes of activity (walking, brisk walking) daily and weekly by locality, using a table and/or a graph

D – 3	Visualise the average number of 10 minute chunks of brisk walking undertaken daily using a table and/or a graph
D – 4	Visualise the national distribution of 10 minute chunks of brisk walking daily
D – 5	Visualise the trends in physical activity through the lifetime usage of the app, split by week in each locality
D – 6	Visualise the trends in Active 10's through the lifetime usage of the app, split by week, in each locality
D – 7	Visualise adherence to goals and changes over time (i.e. return the average number of goals achieved over the last n weeks) Visualise the frequency of goal setting (number of goals set over the past week or month), using a table and/or a graph.
D – 8	Visualise the proportion of app users that adhere to set goals where adherence is defined as meeting goals daily (number of users meeting their set goals daily over a week), using a table and/or a graph.
D – 9	Visualise the average minutes of physical activity and 10 minute chunks per week achieved by those who open and use the app vs those who don't but have it installed (average number of minutes recorded by people who have opened the app for least 5 days over the last week Vs the rest of the population), using a table and/or a graph.
D – 10	Visualise behavior trends for people who have achieved a goal over the past week
D – 11	Visualise the impact that the achievement of a goal or reward has on walking (trends of users who have achieved their goals for at least 5 times over the last week.), using a table and/or a graph.
D – 12	Visualise the correlation between attainment of rewards (which ones) and Activity/Active10s (number of people who attain one specific reward AND have achieved 1, 2, 3, 4 ... Active 10s), using a table and/or a graph.

5.3.2 Development

The identified requirements have been implemented in a web app for decision-makers (protected by username and password) to explore the data gathered with Active10.

The platform offers the user the possibility of seeing the raw submitted data (e.g. Figure 16) and a set of pre-defined dashboards that answer all the analysis requirements. Figure 16 shows a heat map of the distribution of users in the UK and of users that achieve Active10s in the UK, to enable a fast comparison of the app popularity and of the app efficacy.

Results DELETE ALL											
App Days	Time walking	Time brisk walking	Active 10s	Current goal	Goal Achieved	Postcode	Region	Notifications	Goal changed	Week day	userTo
42	0	0	0	1	false	LE1		true	1	Sunday	1
42	2407	241	0	1	false	SW12		true	1	Sunday	1
44	2486	180	0	1	false	DE56		true	1	Sunday	1
43	7340	2400	0	1	false	SS6		true	1	Sunday	1
42	4491	3674	3	1	true	EC4Y		true	1	Sunday	1
42	56	0	0	1	false	TW3		true	1	Sunday	1
43	0	0	0	1	false	No locations		true	1	Sunday	1
46	85	0	0	1	false	CR3		true	1	Sunday	1
46	5445	360	0	1	false	L19		true	1	Sunday	1
42	1922	1140	0	1	false	PR6		true	1	Sunday	1

Figure 15 - Active10: raw data interface

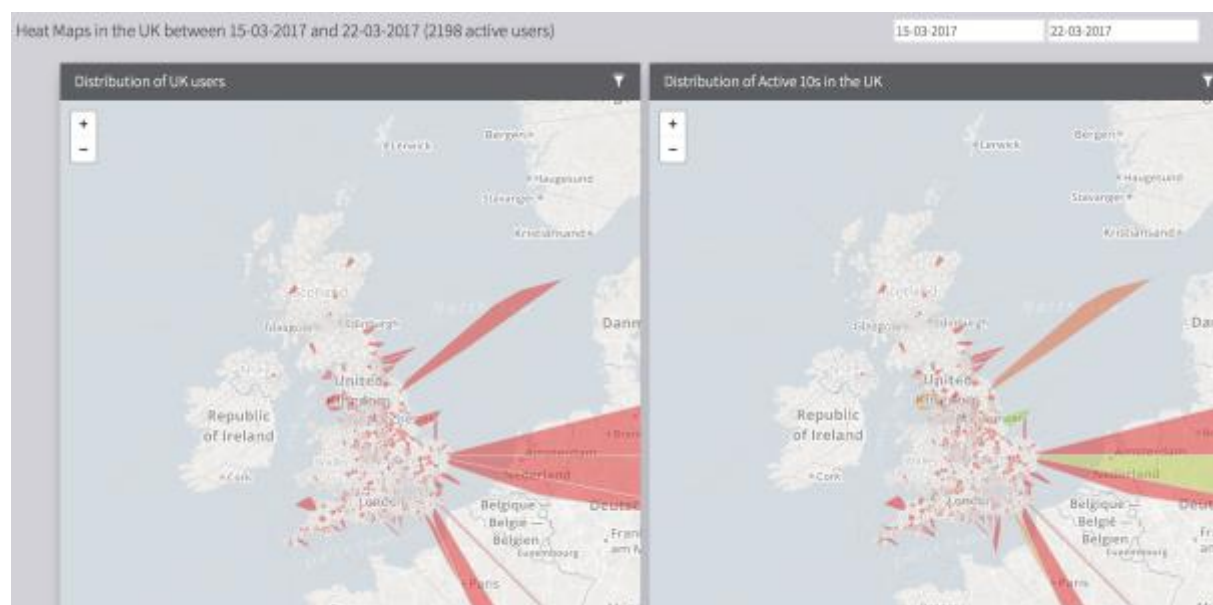


Figure 16 - Active10 interface: heat map

All the dashboards are interactive, allowing the users to refine the visualisation, for example in the above figure by date.

Figure 17 shows on the left a clickable postcode map of the distribution of users in the UK and on the right a line graph that compares the goals set and the number of Active10 achieved. Context-based interaction techniques are used: when first loading the page the graph will show the UK behaviour, whilst when clicking on a postcode it will show the data for that postcode only. More refined date/time filters with boolean options can be applied (see Figure 18).

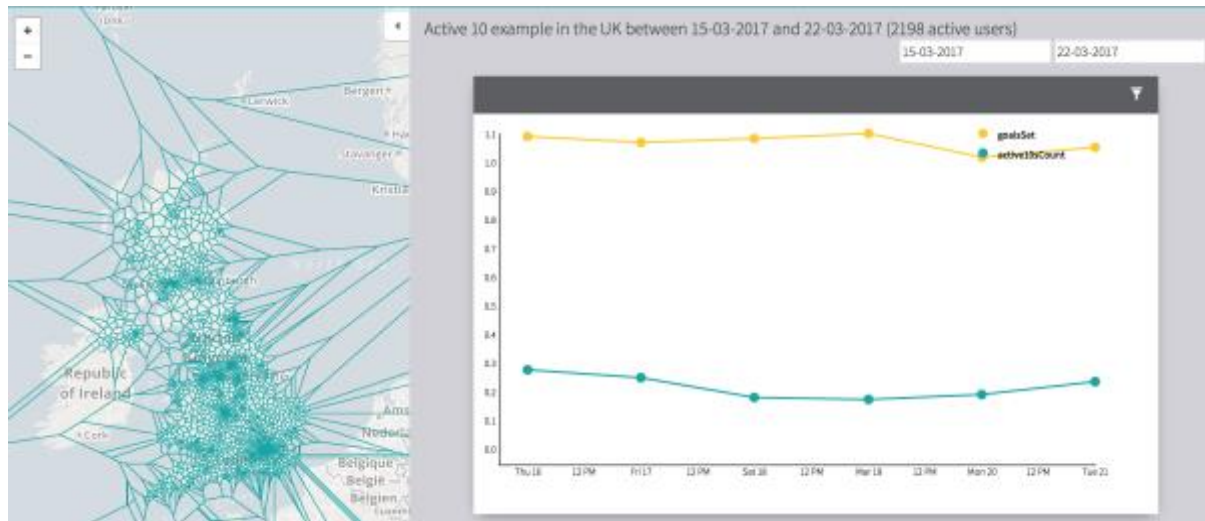


Figure 17 - Active10 interface: chart visualisation

Figure 18 - Active10 interface: filters

As the Active10 app mostly focuses on walking behaviour, a dashboard has been set up for plotting the average number of minutes walking per day (comparing normal walking and brisk walking, see Figure 20).

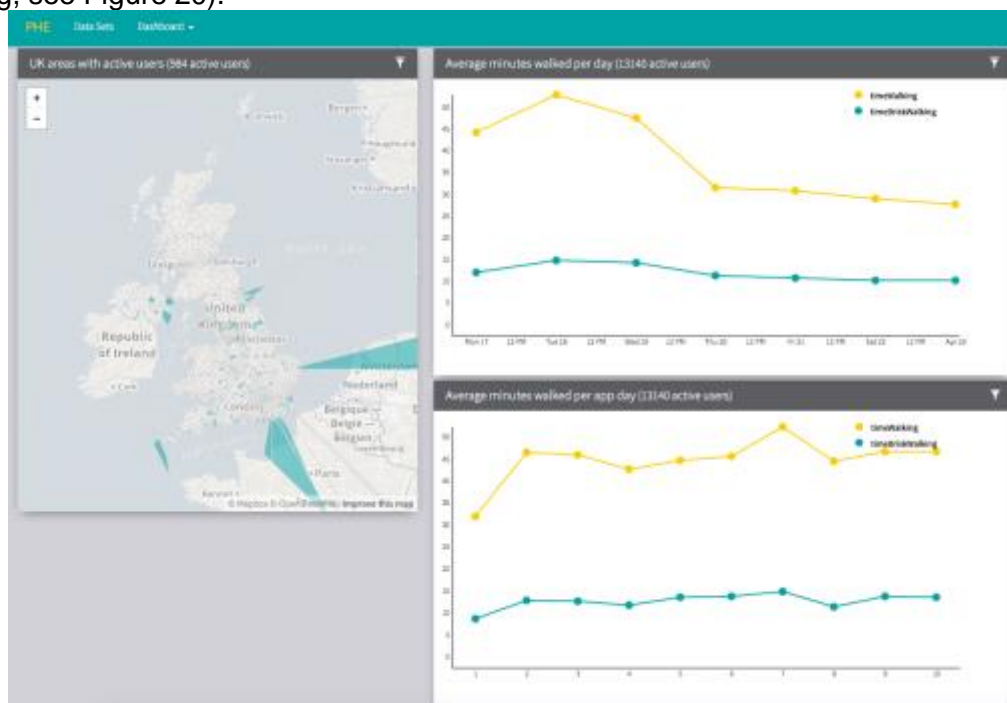


Figure 19 - Active10 interface: dashboard for average number of minutes walking per day

A specific dashboard was set up to evaluate the efficacy of using notifications in the mobile app. Figure 20 shows on the left a clickable postcode map of the distribution of users in the UK and on the right two-line graph that compares the goals set and the number of Active10 achieved when notifications are enabled and when they are disabled.



Figure 20 - Active10 interface: dashboard for notification efficacy

5.3.3 Technical Implementation

As part of the Active10 tracking performed on the user's side (mobile application, see D2.2) specific parameters are tracked: total number of minutes walked, number of brisk minutes walked, speed, etc. These values are stored on the devices and then periodically uploaded to the backend servers.

To ensure security and privacy in data storage and access, the visual analytics server has been deployed on the same machine as the backend server that collects data from users. This facilitates an easy and secure transfer of data between the two servers as it does not expose any data externally while transferring.

Initially, data transfers are performed every 12 hours - a batch at 8 am and another one at 8pm - every day of the week. However, in practice, as the platform started to receive more data, it turned out that it was more efficient to have more frequent data imports to optimise server resources and to provide a valuable user experience.

The data transfer is handled by a script which has been written to export any collected data (in form of daily summaries of user activity - including minutes walked, brisk minutes walked, goals set, goals achieved, etc.) using CSV files. The visual analytics system monitors for any new exported CSV files and once it detects a new file it imports it.

Any imported data is then processed in order to enhance its meaning and value. For example, each daily summary is labelled with an outcode (the first part of a postcode - which determines the user's neighbourhood) based on the user's location (see Figure 21). The outcode is then

used for various analytics such as heat maps of most active users or most popular areas in the UK.

Results								
Received on	User Id	App Days	Time walking	Time brisk walking	Active 10s	Current goal	Goal Achieved	Postcode
23/02/2017 00:00	58aed401b699081e570dcb17	1	5615	2184	1	1	true	KT10

Figure 21 - Active10 interface: labelling of daily summaries

The platform is developed in HTML5, CSS3, the latest versions of open-source mapping and charting JavaScript libraries, in order to offer its users a smooth and productive user experience. The UI is responsive which means that it can be used on various devices with different screen sizes and resolutions (including mobiles and tablets). The backend is running on a Ruby on Rails server which handles data collection and processing. Any processed data is stored in SOLR which is a scalable and high availability data store that can work with very complex queries.

5.4 Routing engine

The main purpose of the routing engine is to allow decision-makers to visualise data – such as pollution information or traffic simulations - on a route between two points. The component has been designed using the requirements outlined by Work Package 4 and it comes as a web application which plots the output of the routing engine on a map in order to make it understandable, accessible and readable.

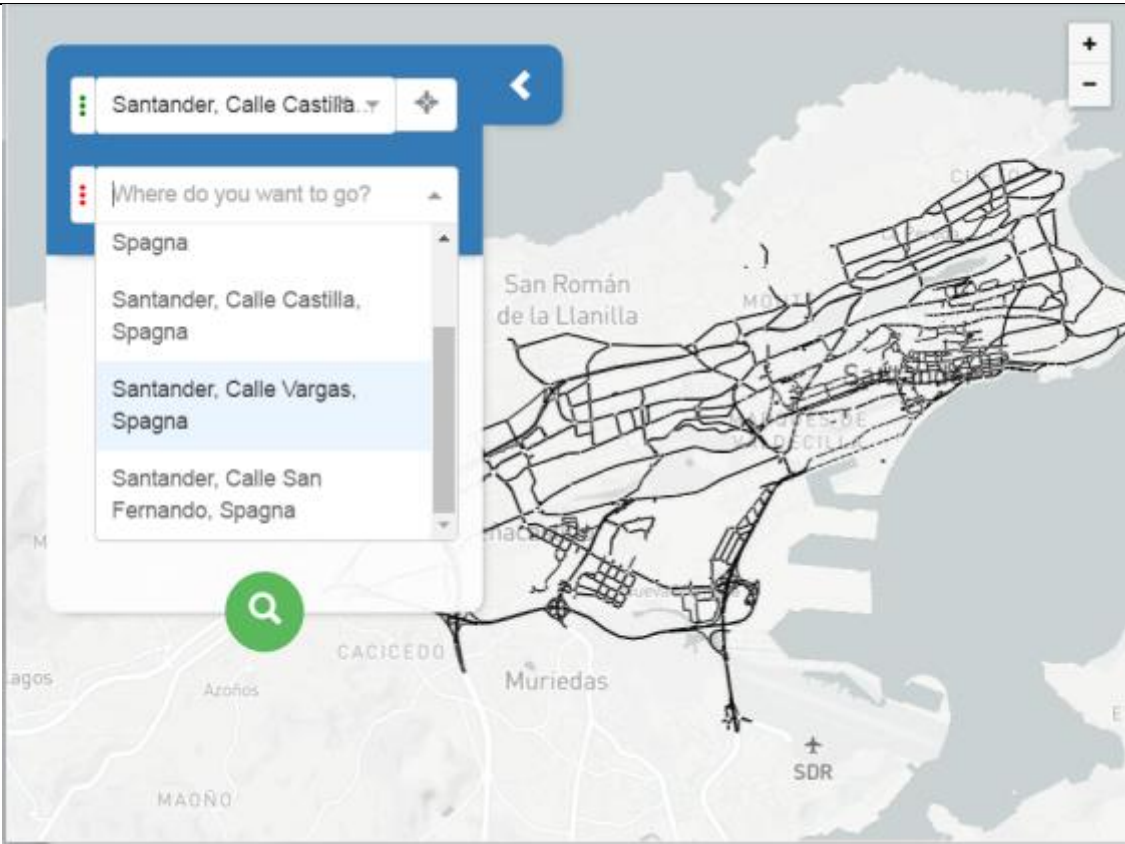
The application will exploit the data model of the city's streets generated by TSS and exposed as a service by WP6 and based on data stored in Seta Data Platform.

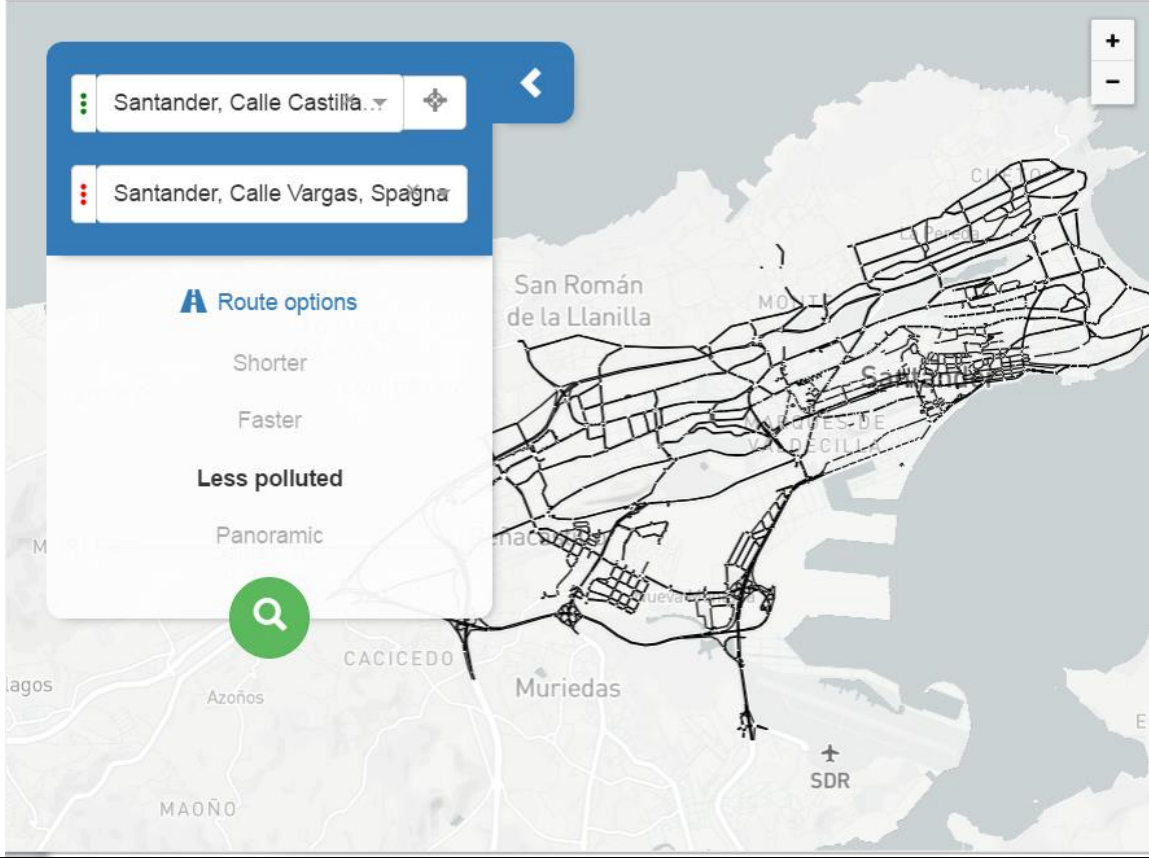
5.4.1 Objective and scenario

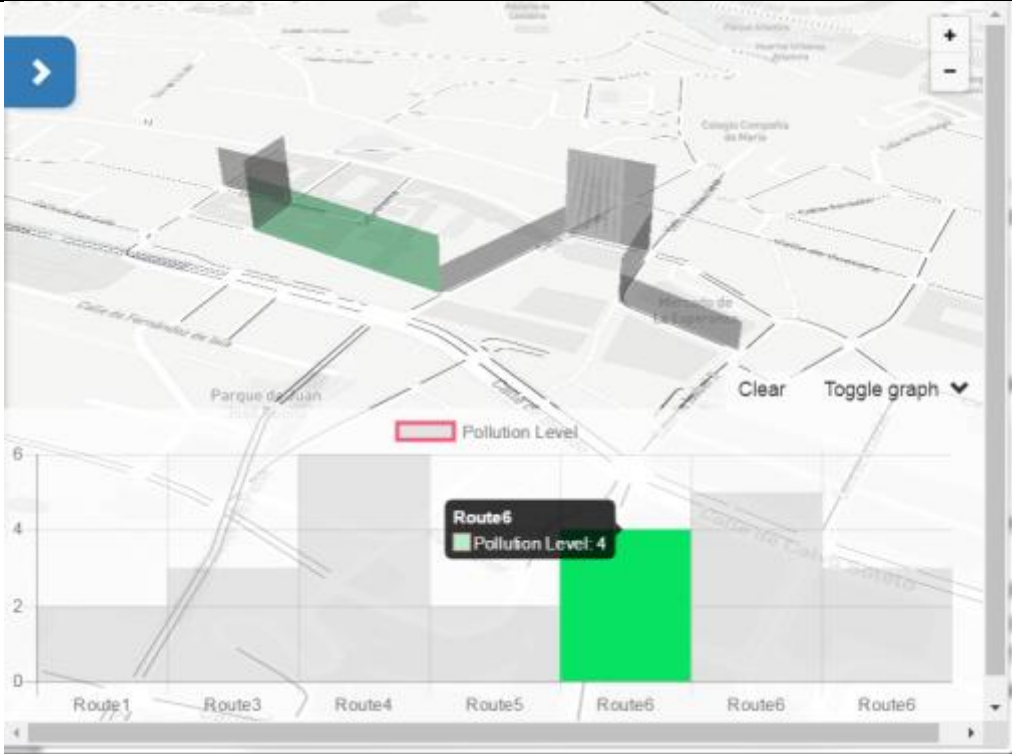
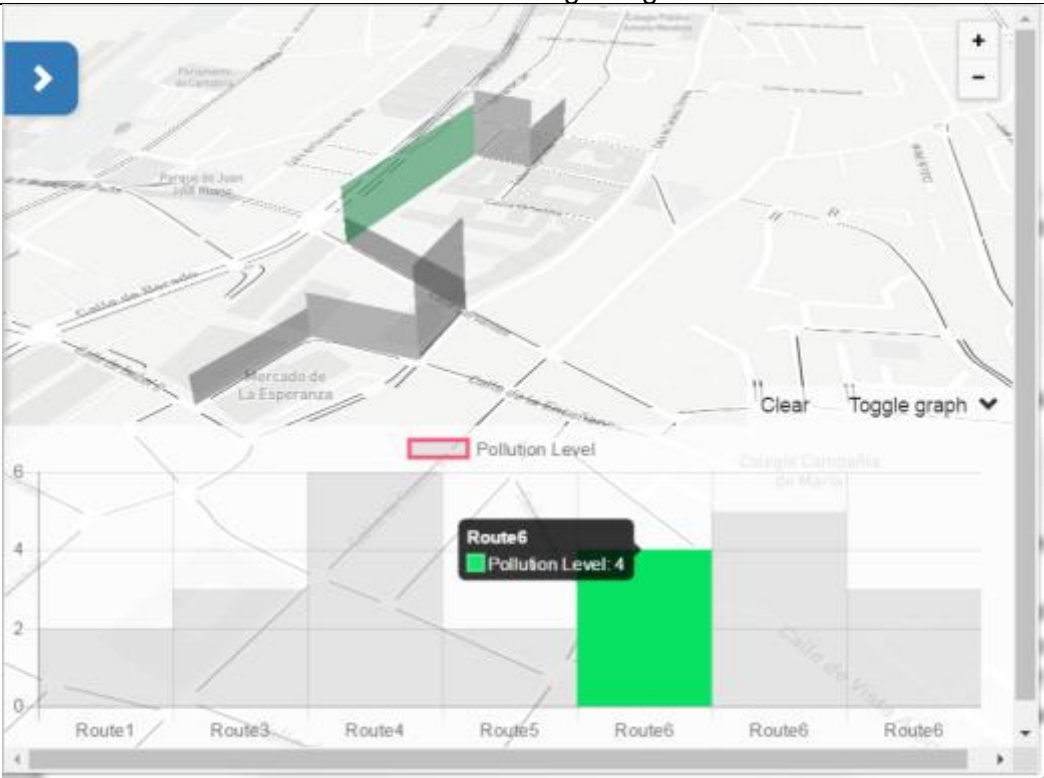
Decision-makers can use the application to analyse graphical visualizations plotted on a map, in order to visually read information based on the data model provided by TSS. The platform allows its users to get either an overview at a city level or zoom-in to specific areas – e.g. a neighbourhood or even a street.

The users could exploit the routing engine output by specifying a start address, destination address and options related to the preferred kind of routing: shortest, fastest, least polluted, calories consumption. The web application will plot on the map a 3D graphic representation of the single segments that compose the whole route, for each segment it will show a 3D bar that represents the value of the selected options in order to maximize the readability and the consumption of this information.

N	Description\Interaction
1	The user can select the start address by taking advantage of the address auto completion.

	
2	The user can select the destination address, and the Route Options. In this example the user selected the “Least Polluted” route.

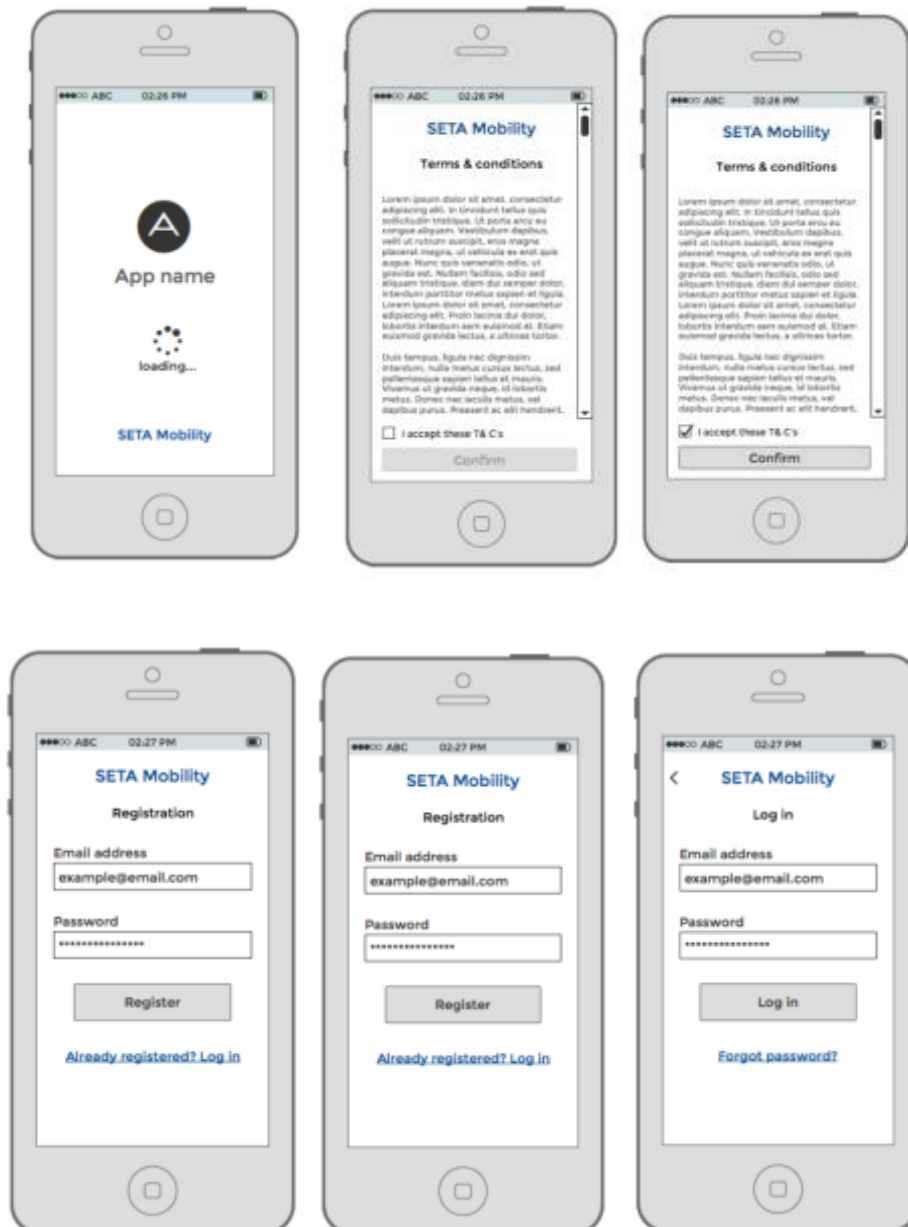
	
3	<p>Once the user presses the search button, the view zooms in to the searched route and a 3D visualisation of the route is plotted. Each segment represents the level of pollution of the part of the route. The segments use a colour scheme in order to highlight their value representation.</p>

	
4	<p>The user can change the point of view in order to maximise the readability of the information of a single segment.</p>
	

5.5 Testing Plans

Plans for testing the decision-makers' platforms in the three case studies are described in Deliverable D1.2, 1.3, 1.4

Appendix A: wireframes







Appendix B: designs

The app designs are available as an interactive app at:
<http://thefloow.invisionapp.com/share/F89ECQ1K2-/screens>



Appendix C: Load/Unload bays app user flow

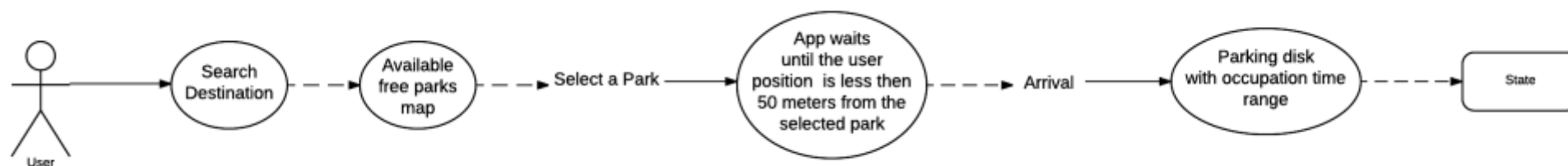


Figure 22 - User flow through the loading/unloading app