nuMIDAS

Deliverable 5.1
Usability and feasibility report

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1 Executive summary

Over the past few years, the transport sector is dealing with major challenges attributed to megatrends, such as climate change, shared mobility, and user-eccentricity. Taking into consideration requirements stemming from sustainability and quality of life principles, the need for developing new methods and tools supporting the planning, management, and monitoring of mobility solutions ensuring a well-structured and well-operating mobility system seems more than needed. This document describes the methodology and analysis used to ensure that the methods and tools identified in WP3 meet the expectations of the end users. For that requirements gathering and usability analysis to investigate the experiences of the end user are done. The collection of end-user preferences and experiences from stakeholders makes it possible to investigate how the new methods and tools are perceived. This task also reviewed the characteristics and limitations of the methods and tools used in the case studies to ensure that the dashboard designs to be developed were feasible and could be practically implemented.

2 Introduction

2.1 About nuMIDAS

The mobility ecosystem is rapidly evolving, whereby we see the rise of new stakeholders and services. Examples of these are the presence of connected and automated vehicles, a large group of organisations that rally to establish various forms of shared mobility, with the pinnacle being all of these incorporated into a large MaaS ecosystem. As these new forms of mobility offerings start to appear within cities, so do new ways in which data are being generated, collected, and stored. Analysing this (Big) data with suitable (artificial intelligence) techniques becomes more paramount, as it leads to insights in the performance of certain mobility solutions, and is able to highlight (mobility) needs of citizens in a broader context, in addition to a rise in new risks and various socio-economic impacts.

Successfully integrating all these disruptive technologies and solutions with the designs of policy makers remains a challenge at current. let alone being able to analyse, monitor, and assess mobility solutions and their potential socio-economic impacts.

nuMIDAS, the New Mobility Data & Solutions Toolkit, bridges this (knowledge) gap, by providing insights into what methodological tools, databases, and models are required, and how existing ones need to be adapted or augmented with new data. To this end, it starts from insights obtained through (market) research and stakeholders, as well as quantitative modelling. A wider applicability of the project's results across the whole EU is guaranteed as all the research is validated within a selection of case studies in pilot cities, with varying characteristics, thereby giving more credibility to these results. Finally, through an iterative approach, nuMIDAS creates a tangible and readily available toolkit that can be deployed elsewhere, including a set of transferability guidelines, thus thereby contributing to the further adoption and exploitation of the project's results.

nuMIDAS, the New Mobility Data and Solutions Toolkit, started at the beginning of 2021 under the Horizon 2020 programme and its is being developed by a European Consortium, composed of 9 partners from 6 countries: Belgium, Czech Republic, Greece, Italy, The Netherlands, and Spain.

The project builds on a distributed selection of case studies in pilot cities to provide a geographic coverage of the EU. The four pilot cities are: Barcelona (Spain), Milano (Italy), Leuven (Belgium), and Thessaloniki (Greece).

2.2 Purpose of this document

The purpose of this deliverable is twofold. On the one hand, it aims to ensure that the methods and tools identified in WP3 meet the expectations of the end users. On the other hand, usability is analysed based on end-user experiences. The collection of end-user preferences and experiences from stakeholders makes it possible to investigate how the new methods and tools are perceived. This deliverable will also review the characteristics and limitations of the methods and tools used in the case studies to ensure that the dashboard designs to be developed are feasible and can be practically implemented.

2.3 Structure of this document

This document is structured as follows. First, the methodology is explained, presenting the different user experience (UX) methods used and how the different methods were evaluated and validated. It also explains how the outcomes were analysed. This is followed by the usability analysis, where an analysis is conducted for each individual use case according to the same scheme, which makes it possible to conduct a comparative analysis of all use cases at the end.

2.4 Acronyms

CJM	Customer Journey Mapping
EC	European Commission
GA	Grant agreement
MaaS	Mobility-as-a-service
nuMIDAS	New Mobility Data and Solutions Toolkit
SDLC	Software Development Life Cycle
WP	Work package
RUS	Remote Usability study
UX	User Experience
UC	Use Case

3 Methodology

The methodology used to develop Task 5.1 of the New Mobility Data & Solutions Toolkit focuses on exploring and testing user experience (UX) methods. User-experience research methods are valuable when producing data and insights, making product and service developers efforts more effective and valuable. According to the International Organisation for Standardisation user experience is defined as "a person's perceptions and reactions resulting from the use and/or expected use of a product, system or service"(ISO FDIS 9241-210). User experience thus explores how a person feels when using a product. The field of user experience is based on the idea that we need to design products around people, rather than teaching people how to use products: user-centred design (UCD), not technology-centred design. To achieve this, there is the need to understand people - their behaviour, their attitudes, their needs, and their goals. The classic system development life cycle, which is also relevant for the nuMIDAS Toolkit, consists of 5 steps according to the SDLC that form an iterative process: Requirement Analysis, Design, Implementation, Testing, Evolution (Gidalevitz, 2016). The aim of nuMIDAS is to develop a tangible, easily available, user-friendly toolkit that provides valid and reliable insights for researchers and policy makers. For this reason, and taking into account the characteristics of the nuMIDAS dashboard, a series of UX methodologies have been selected and combined in the methodology shown in Figure 1. In order to achieve a true user-centric nuMIDAS toolkit, this methodology addresses the need of understanding who are the potential users, what their needs are, and develops the guidelines to incorporate this knowledge into the dashboard design.

The first step of this custom-made methodology is requirements gathering, where the pilot cities representatives are asked about their challenges and needs regarding the use case developed in their city. Subsequently, as part of the exploration of user experience, personas are built that represent the potential users. This is followed by customer journey mapping to determine what actions are required to meet the user's needs. Equipped with these UX methods, testing was then conducted in the form of a Remote Usability Study (RUS). The findings are analysed, classified, and passed on to the bug tracking system Mantis for resolution. The whole process is iterative and repeated when necessary. The methodology has been developed in April and already was evaluated at the end of April. The following section describes each of the individual methods used in this methodology.

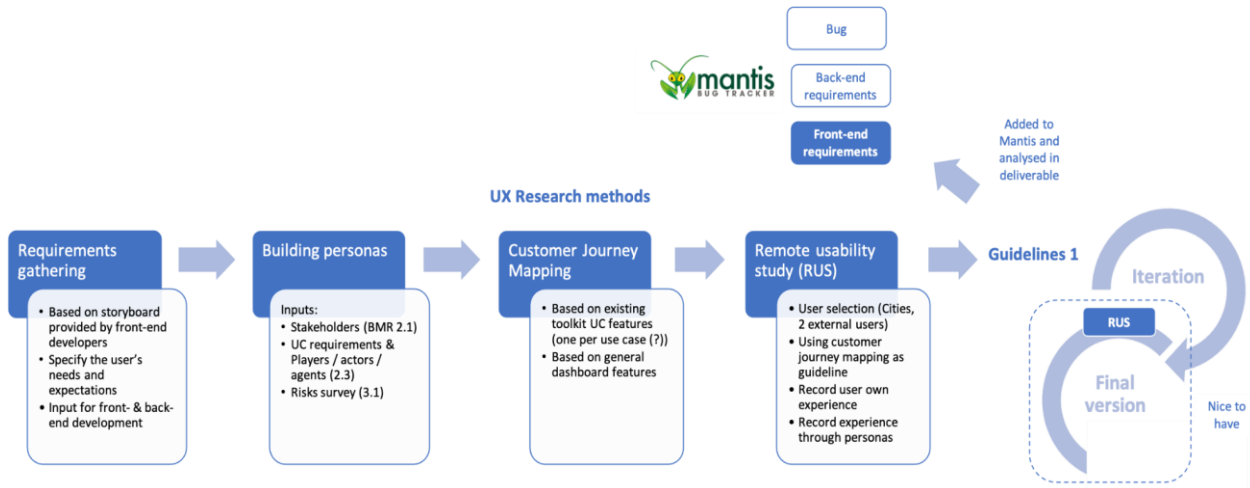


Figure 1: UX Methodology.

3.1 Exploring UX Methods

Exploratory methods are used to understand the problem space and the design scope and to adequately address the needs of the users. The field of user experience has a wide range of research methods. In general, it can be said that projects benefit from combining several research methods as they focus on different goals and types of insights. For the nuMIDAS Toolkit two methods are used: persona building and customer journey mapping

3.1.1 Building personas

Persona building is an important method for aligning design and development teams around user experience. Personas are a tool to promote decisions based on the needs of a real person rather than a generic and undefined "user". They are particularly useful when there are constraints, such as large development teams. A persona is a fictional, yet realistic, description of a typical or target user of the product. “The concept of a persona is a hypothetical, archetype of an actual user, describing that person’s goals, aptitudes, and interests” (Matthews et al., 2012). Even though a persona is only an archetype and not a living person, personas should still be described as if they were real people. Cooper estimates that each design problem will require at least 3 personas. For the toolkit, we identified and developed 5 personas. These are shown in Figure 2 below.

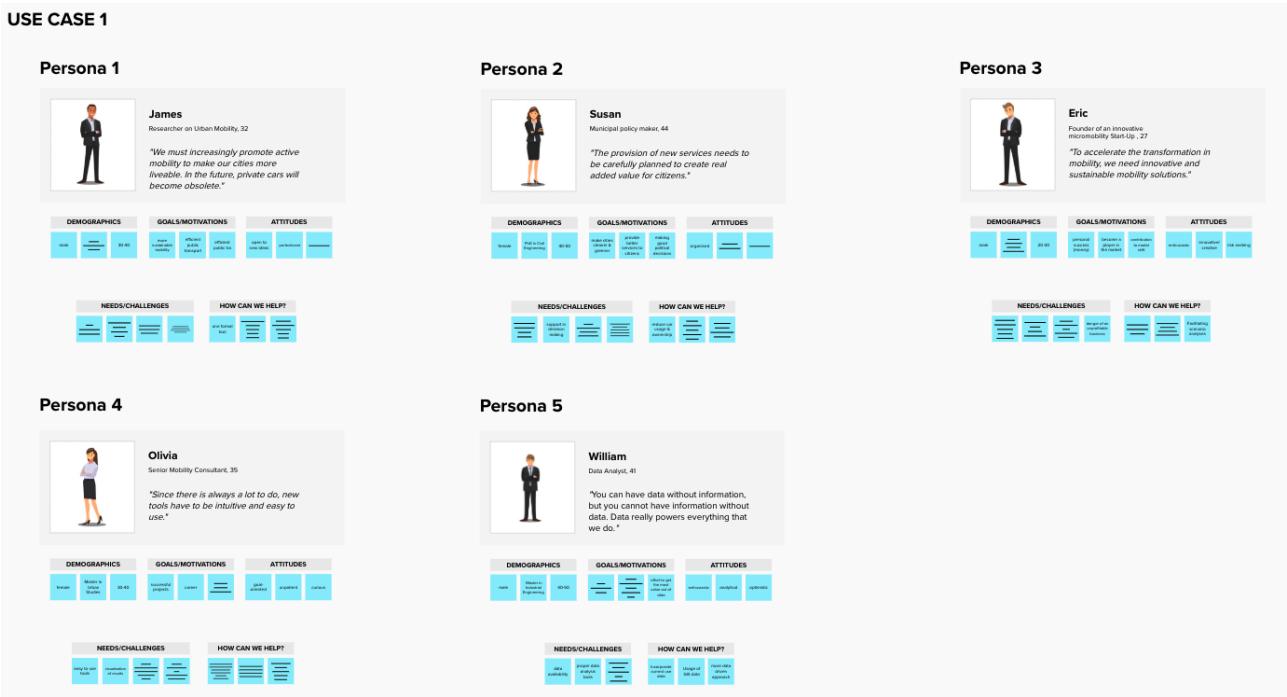


Figure 2: 5 personas identified for usability testing of the toolkit.

The method helps to reflect on potential users of the dashboard and how it is intended to be used in the future. The use of personas has benefits both for the design process and for communication with others as it creates a common understanding between designers, developers, or stakeholders. However, it is important to note that personas do not replace engagement with actual users.

3.1.2 Customer journey mapping

The purpose of Customer Journey Mapping (CJM) is to revise each step of the customer journey and at each of those steps identify how customers feel, what their needs are, what actions are needed to meet those needs, how they make decisions, what questions they might have and how you respond to all of that. CJM is thus a visual representation of the user journey and experience of using a service or space (Marquez and Downey, 2015; Stickdorn and Schneider, 2011). The mapping process can therefore reveal "opportunities, pain points and calls to action" (Risdon, 2011).

What are the benefits of user journey mapping?

1. Switching perspectives: User journey maps are supposed to foster empathy and help product/ service makers put themselves into the shoes of a user. Further, it creates awareness of why users do all the things they do.
2. Aligned understanding. Creating the map forces a conversation within the team and offers a shared mental model and terminology — the foundation for a shared vision.
3. Seeing the big picture: A journey map helps to step back and see the bigger picture, where your work fits in, and where assumptions about the majority of users were wrong. It might even help define KPIs across teams.
4. Uncovering blind spots and opportunities: A user journey map gives a structured and comprehensive overview of which user needs are already tackled and which ones are underserved. Therefore, it helps to discover opportunities and blind spots you can work on in the future. (Ruddigkeit, 2022)

A generic example of a typical customer journey map is depicted in Figure 3.

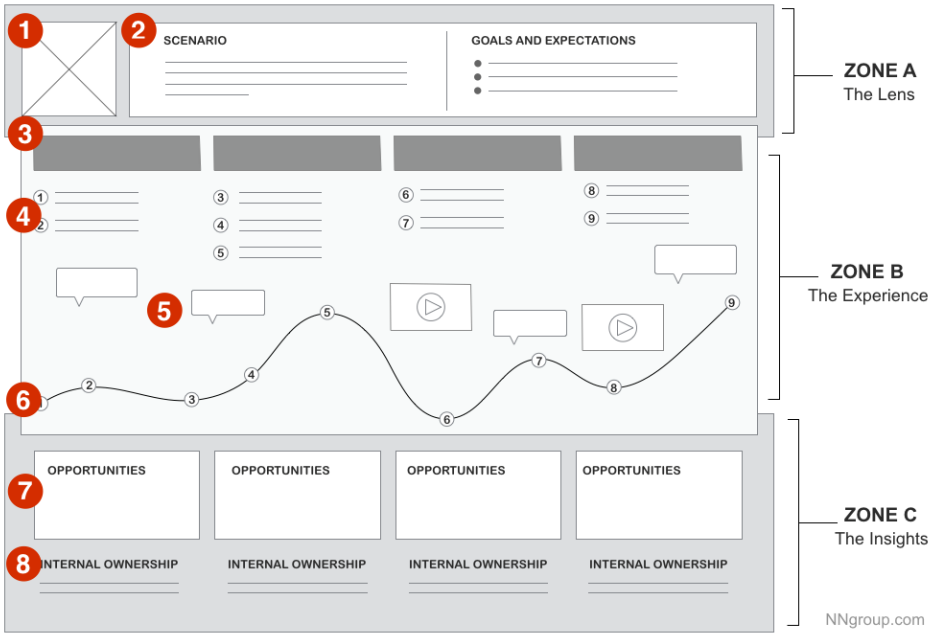


Figure 3: Example of Customer Journey Map.

Zone A: The lens provides constraints for the map by assigning (1) a persona ("who") and (2) the scenario to be examined ("what").

Zone B: The heart of the map is the visualised experience, usually aligned across (3) chunkable phases of the journey. The (4) actions, (5) thoughts, and (6) emotional experience of the user has throughout the journey can be supplemented with quotes or videos from research.

Zone C: The output should vary based on the business goal the map supports, but it could describe the insights and pain points discovered, and the (7) opportunities to focus on going forward, as well as (8) internal ownership. (Kaplan, 2016)

3.2 Testing UX Methods

Testing and validation methods are used to check designs during development and beyond to ensure that systems work well for the intended users. In testing it is very useful to have a predefined framework, e.g. giving guidance through prepared questions. But participants should always have the opportunity to express their experiences in their own words. Qualitative usability testing is considered to be one of the most effective methods to improve usability. Usability refers to how easy an interface is to use and forms an important aspect of the overall user experience (UX).

3.2.1 Remote usability study (RUS)

"Usability evaluation is a fundamental step in the user-centred design process of any interactive system, be it software or a website" (Bastien, 2008). The goal of a usability evaluation is to assess the degree of effectiveness and efficiency of a system and to promote positive user attitudes. It was chosen to conduct user-based evaluations, which are usability evaluation methods in which users participate directly. Their behaviour is observed and recorded to identify design flaws that cause user errors or difficulties. The goal is to find the most design flaws at the lowest cost. Even with four or five participants, 80-85% of an interface's usability problems can be uncovered. Remote usability testing is a method that refers to a situation in which the test evaluator is separated spatially from the test subjects. In this method of remote research, screen (and voice) recording tools are typically used while test participants interact with the product or experience in their natural environment - at home, in the office or at a specific location. A distinction is made between two approaches to remote usability testing: synchronous and asynchronous. At the remote synchronous condition, a facilitator and/or an evaluator collect the data and manage the evaluation session in real time with the participant who is remote. This type of evaluation requires video conferencing applications that allow the evaluator to see what is happening. A study has demonstrated that synchronous remote testing yields comparable results to a traditional user test (Hartson et al., 1996). Furthermore, it comes with the advantages of being more cost effective, time saving and offers freedom from facilities.

More precisely, we have opted for moderated (remote) usability tests. In moderated usability tests, a real person is present (remotely) to facilitate (i.e. moderate) the test. The moderator works directly with the test participants, guiding them through the study and assisting them with questions if they encounter difficulties in completing the tasks. Moderated testing is best when a high level of interaction is needed between the moderator and the participants. For example, when studying a prototype with limited functionality or a complicated process or concept, moderated testing provides the interaction needed to guide a participant through the study. It is also a great way to conduct interviews, understand the customer journey and discover pain points. Participants can also ask for more information if they get stuck or confused. It also aims to create a trusting environment for the tester, facilitating the opportunity for candid feedback.

We took the following approach in conducting the remote usability testing. First, a basic introduction about nuMIDAS and the toolkit was given and the participants were asked for their consent to record the Zoom-session and informed about the data processing. Afterwards, personal information of the participants was collected (to better understand the persona type) and the participants were guided through the six steps Log-In, City Selection, Use Case Board, Scenario Management, Scenario Presentation and General Management along the replicated Customer Journey Map (see Figure 3). Using prepared open questions, the participants' thoughts were examined and at the same time the sentiment of the participants was tracked. The tool Mural was used to record all the data and information.

All use cases were evaluated with several participants who also correspond to the personas built. The participants are from different organisations and fulfil different roles, mainly from our focal group of researchers and policy makers. The following Table 1 outlines the persons interviewed, as well as their relation to the corresponding use case, their organisation, and their type of persona.

Table 1: Subjects of the Remote Usability Study.

Use case	RUS date	Organisation	Persona type	N of participants
UC 1	22/4/22	AMAT	Policy maker	1
UC 1	26/4/22	Poliedra	Researcher	1
UC 1	4/5/22	Leuven	Policy maker/ Researcher	1
UC 1	5/5/22	AMAT	Researcher	1
UC 4	27/10/22	Leuven	Policy maker/ Researcher	1
UC 4	28/10/22	AMAT	Researcher	1
UC 4	31/10/22	Leuven	Researcher	1
UC 5	13/12/22	AMBi	Mobility Manager	1
UC 5	13/12/22	AMBi	Data Consultant	1
UC 5	15/12/22	AMAT	Researcher	1
UC 2	22/12/22	Poliedra	Researcher	1
UC 2	22/12/22	AMAT	Policy Maker	1

3.3 Analysis

Following the Remote Usability Study, the results were evaluated and analysed. In addition, pain points that affected the user experience as well as opportunities for improvement were identified. The issues mentioned by the testers were classified into different categories according to Jakob Nielsen's Usability Heuristics for User Interface Design. We used the following usability heuristics for categorisation:

Table 2: Categorisation of RUS results.

Category	Usability heuristic	Explanation
1	Match between system and the real world	Words, phrases, and concepts are used that are not familiar/ understandable to the user, or elements are arranged counterintuitively.
2	Help and documentation	Help and documentation should be easily accessible and understandable for the user.
3	Aesthetic and minimalist design	Interfaces should not contain information that is irrelevant or rarely needed, instead the UI design should focus on the essentials.
4	Recognition rather than recall	Certain information to use the design effectively is not visible or available which results in higher cognitive effort from the user as he/she has to remember a lot of things.
5	Error prevention	Lack of measures to avoid errors such as helpful constraints, good defaults, reducing memory burdens, and warnings.
6	Consistency and standards	Failing to maintain consistency (internal & external) and non-compliance with established standards.
7	Flexibility and efficiency of use	Giving users more options that they can use the dashboard with the functions they need in an efficient way.
8	User control and freedom	Users are not permanently in control of the system and may feel stuck or frustrated.

In addition to the qualitative analysis of the use cases, there is also a quantitative analysis of the results. The frequency of the (grouped) results is presented graphically, while the complete list with the individual results is in the appendix. Moreover, the development of sentiment during the course of the Customer Journey is quantified and visualised.

4 Usability analysis

To ensure a high level of usability of the New Mobility Data and Solutions Toolkit, the previously mentioned UX methods were explored and evaluated. For each of the six different use cases, the personas and a general customer journey map are analysed in the following. Subsequently, a detailed evaluation and descriptive analysis of the results of the remote usability study is conducted. These results are of great importance as they are passed on to the developers via the Mantis platform and thus influence the backend and frontend development, making the nuMIDAS toolkit as user-friendly as possible.

4.1 Use Case1

Use case 1 focuses on the pre-planning of shared mobility services in the city of Milan. This use case aims to support the definition of the optimal fleet size for shared mobility services (e.g. shared bikes, scooters), taking into account the parameters and constraints related to mobility, finances, socio-economic aspects, and service delivery. The main users of this use case will be policy makers and mobility researchers.

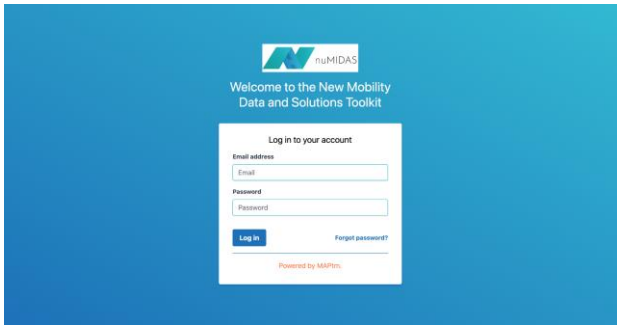
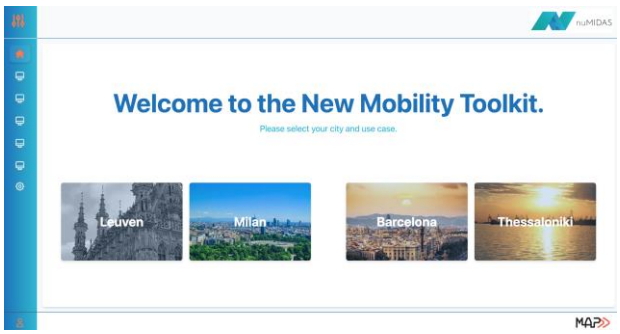
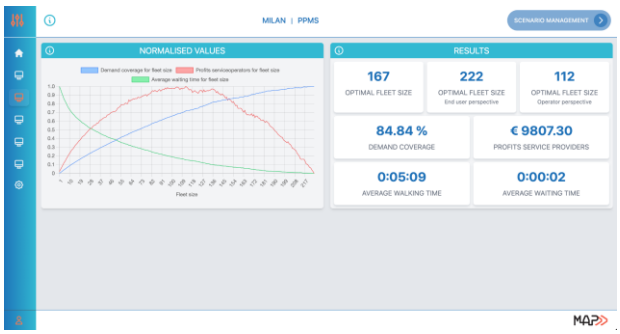
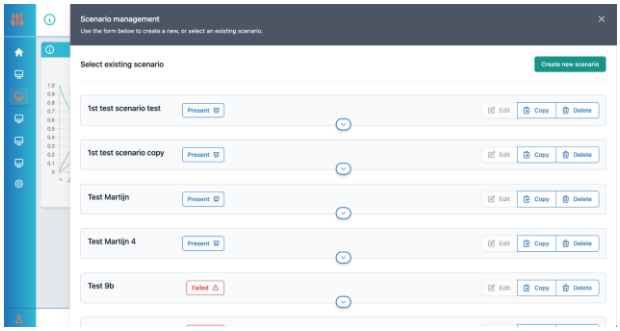
4.1.1 Persona analysis

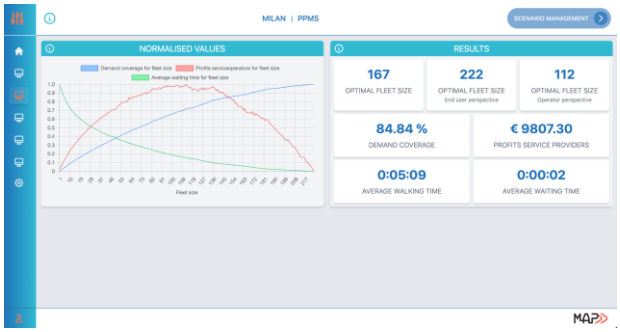
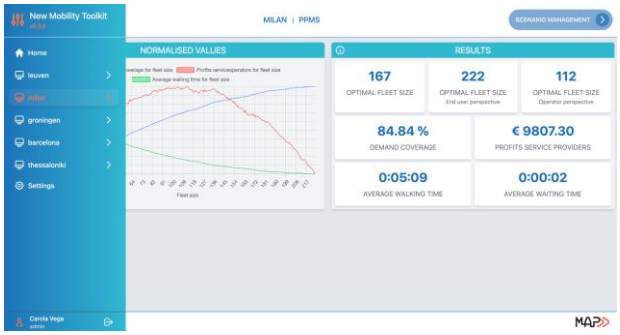
As already mentioned, mainly policy makers and mobility researchers will be using the use case to determine the optimal fleet size of shared mobility services in different parts of the city. For this reason, we specifically looked for people from these two target groups for the remote usability study. In total, we conducted the remote usability study for Use Case 1 with four people from respective organisations. One of them was a policy maker, two were researchers, and one person represents both roles in his job. In this case, all test persons were male and in the age group of 30-40 years. 3 of the 4 test persons have a doctoral degree.

4.1.2 General customer journey mapping

The following table represents the customer journey while using the nuMIDAS dashboard.

Table 3: Customer Journey Mapping UC1.

	Log In: - User enters nuMIDAS dashboard website - User accesses his account by logging in with his credentials
	City/ Use Case selection: - User selects his city first - Once the city is selected, the different use cases are displayed
	Use Case board: - User automatically enters the use case board - User can create new and edit scenarios in the "Scenario Management"
	Scenario Management: - User can set individual parameters for each scenario

	Scenario Presentation: - Visual representation of the results by means of a graph and some selected KPIs - User can perform a basic sensitivity analysis with the results
	General Navigation: - User can switch between the different use cases and cities - The settings can be accessed via this

4.1.3 Use case analysis

Three different analyses were performed to evaluate the feedback and information of the usability sessions. The three different analyses explained in Chapter 3.3, it includes a frequency analysis, categorisation, and sentiment analysis.

4.1.3.1 Frequency of issues

The graph below (Figure 4) shows the individual issues raised by the testers and their frequency. The priority was defined by the number of times an issue was reported and the impact on the user. It was found 8 issues in general. A total of 5 issues were reported by all 4 testers and therefore have a particularly high priority to be fixed.

The issues mentioned more frequently were related to the input fields when creating a scenario and the freedom to edit and/or cancel a scenario. Furthermore, it was mentioned 4 times the need to have the user settings more accessible and easier to find.

Some examples of the issues more mentioned:

- Missing information on input fields when creating a scenario;
- Missing units at input fields when creating a scenario;
- Editing of scenario not possible.

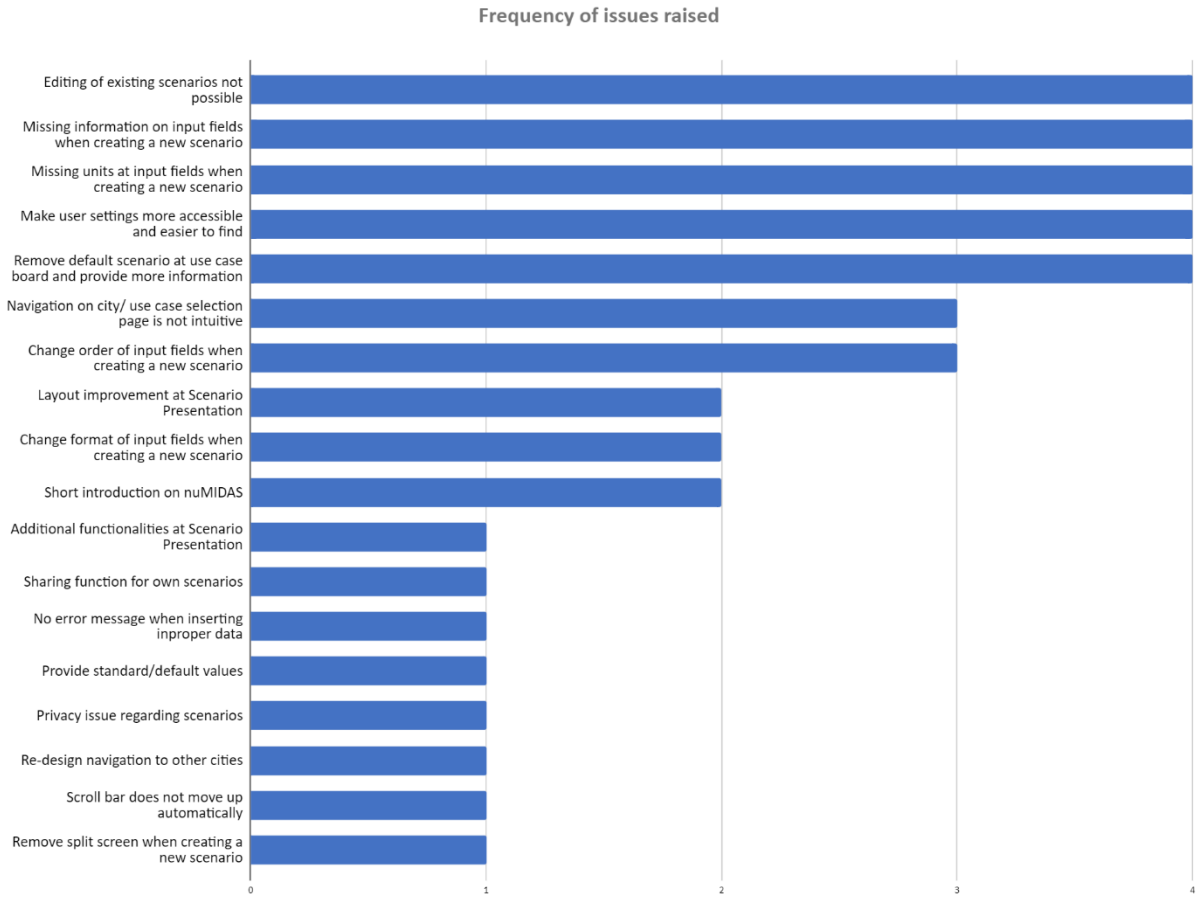


Figure 4 - Frequency of issues for UC1.

4.1.3.2 Issues categorisation

Figure 5 shows the issues categorisation graph. Most issues were reported in the category *Aesthetic and minimalist design* (35%), which particularly concerned the layout and the intuitiveness of the navigation. The second most frequently reported issues (17%) were in the category *Recognition rather than recall*, which referred to missing information, explanations, and units. In third place, with 11% each, were three categories. *Match between system and the real world*, where the reported issues related to the interface and navigation. *Error prevention* refers to missing standard values and error messages. As well as the need of further potential functionalities that fall under the category *Flexibility and efficiency of use*.

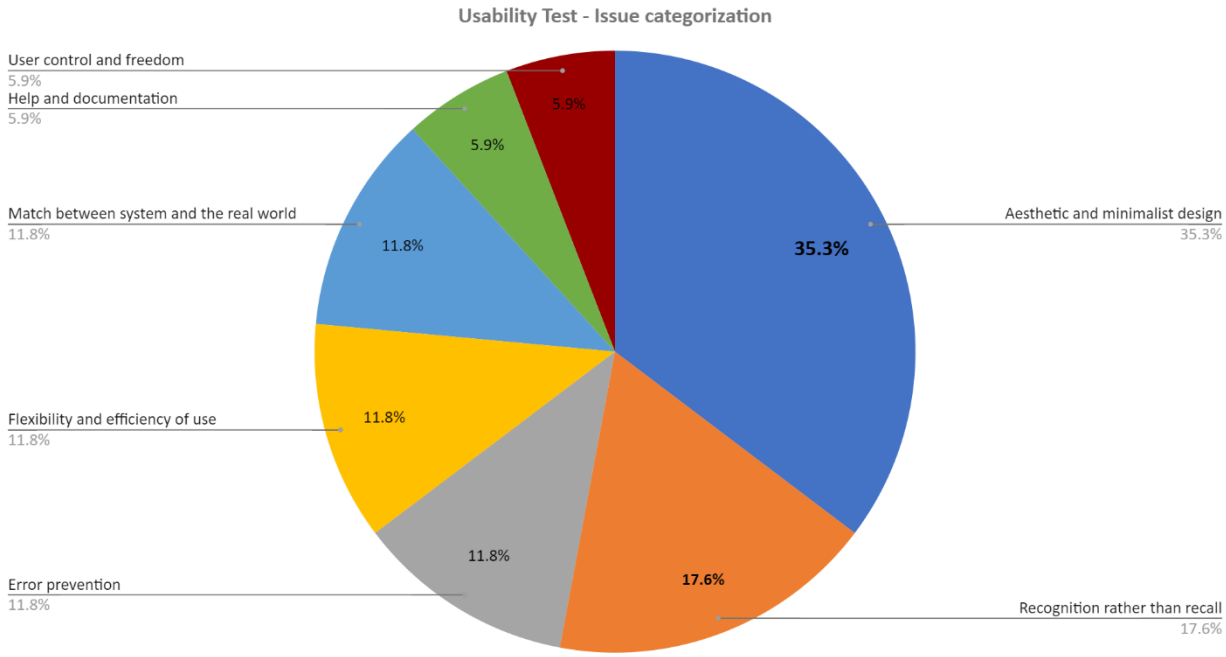


Figure 5 - Issues categorisation UC1.

4.1.3.3 Sentiment analysis

Lastly an analysis of sentiment was performed. In this analysis a 7-point Likert type scale was used to quantify testers' emotions. The two extreme points negative/dissatisfied (1) and positive/satisfied (7) and (4) for neutral. There is an individual line for each tester and an average line (grey) for all user's average sentiment.

Figure 6 shows that overall, the best stage of the user journey was the Login. This grey line shows that at the beginning, when logging in, the testers were very positive and enthusiastic. The City Selection, the Use Case Board and the Scenario Management still need to be improved. The presentation of the results, on the other hand, was again met with more enthusiasm.

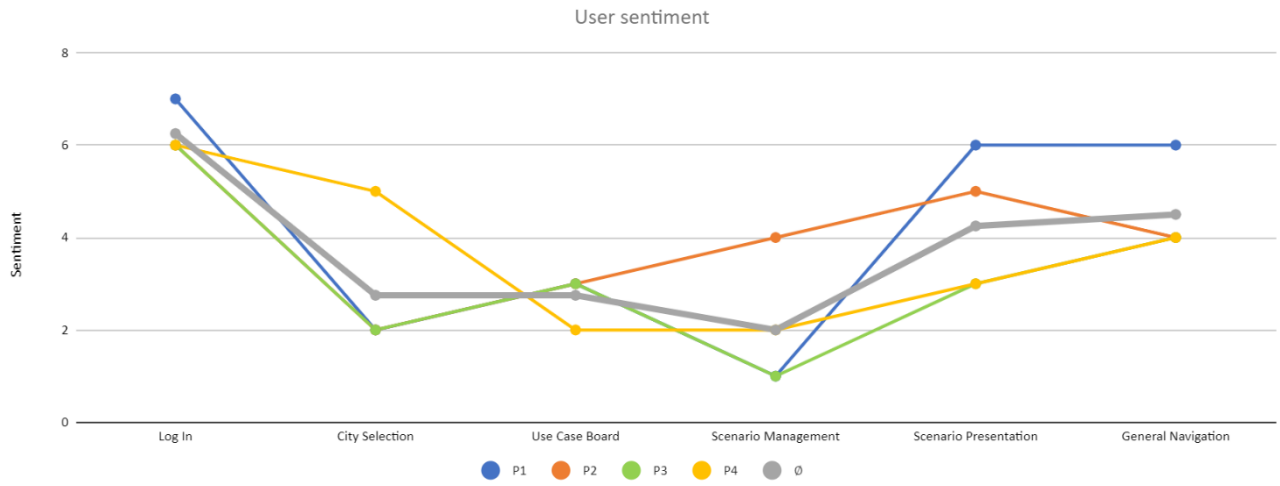


Figure 6 - User Sentiment analysis UC1.

4.2 Use case 2

Use case 2 is about operative area analysis of shared mobility. It aims to redefine the operational areas of sharing services in the city of Milan and to enable the decision-maker to explore the expansion and redistribution of operational areas. In fact, the purpose of the tool is to help the decision maker explore the different areas, the evaluated areas, of the city to be included within a basic operational area, defined as the set of currently served areas. In this way, through an iterative approach, the decision maker can assess, on the basis of the KPIs provided by the tool, which and how many areas should be included within the operational area for each individual mode of shared transport.

4.2.1 Requirements gathering

The purpose of the requirements gathering is to define the needs and expectations of a potential user (policy making, mobility expert, etc.) of the toolkit, before the development of the front end and usability tests of the respective dashboard.

For Use Case 2, a session was held with representatives from the city of Milan as the main users and policy makers involved in the project for the city.

Firstly, the use case's main goal, expected results and outputs (KPIs) were defined. The following was stated/mentioned during the session:

- Goal: Trade-off between the city and operator perspective; the city will get a lot of shared mobility services (an increase of operative area in Milan) and operators will get better information on economic attractive areas (which guarantee profit for the operators).
- Expected results: Identification of additional areas that are not yet served that could have the trade-off.
- Expected Outputs/KPIs: Information on areas: population, number of daily trips, OD data, demand. See the economic potential of the individual areas, colour coded by the necessary areas to cover, and could have and should not have areas.

A “mock up” of the customer journey for UC2 performed in the session is presented below in Figure 7.

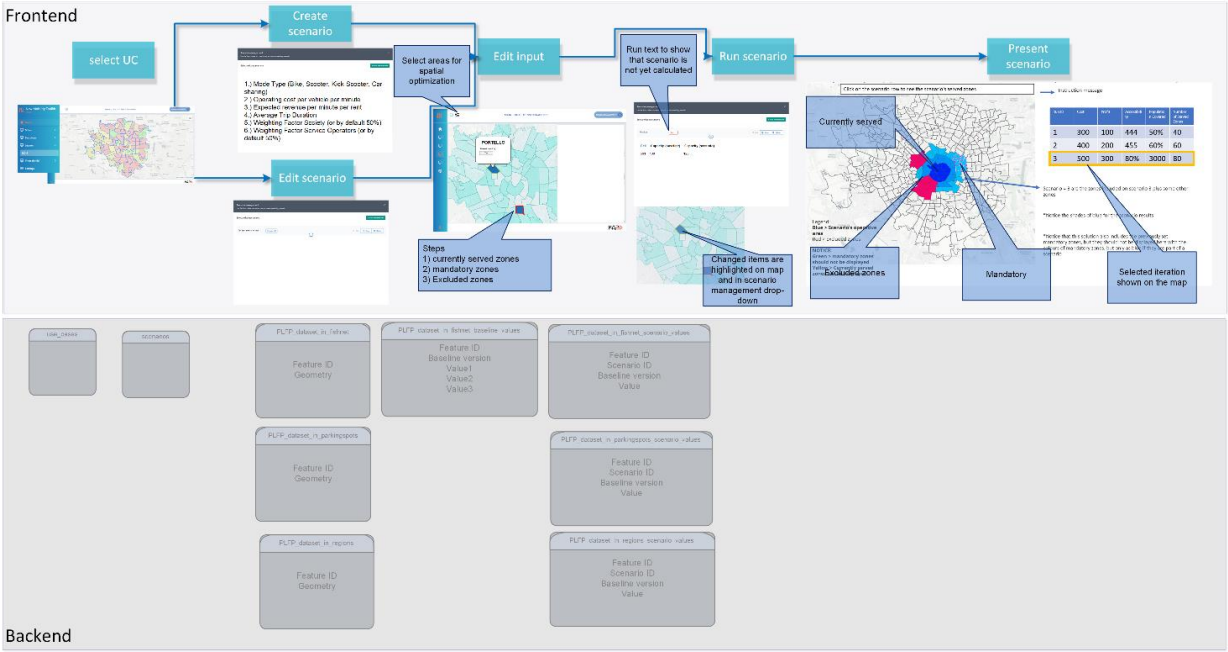


Figure 7: Workflow design UC2.

The main requirements mentioned are listed in Table 4.

Table 4: Requirements gathering UC2.

Part	Requirement
Create scenario	Before data input, the map should only show the outlines (no colour coding in advance).
	Turn on/off different layers in the map (e.g. neighbourhood shapefiles).
	"Bubble" visualisation of data associated to shapefile.
	Have similar input fields layout to UC1.
	End user does not click/ select any areas in particular using the map - user only adds input through input fields.
Visualisation of results	Have the map with three colours (green, yellow, red) representing the necessary, could have and should not have areas.
	Add highlight areas that are already fully covered.
	Have a split-screen layout: Showing Map and KPIs, what does the green/ yellow/ red areas really represent (% population covered, % daily trips).
	Output could be a shapefile with three columns: red, yellow, green; or just Boolean values.
	Red shapefile (should not areas) is not really mandatory.
	Compare visualisation of initial state and scenario produced is not required.
Export results	Have function to export the shapefile.

Following the RUS categorisation presented in Chapter 3.3, the requirements suggested by the representatives of the city of Milan can be categorised and classified as in Figure 8. It is possible to see that the majority of the requirements mentioned are related to *Aesthetic and minimalist design (*69,2%), followed by *Flexibility and efficiency of use (*15,4%) and then by *Recognition rather than recall (*7,7%) and *help and documentation (*7,7%). Most of the comments of the requirements are connected with the clear and easy representation of the information while creating a new scenario and in the visualisation of the results, such us the representation on the map, respective layers and KPI representation. Some comments were also mentioned in order to have further potential functionalities, such us turn on different layers on the map and have the results on the map and as KPI in a table.

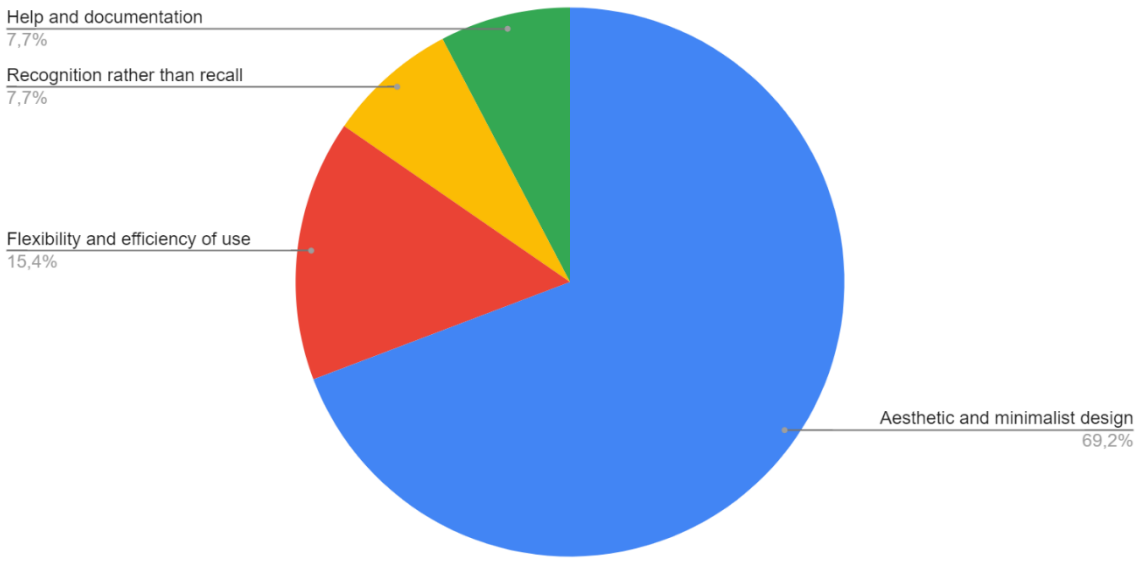


Figure 8: Requirements categorisation UC2.

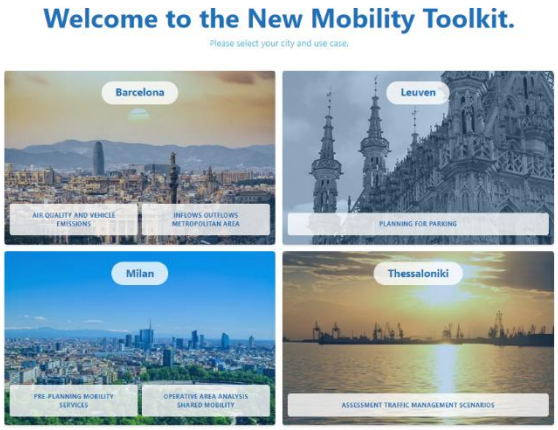
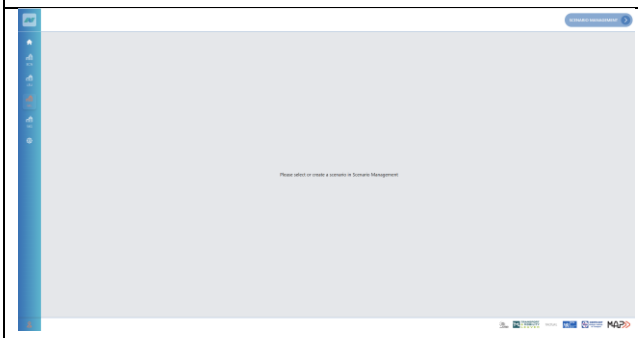
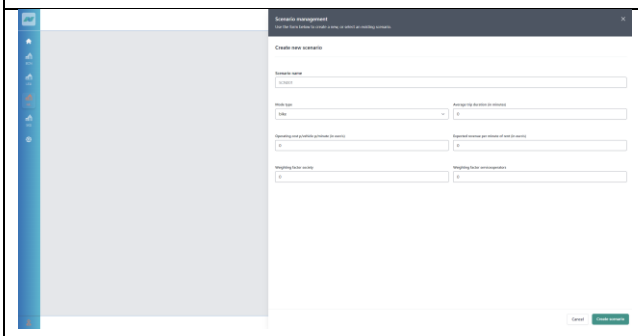
4.2.2 Persona analysis

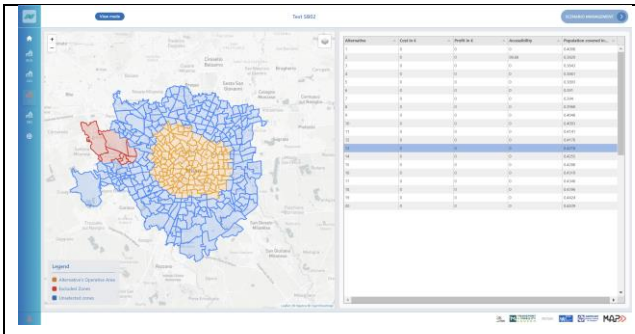
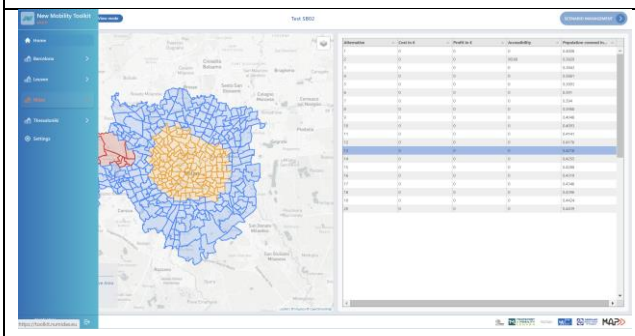
Mainly policy makers and mobility researchers will be using the use case to determine the operational areas of shared mobility services in different parts of the city. That way, we specifically looked for people from these two target groups for the remote usability study. In total, we conducted the remote usability study for Use Case 2 with 2 people from the city of Milan. The tester was a policy maker and a researcher, both male and in the age group of 30-40 years.

4.2.3 General customer journey mapping

Table 5 represents the customer journey for UC2 while using the nuMIDAS dashboard.

Table 5: Customer Journey Mapping UC2.

	Log In: - User enters nuMIDAS dashboard website - User accesses his account by logging in with his credentials
	City/ Use Case selection: - Select the Use Case
	Use Case board: - User automatically enters the use case board - User can create new and edit scenarios in the “Scenario Management”
	Scenario Management: - User can set individual parameters for each scenario.

	Scenario Presentation: - Visual representation of the results by means of a colour scheme in the map and click to see more details and KPIs. - User can perform a basic sensitivity analysis with the results
	General Navigation: - User can switch between the different use cases and cities - The settings can be accessed via this

4.2.4 Use case analysis

Three different analyses were performed to evaluate the feedback and information of the usability sessions. The three different analyses explained in Chapter 3.3, it includes a frequency analysis, categorisation, and sentiment analysis.

4.2.4.1. Frequency of issues

The graph Figure 9 shows the individual issues raised by the testers and their frequency. The priority was defined by the number of times an issue was reported and the impact on the user. 15 issues were raised and a total of 8 issues were reported by the 2 testers and therefore have a particularly high priority to be fixed.

The issues mentioned more frequently were related to the input fields and area selection when creating a scenario as well as the labels and instructions for correct visualisation of the results. Furthermore, it was also mentioned 2 times the need to have in the Main Menu a brief description/explanation of the use cases.

Some examples of the issues more mentioned:

- Clarify that the weighting factors are a percentage and complementary;
- Add instructions on what to do in edit mode;
- Add instructions to click on the table to see the results on the map.

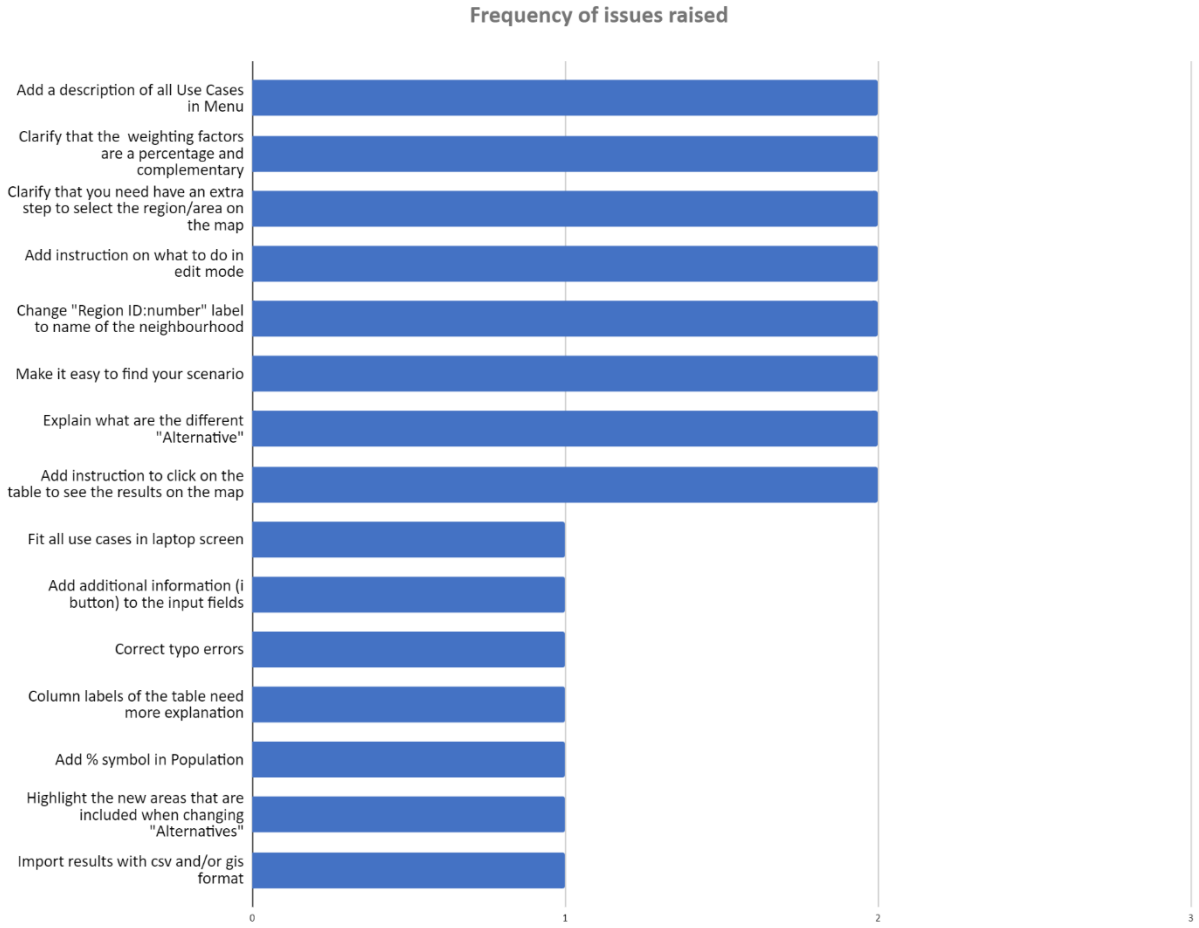


Figure 9:Frequency of issues for UC2.

4.2.4.2. Issues categorisation

Figure 10 shows the issues categorisation graph. Most issues were reported in the category *Recognition rather than recall (*33%), which refers to missing information, explanations, and units. The second most frequently reported issues were in the category *Help and documentation* (27%), that concerns the need of help and documents to guide the user navigating. In third place, with 13% each, were two categories. *Match between system and the real world*, where the reported issues related to the interface and navigation and *Aesthetic and minimalist design* which concerned the layout and the intuitiveness of the navigation.

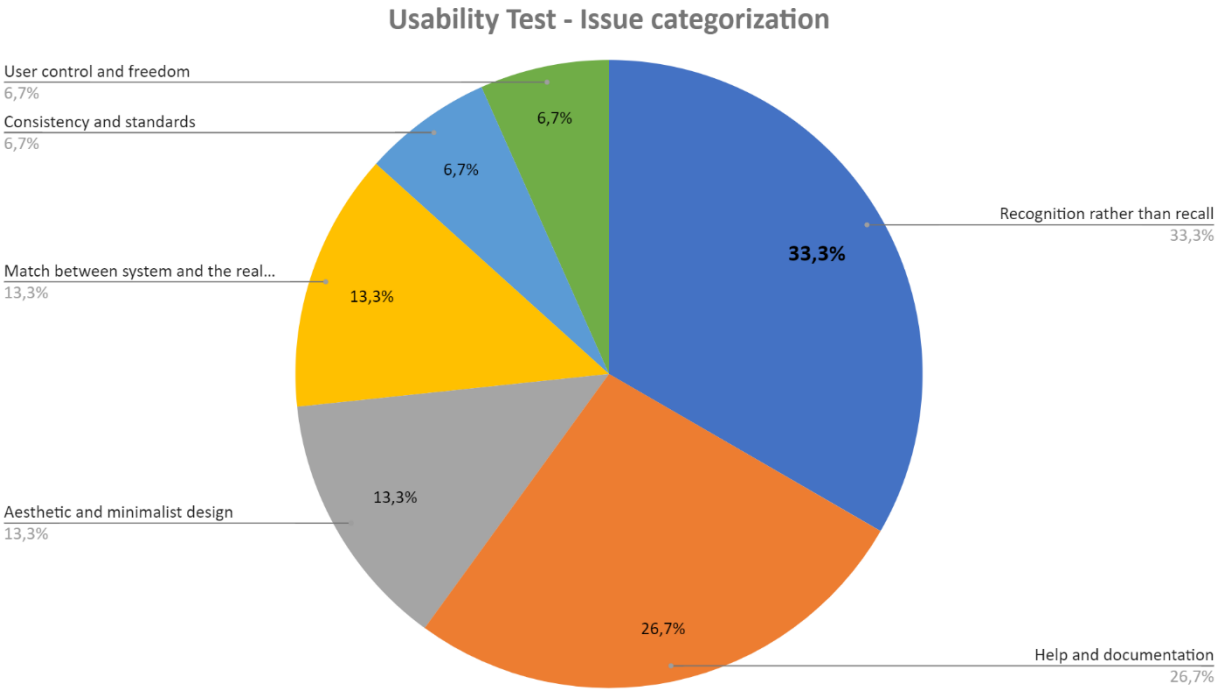


Figure 10: Issues categorisation UC2.

4.2.4.3. Sentiment analysis

Lastly an analysis of sentiment was performed. In this analysis a 7-point Likert type scale was used to quantify testers' emotions. The two extreme points negative/dissatisfied (1) and positive/satisfied (7) and (4) for neutral. There is an individual line for each tester and an average line (grey) for all user's average sentiment.

Figure 11 shows that overall, the best stage of the user journey was the Log in and General Navigation. This grey line shows that at the beginning, when logging in and in the City Selection, the testers were very positive and enthusiastic. For one hand, the Scenario Management and Scenario Presentation still need to be improved. On the other hand, the general navigation, was again met with more enthusiasm.

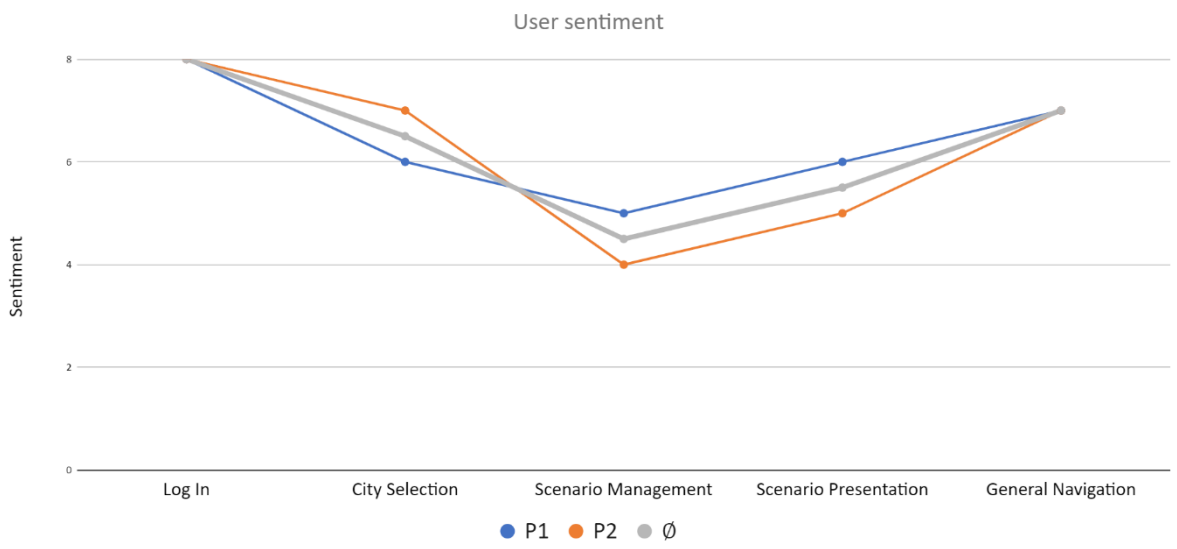


Figure 11: User Sentiment analysis UC2.

4.3 Use case 3

Use case 3 scope is to support air quality and vehicle emissions analysis based on multi-source data in the city of Barcelona. It aims to show the CO2 emission and air quality properties in the city. In fact, the purpose of this use case is to forecast the effect of vehicle-induced emissions and weather on air quality in a short- to medium-term basis.

4.3.1 Requirements gathering

The purpose of the requirements gathering is to define the needs and expectations of a potential user (policy making, mobility expert, etc.) of the toolkit, before the development of the front end and usability tests of the respective dashboard.

For Use Case 3, a session was held with representatives from the city of Barcelona and the developers of the tool as the main users and policy makers involved in the project for the city.

Firstly, the use case's main goal, expected results and outputs (KPIs) were defined. The following was stated/mentioned during the session:

- Goal: Short- and mid-term emissions forecasting.
- Expected results: Identification of areas in the map and emission and air quality information of that areas during a period of time defined by the user.
- Expected Outputs/KPIs: air quality index.

A “mock up” of the customer journey for UC2 performed in the session is presented below in Figure 12.

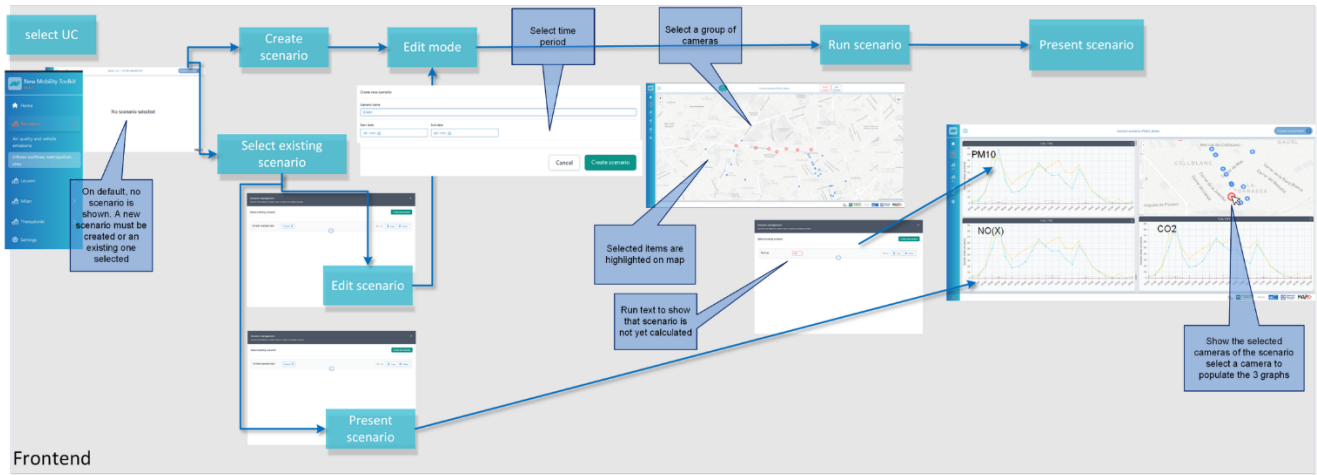


Figure 12: Workflow design UC3.

The main requirements mentioned are listed in Table 6:

Table 6: Requirements gathering UC3.

Part	Requirement
Create scenario	Have a map with the possible locations (cameras) to select.
	Selection of period should be simple and by short periods.
	Possibility, to have parameters that users can change to stimulate the emissions (e.g. based in fleet type (EURO) and change in traffic (% increase, % decrease)).
Visualisation of results	Do not show the speed between two points.
	Show the areas that have been edited in a map.
	Show data clustered by municipalities.
	Have simple graphs showing the increase in emissions.
Export results	Ideally, have the option of exporting the data.

Following the RUS categorisation presented in Chapter 3.3, the requirements suggested by the representatives of the city of Barcelona can be categorised and classified as in Figure 13. It is possible to see that the majority of the requirements mentioned are related to *Aesthetic and minimalist design* (50%), followed by *Flexibility and efficiency of use* (25%). That is, most of the requirements refers to the layout and the intuitiveness of the navigation when it was mentioned about how to show the results and select the input areas in an effective and clear way, as well as to further functionalities of the tool when it was proposed some further inputs.

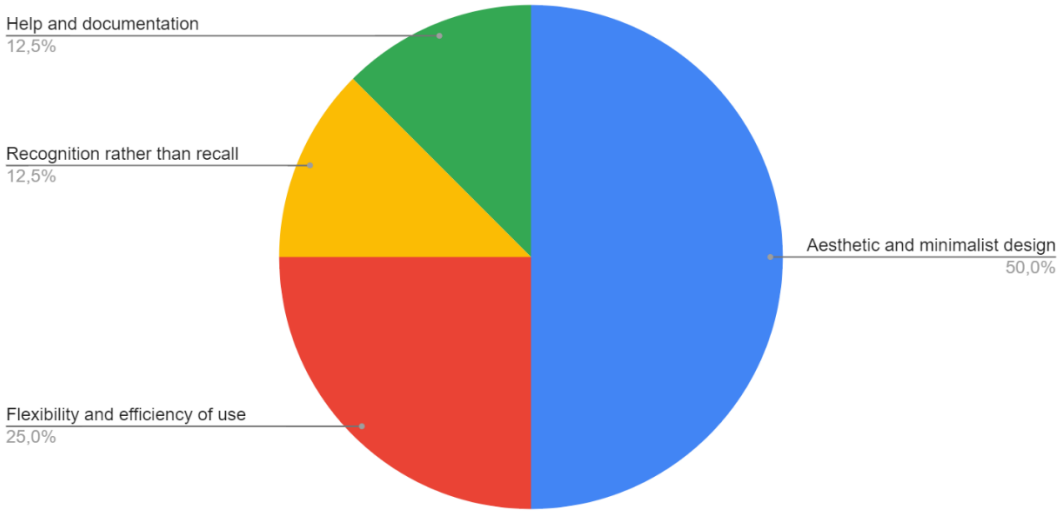


Figure 13: Requirements categorisation UC3.

For Use Case 3 no usability analysis was done due to lack of time and it was prioritised to do the usability testing for the use cases most developed.

4.4 Use case 4

Use Case 4 focuses on planning for parking in the city of Leuven. The goal of this use case is to support impact assessment of on-street parking restriction policies within inner cities as well as to evaluate the parking pressure relocation and traffic impacts (parking spots, demand and searching time). The main users of this use case will be policy makers and mobility researchers.

4.4.1 Requirements gathering

The purpose of the requirements gathering is to define the needs and expectations of a potential user (policy making, mobility expert, etc.) of the toolkit, before the development of the front end and usability tests of the respective dashboard.

For Use Case 4, a session was held with representatives from the city of Leuven as the main users and policy makers involved in the project for the city.

Firstly, the use case's main goal, expected results and outputs (KPIs) were defined. The following was stated/mentioned during the session:

- Goal: Simulate the impact of changes in parking policy
- Expected results: possibility/feasibility of reducing a number of parking spaces to support policy changes.
- Expected Outputs/KPIs: parking pressure/waiting time/ searching times, occupancy rates, financial KPIs, extra vehicle kilometres, CO2 emissions.

A “mock up” of the customer journey is presented bellow in Figure 14.

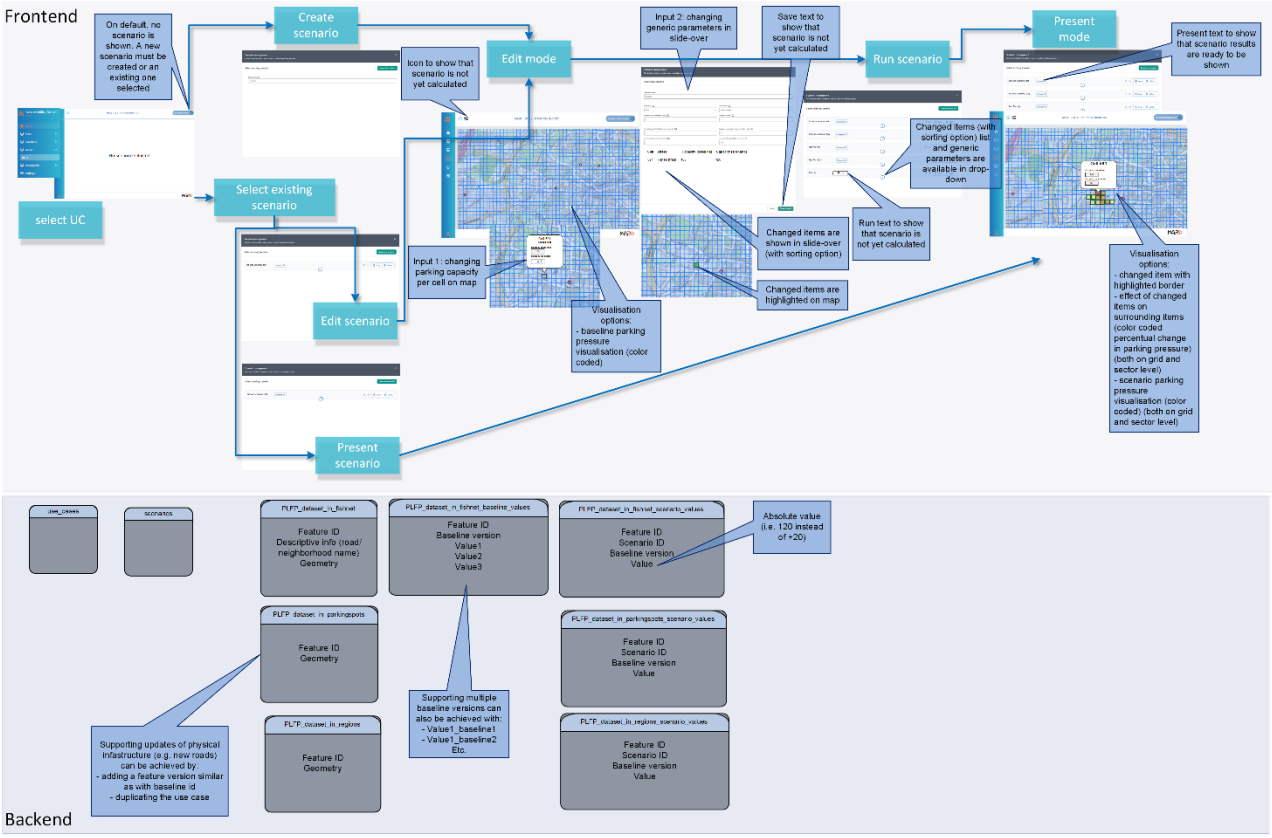


Figure 14: Workflow design UC4.

The main requirements mentioned are listed in Table 7.

Table 7: Requirements gathering UC4.

Part	Requirement
Create Scenario/Edit	Be clear between what is editable (grid cells) and what is not (segments, polygons).
	Have selection of the cells on the map and ability to see cell information in the extra list (split screen). Ideally, include the selection of more than one cell at once (e.g. 20 - whole district) and the ability to change/edit all of them at once (e.g. reduce by 20%).
	Allow easy changes after the scenario is calculated (sensitivity analysis).
Run Scenario	Display the calculation time and if calculation is still running.
Visualisation of results	Visualise the needed information in the map as layers and add function to switch between layers.
	Ideally, have the information by segment; click on certain segments and consult parameters (bubble).
	Have the grid of cells associated/ super-imposed to the segments/ polygons to be easy/ clear to visualise.
	Capacity should not be colour coded, while parking pressure should be colour coded in a gradient depending on the %.
	Ideally, tool should be able to translate/cluster grid cells to meaningful areas.
Export results	Function for exporting data output could be useful but is not a priority (export map [graphic] and grid cell data [Excel, CSV])

Following the RUS categorisation presented in Chapter 3.3, the requirements suggested by the representatives of the city of Leuven are categorised in Figure 15. It is possible to see that the majority of the requirements mentioned are related to *Flexibility and efficiency of use* (41,7%), followed by *Aesthetic and minimalist design* (25%) and *Recognition rather than recall* (16,7%). Most of the comments and requirements are connected with the clear and easy setup of scenarios and the visualisation and understanding of the results. For that, is essential to focus on the aesthetics, design, and functionalities of the dashboard. Overall, for the city of Leuven it is important to have a clear visualisation of the data and KPIs.

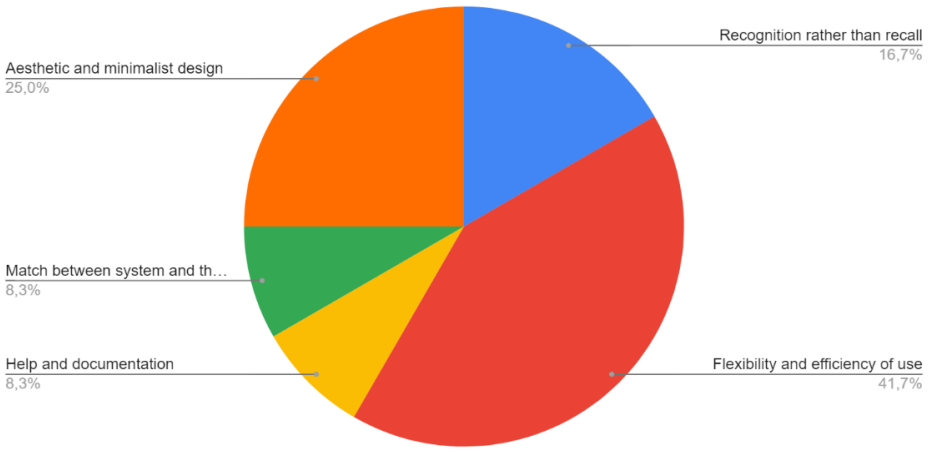


Figure 15: Requirements categorisation UC4.

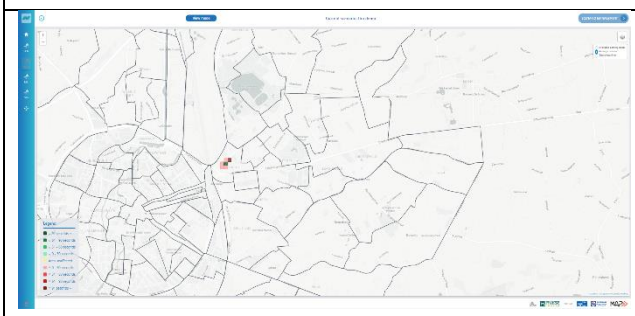
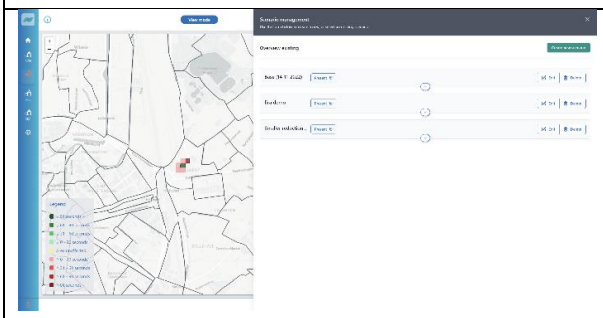
4.4.2 Persona analysis

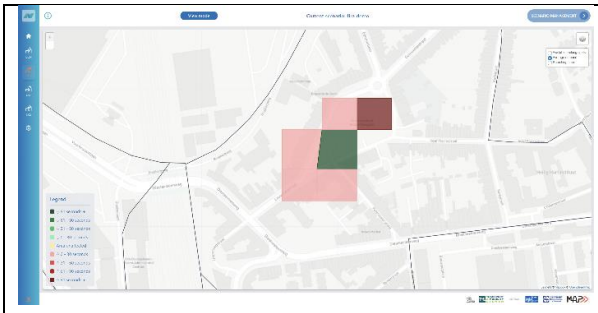
The purpose of this use case, as stated before, is to support policies decision-making in the scope of planning for parking in order to be able to evaluate the impact of reducing parking spots of the city. For that reason, we specifically looked for people from these target groups for the remote usability study. In total, we conducted the remote usability study for Use Case 4 with 3 people. One of them was a policy maker, one researcher and one person represents both roles in his job. One of them was a women, and the other two were men, all in the age group of 30-40 years old.

4.4.3 General customer journey mapping

Table 8 represents the customer journey while using the nuMIDAS dashboards for this use case.

Table 8: Customer Journey Mapping UC4.

	Log In: - User enters nuMIDAS dashboard website - User accesses his account by logging in with his credentials
	City/ Use Case selection: - Select the Use Case
	Use Case board: - User automatically enters the use case board - User can create new and edit scenarios in the "Scenario Management"
	Scenario Management: - User can set individual parameters for each scenario.

	Scenario Presentation: - Visual representation of the results by means of a colour scheme in the map and click to see more details and KPIs. - User can perform a basic sensitivity analysis with the results
	General Navigation: - User can switch between the different use cases and cities - The settings can be accessed via this

4.4.4 Use case analysis

Three different analyses were performed to evaluate the feedback and information of the usability sessions. The three different analyses explained in Chapter 3.3, it includes a frequency analysis, categorisation, and sentiment analysis.

4.2.4.4. Frequency of issues

The diagram below (Figure 16) shows the individual issues raised by the testers and their frequency. The priority is defined by the number of times an issue was report and the impact on the user. It was found 15 issues in general. There were 7 issues mentioned more frequently (a total of 3 times).

The issues mentioned more frequently were all related to how the results are presented and how the labels were named. The purpose is to adapt/change the name of labels or results presentation in order the user can understand easily. Some examples of the issues more mentioned:

- Default values in the create new scenario not logical;
- Explain better label such us expansion level;
- Not clear labels in the cells set up and visualization.

Furthermore, when the user clicks to run the scenario, the window of running scenario closes what makes difficult for the user to understand what the status of the scenario was. It was suggested to keep this window open as a solution to have a better visualization of the status of the running scenario.

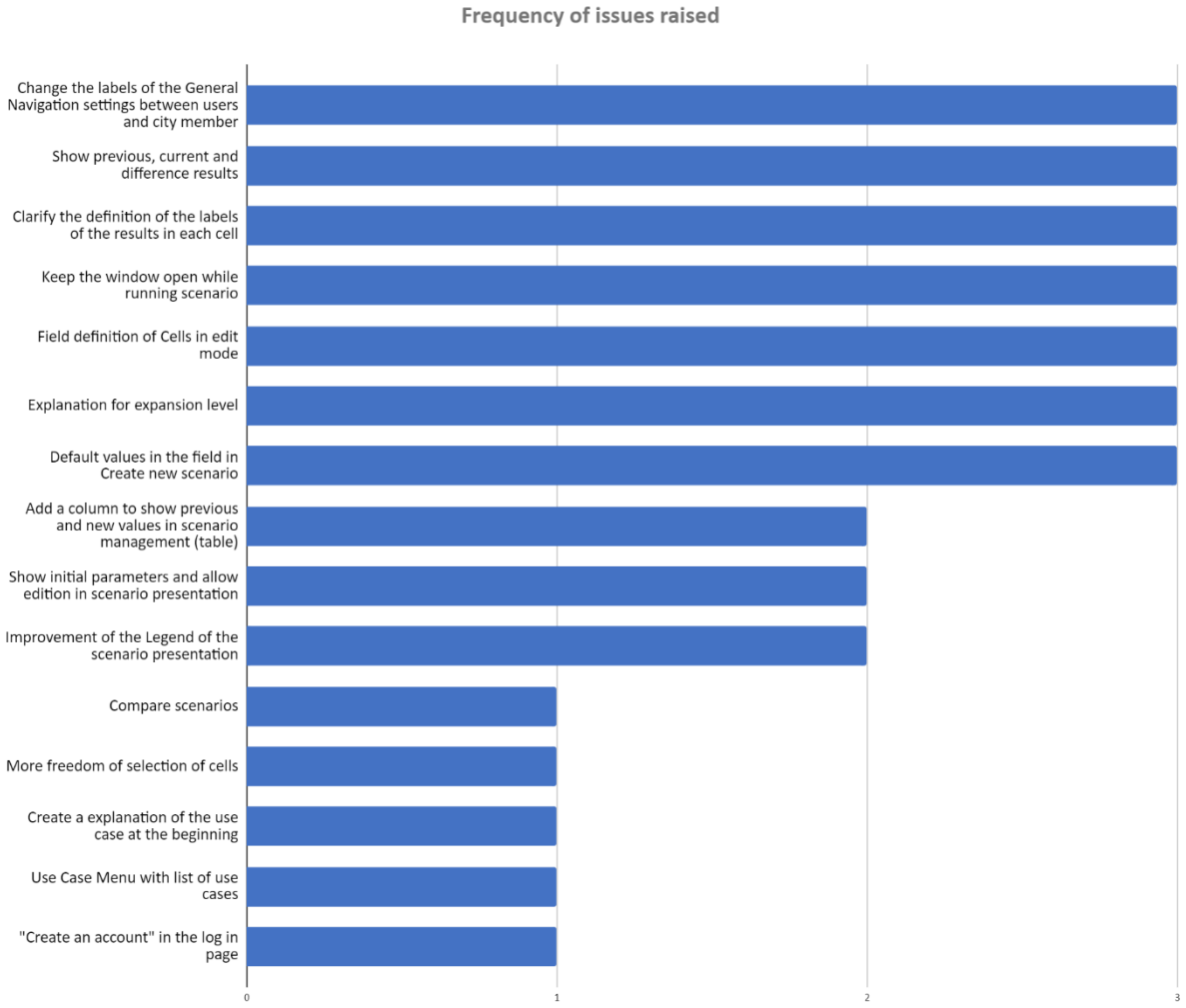


Figure 16 - Frequency of issues for UC4.

4.2.4.5. Issues categorisation

Figure 17 shows the issues divided by category as described in Chapter 3.3. Most issues were reported in the category *Recognition rather than recall* (33%) which refers to missing information, explanations, and units. The second most reported category was *Flexibility and efficiency of use (*21%) which refers to further potential functionalities. In third both, *Help and documentation* (14%) to further explain and documents to help the user understand the use case and functionalities, and *User control and freedom* (14%) that refers to freedom and control of the user to create new scenarios and navigate.

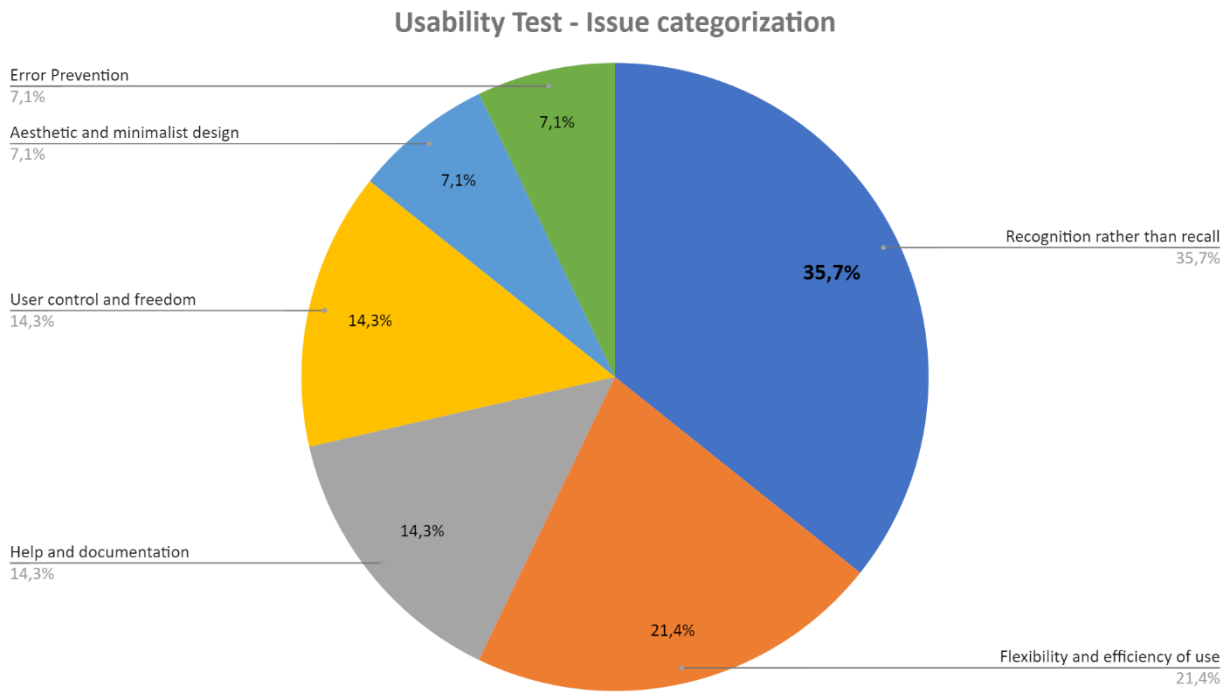


Figure 17 - Issues categorisation UC4.

4.2.4.6. Sentiment analysis

Lastly an analysis of sentiment was performed. In this analysis a 7-point Likert type scale was used to quantify testers' emotions. The two extreme points are negative/dissatisfied (1) and positive/satisfied (7) and (4) for neutral. There is an individual line for each tester and an average line (grey) for all user's average sentiment.

Figure 18 shows that overall, the best valued stage of the user journey was the Log in. On average when logging in, the testers were very positive and enthusiastic. The city selection obtained also positive feedback. However, in the scenario management and scenario presentation the testers were less positive which means these phases still need to be improved. In the General Navigation, the user showed again more positive and enthusiastic feelings.

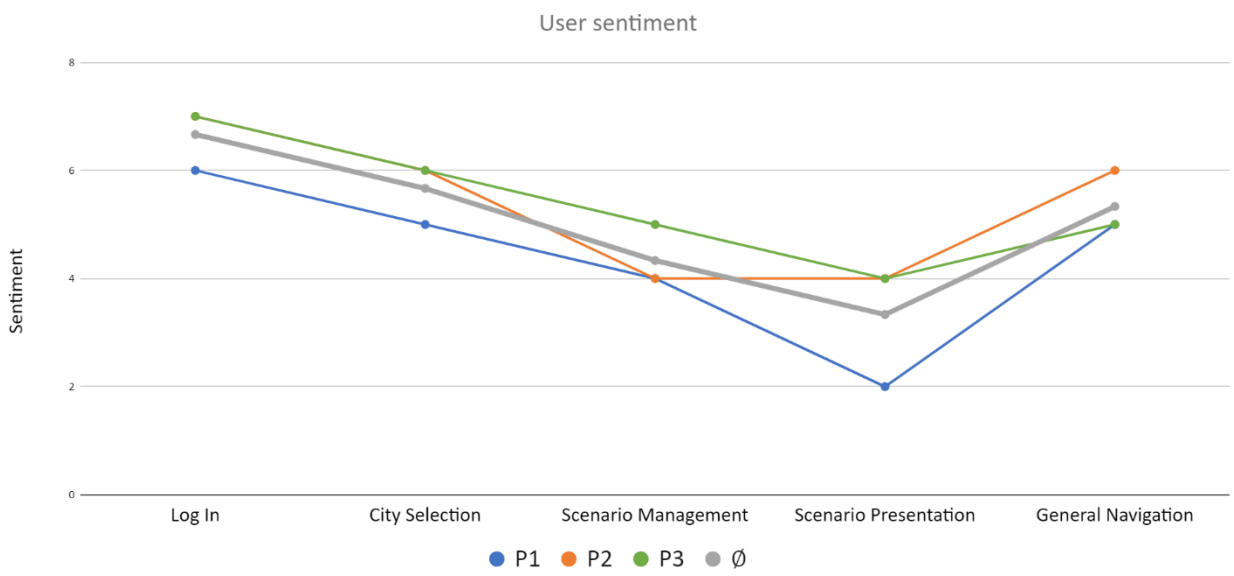


Figure 18 - User Sentiment analysis UC4.

4.5 Use case 5

The scope of Use Case 5 is the estimation of in- and out-flows of a specific zone of a metropolitan area, i.e., from its boundaries to the remaining districts. In other words, the use case will show an estimation of trips origin and destination based on ANPR (Automated Number Plate Recognition) system detections and census data. The purpose of this tool is to deliver analytic data towards the improvement of transport planning within a metropolitan area, including the enhancement of park and ride services or the creation of new routes for existing public transport services. Once again, the main users of this tool will be policy makers and mobility experts working in traffic planning and urbanism.

4.5.1 Requirements gathering

The purpose of the requirements gathering is to define the needs and expectations of a potential user (policy making, mobility expert, etc.) of the toolkit, before the development of the front end and usability tests of the respective dashboard.

For Use Case 5, a session was held with representatives from the city of Barcelona working at AMB, as they are the main possible users and policy makers involved in the project for the city.

Firstly, the use case's main goal, expected results and outputs (KPIs) were defined. The following was stated/mentioned during the session:

- Goal: Observe and analyse the traffic flows in the metropolitan area of Barcelona based on ANPR cameras.
- Expected results: Flows of traffic on different weekdays/daytimes (O-D, one-many, many-one, many-many).
- Expected Outputs/KPIs: OD matrix (CSV, Excel); visualization of traffic flows; statistics.

A “mock up” of the customer journey is presented bellow in Figure 19. This workflow map was used for the requirements session to guide the representatives.

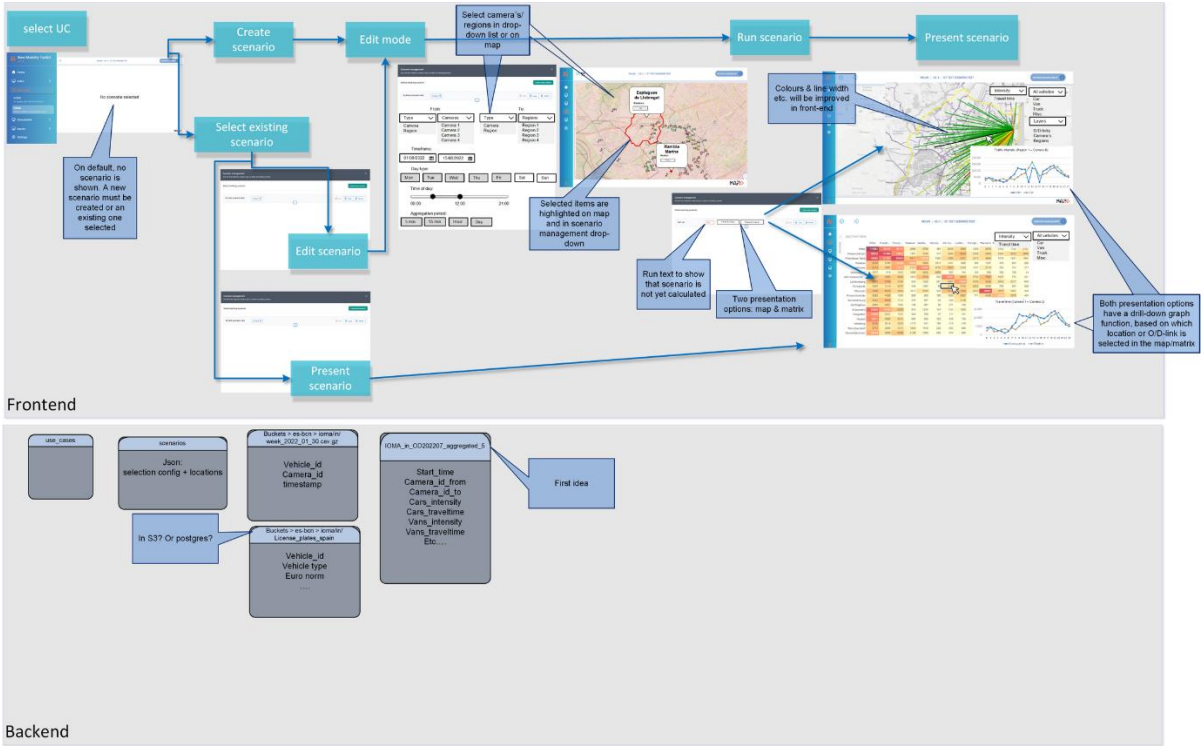


Figure 19: Workflow design UC5.

The requirements gathered in the session are shown in Table 9.

Table 9: Requirements gathering UC5.

Part	Requirement
Create Scenario/Edit	Suggested inputs are sufficient (timeframe, day type, time of day, aggregation period).
	Ideally, have sections/zones on the map (e.g. municipalities) - but no data and flows of all sections.
	Preferably, automatically select cameras by selecting an area. E.g. drawing an area on the map to select cameras like on real estate websites.
	Have an option to switch on/off an additional layer on the map with the different zones.
	Have the possibility to select cameras on the map but also in a list (e.g. list in split-screen).
	Colour coding of the cameras was not quite clear (cameras that belong to the same area?).
Visualisation of results	Have the information by section and by O/D.
	Add some statistics like percentage of cars/buses and travel times Information on the vehicle registration.
	Have the information break down by registration.
	Have more clear line representation in the map.
	Find a prettier and clearer chart.
	Display some basic information when clicking (mouse-over) on the lines (e.g. O/D names, percentage of cars/buses, etc).
Export results	Export point-to-point data in CSV/Excel.

Following the RUS categorisation presented in Chapter 3.3, the requirements suggested for use case 5 are categorised in Figure 20. It is possible to see that the majority of the requirements mentioned are related to *Flexibility and efficiency of use* (46,2%), followed by *Aesthetic and minimalist design* (30,8%) and *Help and Documentation (*15,4%). Most of the requirements are related to how to select the cameras (input fields) and how to visualise the results, which is further functionalities and flexibility for the user to use and analyse the data. For AMB, is important to have the cameras selected highlighted on the map as well as have a matrix O/D with the respective data. Another suggestion is to have the information discriminated by type of vehicle (bus, cars, etc.).

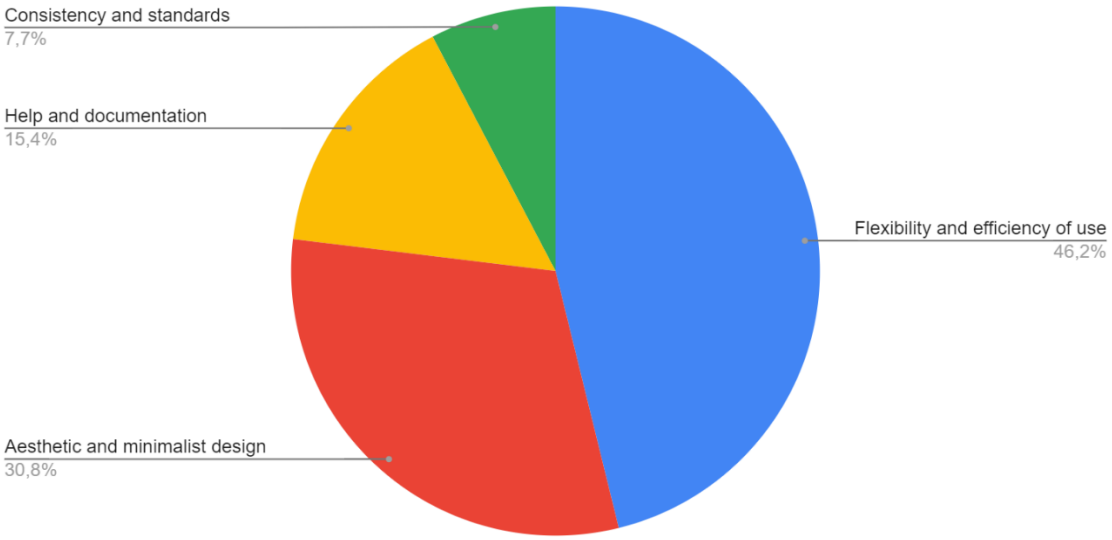


Figure 20: Requirements categorisation UC4.

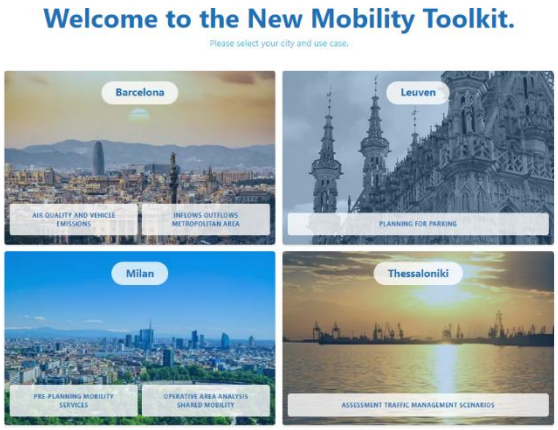
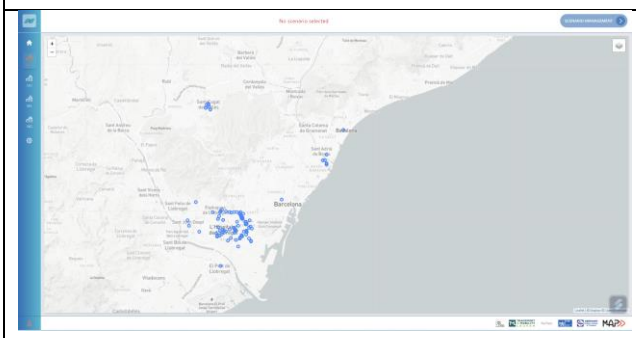
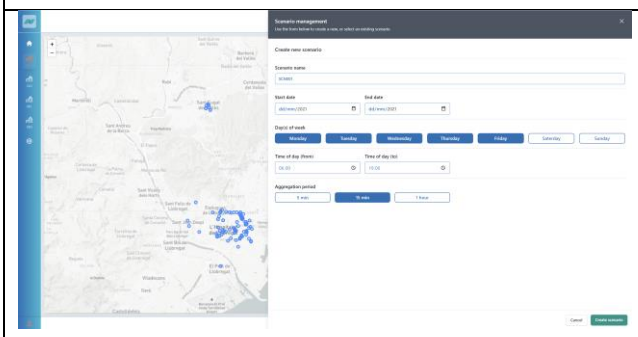
4.5.2 Persona analysis

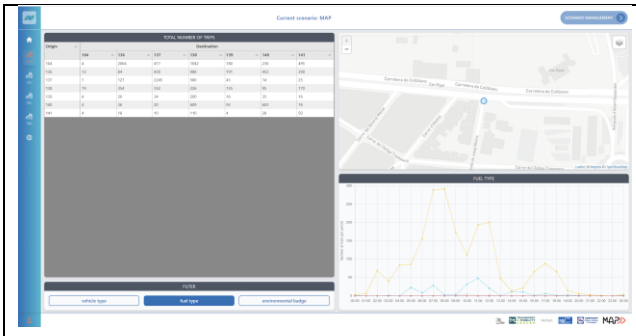
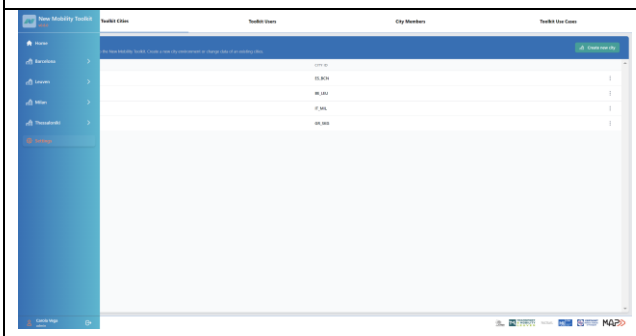
The purpose of this use case is to inform transport planning authorities about which prevailing traffic conditions are a product of internal, inbound, outbound, or through-going vehicle trips as well as about users and their mobility patterns. For that reason, we specifically looked for people from these target groups for the remote usability study. In total, we conducted the remote usability study for Use Case 5 with 3 people. One of them was a researcher, the other person was a mobility coordinator/manager and one person represents a data consultant. One of them was women, and the other two men, one in the age group of 30-40 years old and the other two in the age group of 50-55 years old.

4.5.3 General customer journey mapping

Table 10 represents the customer journey while using the nuMIDAS dashboards for this use case.

Table 10: Customer Journey Mapping UC5.

	Log In: - User enters nuMIDAS dashboard website - User accesses his account by logging in with his credentials
	City/ Use Case selection: - Select the Use Case
	Use Case board: - User automatically enters the use case board - User can create new and edit scenarios in the “Scenario Management”
	Scenario Management: - User can set individual parameters for each scenario.

	Scenario Presentation: - Visual representation of the results by means of a colour scheme in the map and click to see more details and KPIs. - User can perform a basic sensitivity analysis with the results
	General Navigation: - User can switch between the different use cases and cities - The settings can be accessed via this

4.5.4 Use case analysis

Three different analyses were performed to evaluate the feedback and information of the usability sessions. The three different analyses explained in Chapter 3.3, it includes a frequency analysis, categorisation, and sentiment analysis.

4.5.4.1 Frequency of issues

The diagram below (Figure 21) shows the individual issues raised by the testers and their frequency. The priority is defined by the number of times an issue was report and the impact on the user. It was found 20 issues in general. There were 4 issues mentioned more frequently (a total of 3 times).

The issues mentioned more frequently were all related to difficulties in creating a scenario and how the results are presented. The goal is to add instructions so the user can understand what is necessary to do when creating a new scenario as well as how to easily and properly visualise the results. Some examples of the issues more mentioned:

- Add instruction in edit mode;
- Add instruction to how to navigate in the table;
- Add fixed legend to the line graph.

Furthermore, when the user creates a new scenario, it goes to the end of the list in Scenario Management. It would help to have the scenarios sorted by the most recent, so a new user could easily find the new scenario (without the need of scroll down).

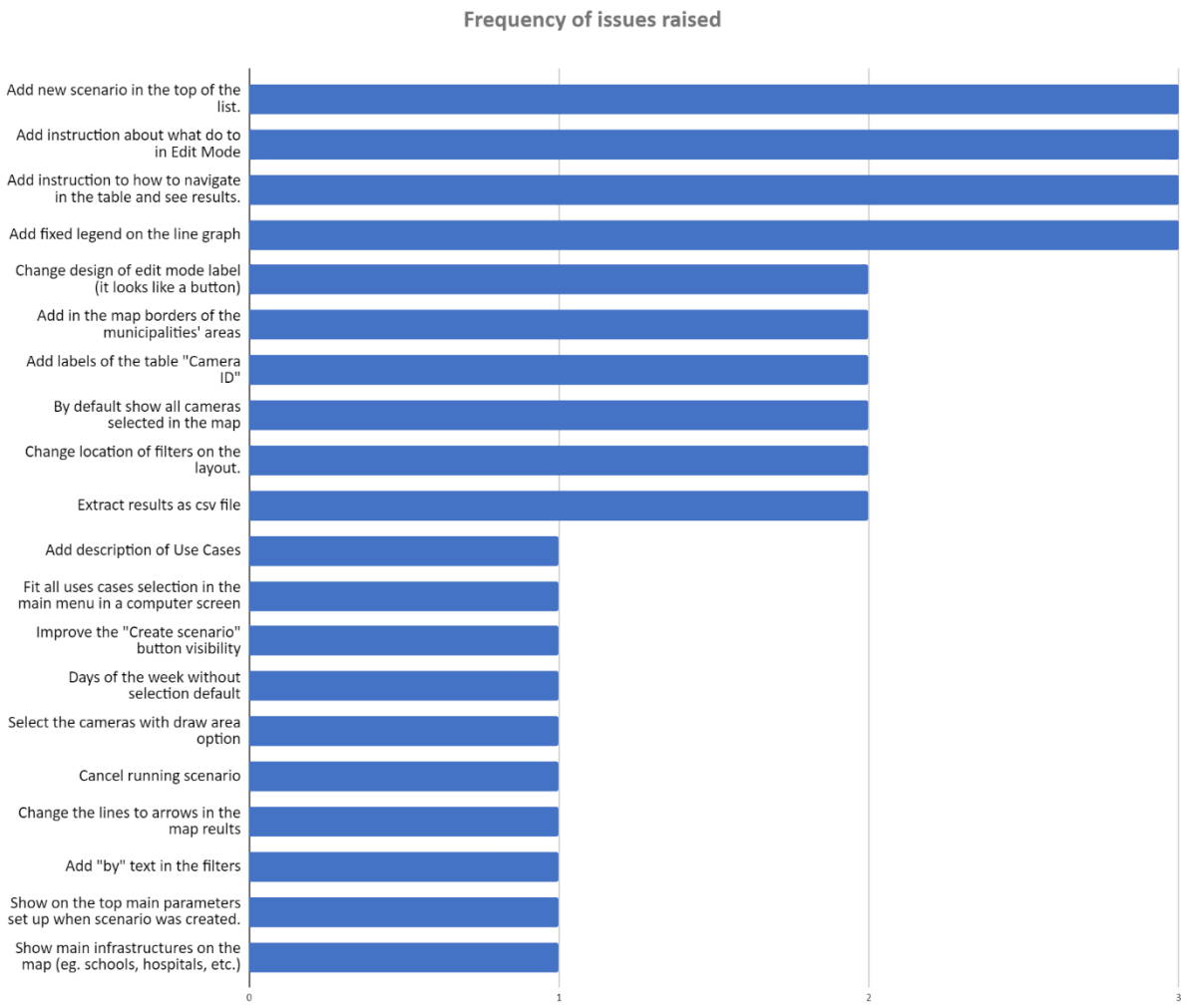


Figure 21: - Graph showing the frequency of issues raised for UC5.

4.5.4.2 Issues categorisation

Figure 22 shows the issues divided by category as described in Chapter 3.3.

Most issues were reported in the category "*Recognition rather than recall*" (30%) which refers to missing information, explanations, and units. The second most reported category was "*Aesthetic and minimalist design*" (25%), which particularly concerned the layout and the intuitiveness of the navigation. The third is "*Help and documentation" (*20%), which refers to further explanations and documents to help the user understand the use case and functionalities. Followed by "*User control and freedom*" (10%) that refers to freedom and control of the user to create new scenarios and navigate; and by "*Flexibility and Efficiency of use"* (10%) related with further potential functionalities.

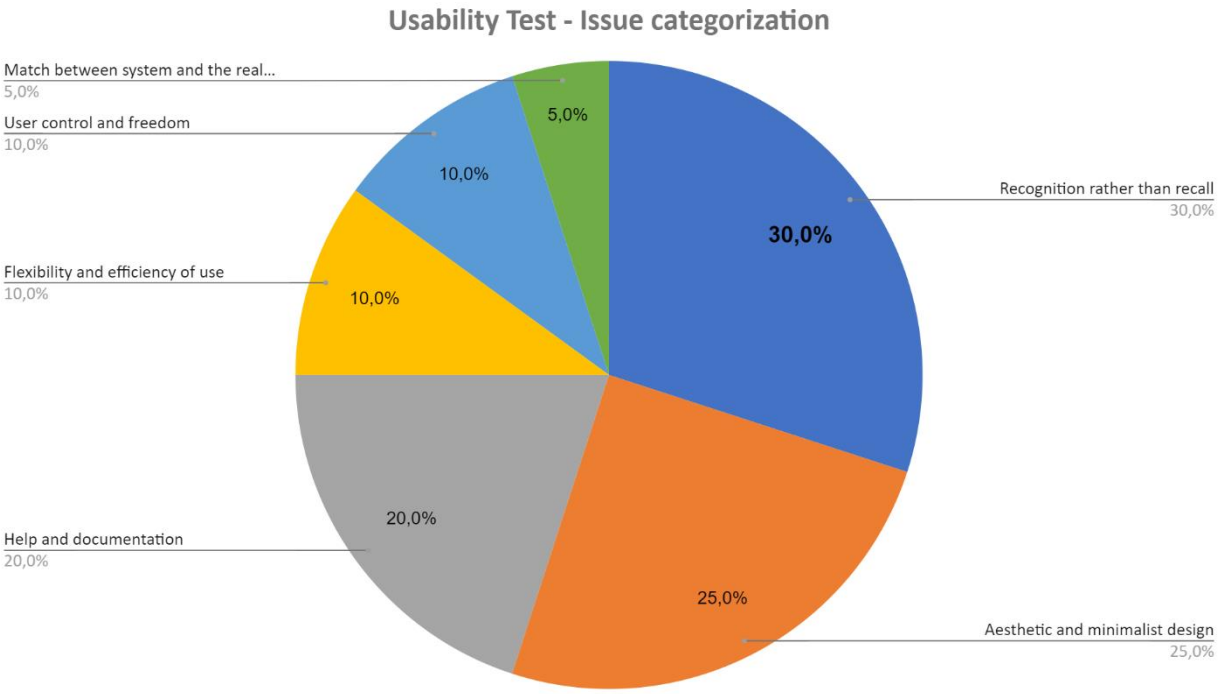


Figure 22: Issues categorisation UC5.

4.5.4.3 Sentiment analysis

Lastly an analysis of sentiment was performed. In this analysis a 7-point Likert type scale was used to quantify testers' emotions. The two extreme points are negative/dissatisfied (1) and positive/satisfied (7) and (4) for neutral. There is an individual line for each tester and an average line (grey) for all user's average sentiment.

Figure 23 shows that overall, the best valued stage of the user journey was the Log in. On average when logging in, the testers were very positive and enthusiastic. The city selection also obtained positive feedback. However, in the scenario management and scenario presentation the testers were with a medium satisfaction because some clarifications, labels and legends still need to be improved. In the General Navigation, the user showed again positive and enthusiastic feelings.

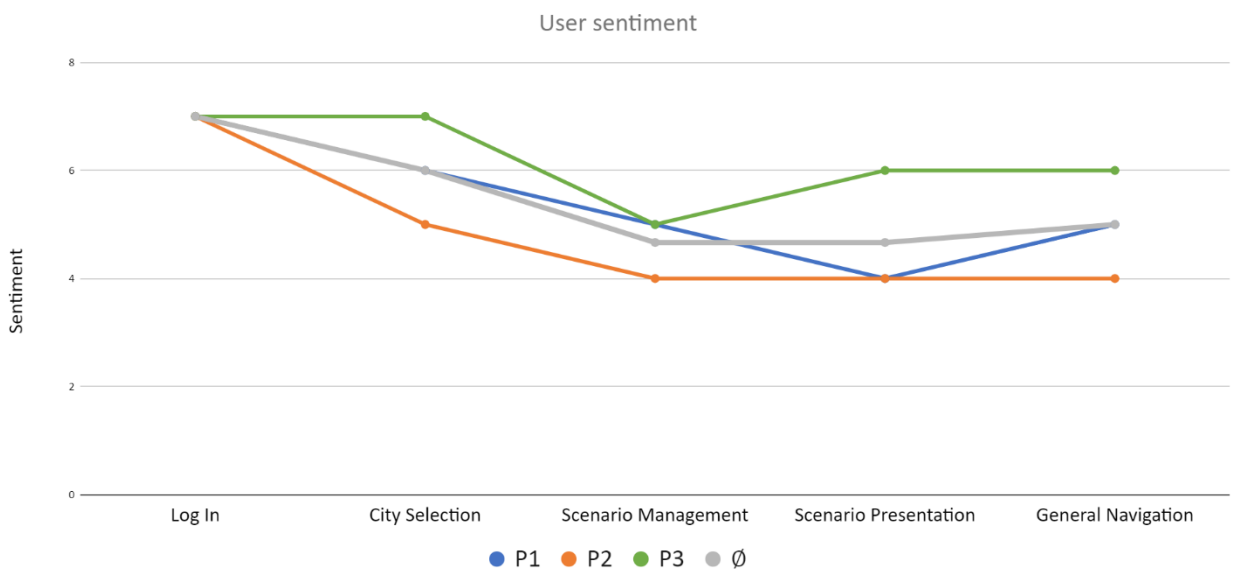


Figure 23: User Sentiment analysis UC5.

4.6 Use case 6

Use Case 6 involves data-driven assessment of traffic management scenarios. The tool will analyze key Performance Indicators (e.g., related to speed, traffic flow, travel times, road safety, and emissions) that comprise trigger and target values of the activated traffic management scenarios, supporting the data-driven comparative assessment of the performance.

4.6.1 Requirements gathering

The purpose of the requirements gathering is to define the needs and expectations of a potential user (policy making, mobility expert, etc.) of the toolkit, before the development of the front end and usability tests of the respective dashboard.

For Use Case 6, a session was held with representatives from the city of Thessaloniki working at CERTH, as they are the main possible users and policy makers involved in the project for the city.

Firstly, the use case's main goal, expected results and outputs (KPIs) were defined. The following was stated/mentioned during the session:

- Goal: to have available a tool to assist the assessment of traffic management scenarios.
- Expected results: Several indicators that will demonstrate the effect of traffic management scenario to operational efficiency of cities network and environmental performance.
- Expected Outputs/KPIs: Travel times, delays, waiting times, network capacity, emissions.

A “mock up” of the customer journey is presented bellow in Figure 24. This workflow map was used for the requirements session to guide the representatives.

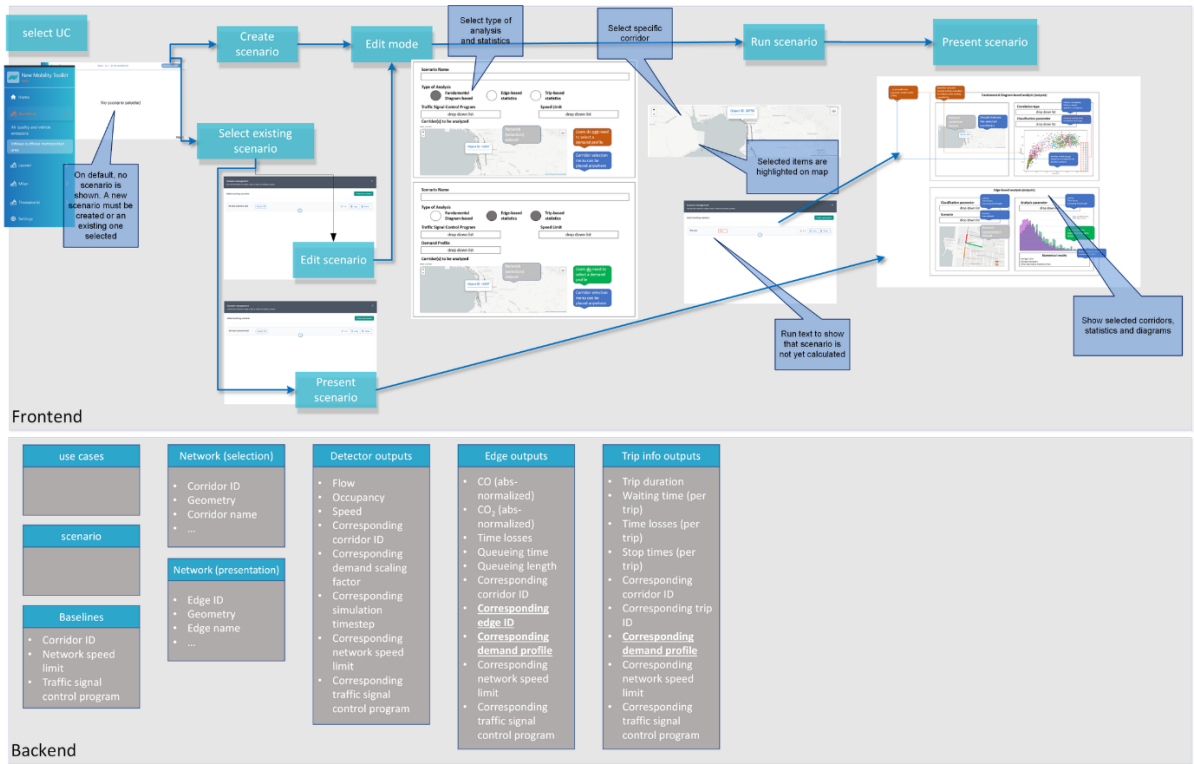


Figure 24: Workflow design UC6.

The requirements gathered in the session are shown in Table 11.

Table 11:Requirements gathering UC6.

Part	Requirement
Create Scenario/Edit	Have an explanation about the two types of analysis
	For the corridor selection should be possible to select just one or a group of corridors.
	Have the group of corridors setup in order to avoid non-sense selection.
	Have proper instructions about the corridor selection.
	Additional inputs suggested for the future: this is a flexible and adaptable use case. some examples: are routing function, level of noise, etc.
Visualisation of results	Have 3 different outputs based on the type of analysis chosen. Ideally, for the edge-based analysis have just one field selection in the Analysis parameters (CO2, time losses, queuing)
	Have to select field/filters to see certain outputs.
	In the fundamental diagram-based analysis, is necessary to have the baseline scenario and potential scenario in different graphs or another diagram with a trend line representing the baseline.
	In the edge-based analysis the map should give the possibility to see the baseline or new scenario (optional).
	Allow navigation on the map (left side results).
	In the fundamental based analysis, the Classification parameter should be optional to select a percentage/specific of the demand we want to analyse.
	Possible add-ons: create their own traffic signal. Create Use Case with real time data of detectors.

Following the RUS categorisation presented in Chapter 3.3, the requirements suggested for use case 6 are categorised in Figure 25. It is possible to see that the majority of the requirements mentioned are related to *Flexibility and efficiency of use* (50%), followed by *Aesthetic and minimalist design* (25%) and *Recognition rather than recall (*17%). Most of the requirements are related to the understanding of the different type of analysis and the respective presentation of the results. Furthermore, in the Creation of Scenario phase the clear selection of the corridors was mentioned as a fundamental step for the effectiveness of the tool.

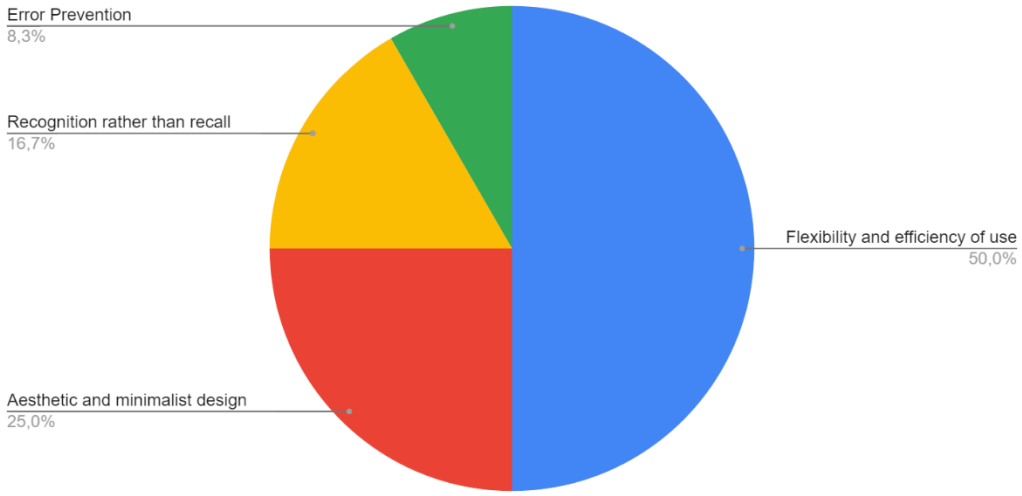


Figure 25: Requirements categorisation UC6.

4.7 Comparative analysis

This chapter encompasses a comparative analysis of the requirements gathered and the results from the usability test. Three main comparative analysis are proposed based on the analysis of the requirements (categorisation) and of the usability test (frequency, categorisation, and sentiment):

- Requirements comparative analysis, representing the number of requirements by category for each use case.
- Usability comparative analysis, consisting of the comparison between the issues raised in each use case. Two analyses were done: Categorisation and Sentiment Comparative analysis.
- Compare requirements and usability issues, comparing the number of issues for each category raised in the requirements sessions and in the usability sessions.

4.7.1 Requirements comparative analysis

To compare the requirements, the total number and number by category was analysed for each use case.

The requirements gathering was done for 5 use cases: UC2, UC3, UC4, UC5, UC6. Figure 26, shows the number of requirements per category for the different use cases. The categories most referred are *Aesthetic and minimalist design* and *Flexibility and efficiency of use.*

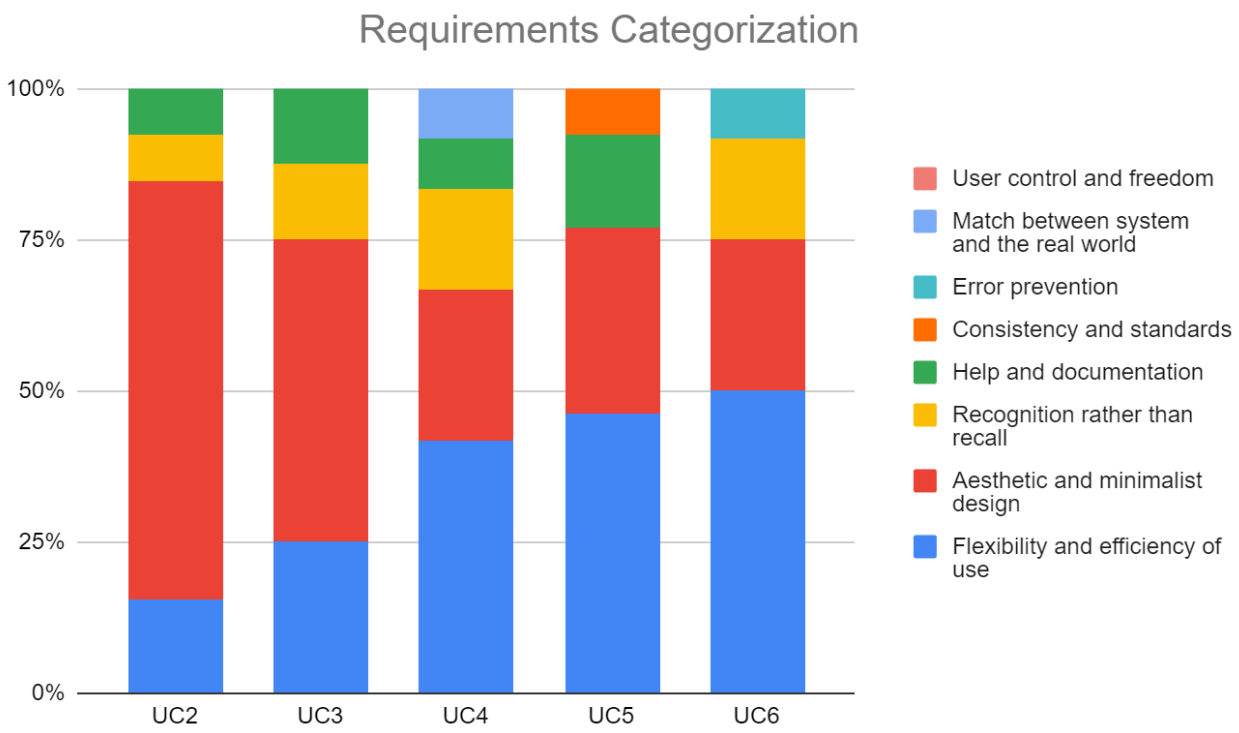


Figure 26: Requirements categorisation comparative analysis.

4.7.2 Usability issues comparative analysis

Four use cases were evaluated, it is shown below the comparative analysis between the issues raised in the RUS sessions. The RUS session was held in different dates over 2022, the specific dates can be found in Chapter 3.2.1. The different use cases were evaluated in different dates, as bellow:

- Use Case 1: April/May 2022
- Use Case 2: end of December 2022
- Use Case 4: October 2022
- Use Case 5: Begin December 2022

Figure 27: Timeline of RUS Sessions.

The purpose of these analysis is to understand the evolution of the development of the tool over time as well as identify trends and patterns of issues raised in all use cases.

4.7.2.1 Usability issues categorisation comparative analysis

The categorisation comparative analysis consists of evaluate the number of issues in each category for the different use cases evaluated. Figure 28 is a bar graph that shows for each use case (x-axis) the number of issues raised by category (y-axis). It is possible to see, that UC5 (20 in total) had more issues raised, followed by UC1 (17 in total).

In average, most of the issues raised were in the category of *Aesthetic and minimalist design, Recognition rather than recall* and *Flexibility and efficiency of use* and *Help and documentation.* For one hand, UC4 and UC2 had the lower issues in the category of *Aesthetic and minimalist design.* For other hand, they have a lot of issues in the *Recognition rather than recall category.* Issues regarding *Help and documentation* was more noticed in UC2 and UC5.

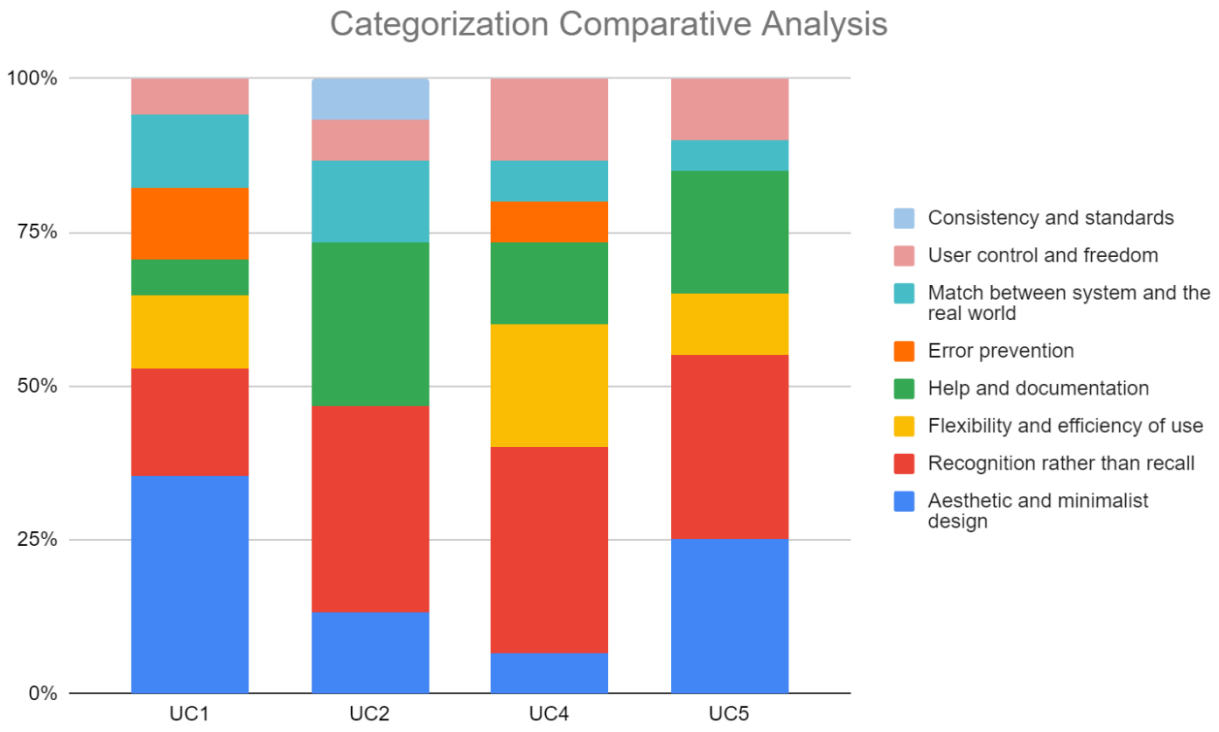


Figure 28: Bar graph categorisation comparative analysis.

4.7.2.2 Sentiment comparative analysis

The sentiment analysis evaluates the feeling and enthusiasm of the users over the journey mapping of the tool for each use case.

Figure 29, shows the user's average sentiment for each use case. From the graph is possible to see that, for *City Selection* and *Scenario Management* the sentiment improved sharply between UC1 and the other use cases. A more slightly improvement is also noticed in the *Log in* and *General Navigation*. The reason for that can be the fact that UC 1 was evaluated firstly and consequently improvements were implemented based on the feedback and issues raised on the usability sessions for UC1.

For *Scenario Presentation* is not visible a significant trend between the different use cases, probably because the presentation of results and respective output are completely different for each use case.

Overall, for all use cases the users show less enthusiasm and happiness when navigating in the scenario management and presentation. This can be overcome by future deployment and improvements of the toolkit.

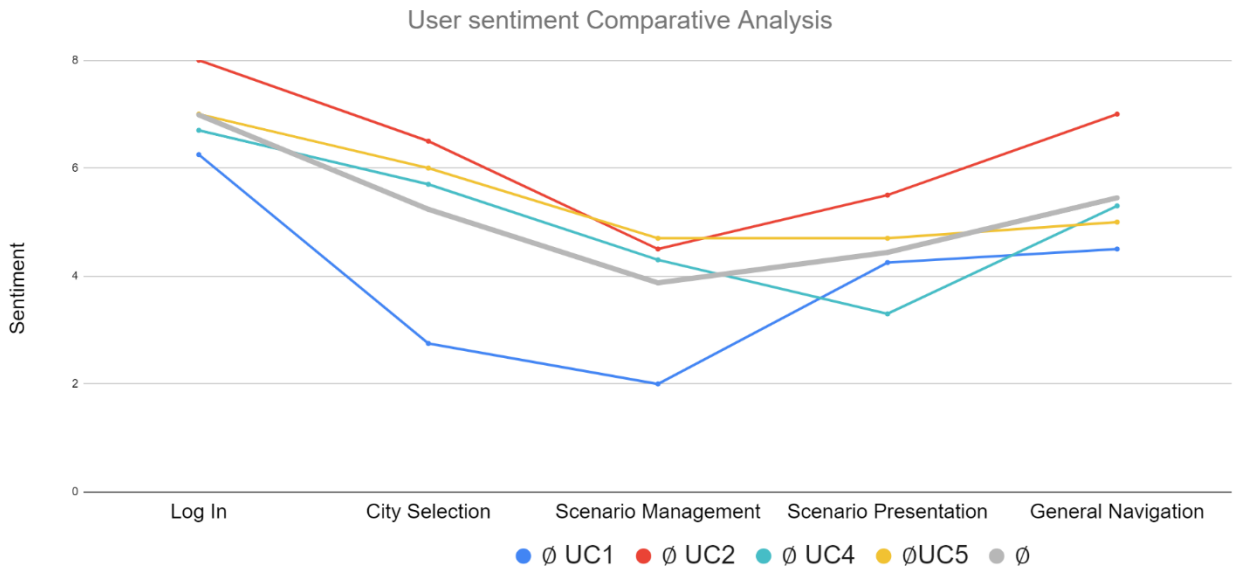


Figure 29: Sentiment comparative analysis.

4.7.3 Requirements categorisation vs. usability issues categorisation

The aim of this comparative analysis was to evaluate the differences between the requirements suggested (before the development of the front end) and the usability issues raised (after the development of the front end). To be able to visualise it was compared the number of issues in each category for the requirements and the usability issues. Figure 30, Figure 31 and Figure 32 the results of this study for UC2, UC4 and UC5 respectively.

In UC2, it can be seen that the number of requirements was higher than the usability issues in the categories of *Aesthetic and minimalist design* and *Flexibility and efficiency of use*, what can mean that most of the requirements raised were taken into account during the development decreasing this number when doing the usability test. For the others, the opposite happens what can show that some user needs where only detected when evaluating the tool.

For UC4, the results show the same positive difference in number of requirements and issues for the same categories. The reason for that can mean that during the requirements sessions is easier to detect user needs in the categories of *Aesthetic and minimalist design* and *Flexibility and efficiency of use.*

Finally, the results of UC5 indicates a similar trend in the same categories.

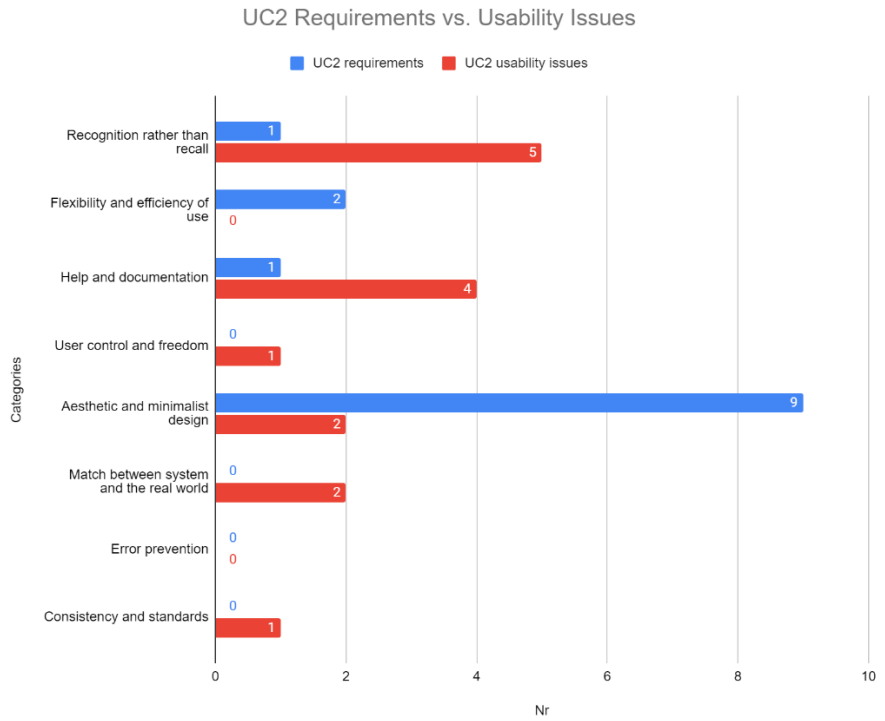


Figure 30: UC2 Requirements versus Usability issues analysis.

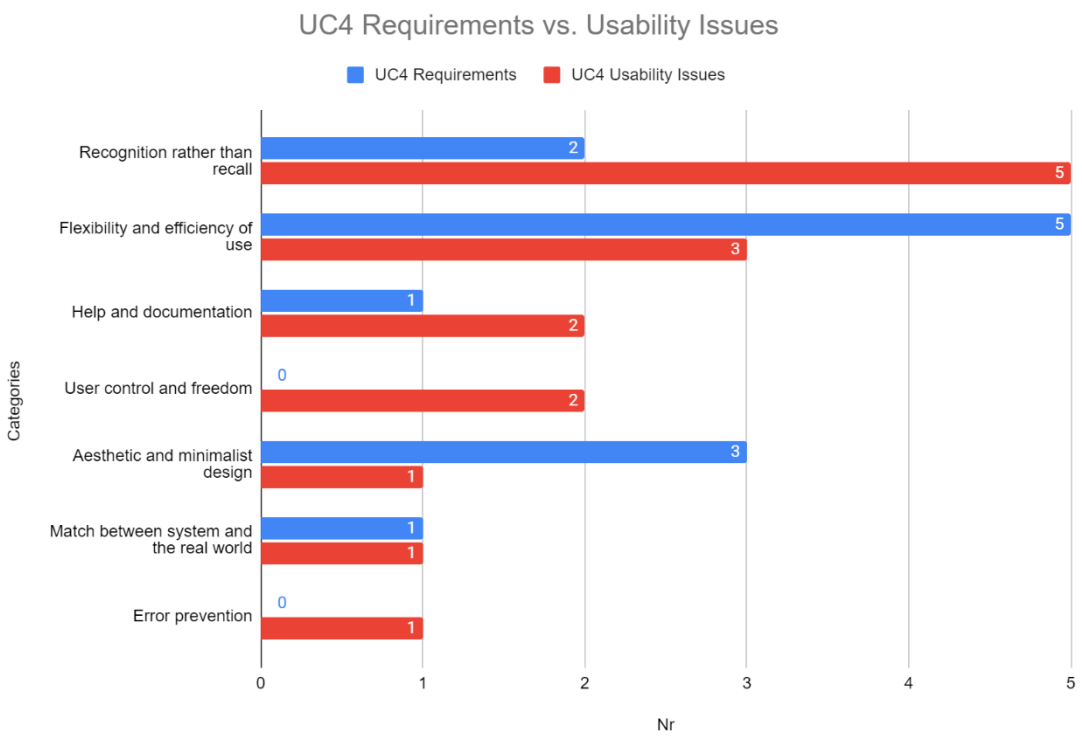


Figure 31: UC4 Requirements versus Usability issues analysis

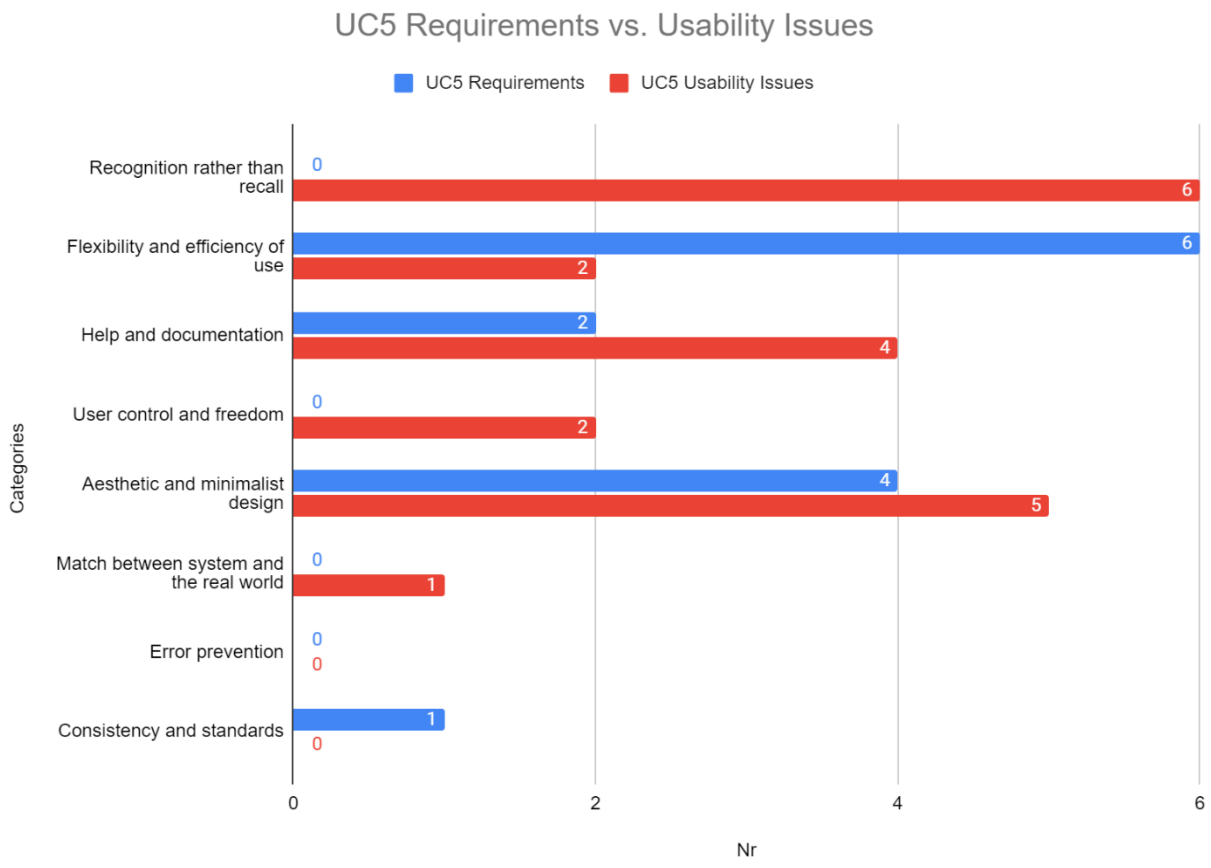


Figure 32: UC5 Requirements versus Usability issues analysis

5 Conclusions

We worked on a user-centric design approach to ensure a high level of usability of the New Mobility Data and Solutions Toolkit. For each of the six different use cases, the UX methodologies are applied and the results analysed. It was done the requirements gathering for UC2, UC3, UC4, UC5 and UC6, and the usability test sessions for UC1, UC2, UC4 and UC5. These results are of great importance as they are passed on to the developers via the Mantis platform and thus influence the backend and frontend development, making the nuMIDAS toolkit as user-friendly as possible. The development of a suitable and easy to use tool, it is necessary in order policy makers and mobility experts with no previous knowledge of the tool can use it and navigated easily, supporting them on the decision-making process.

The main results show that most of the issues raised are during the Scenario Creation and Scenario Presentation and in the categories of *Aesthetic and minimalist design, Flexibility and efficiency of use* and *Recognition rather than recall.* In the comparative analysis it was also possible to conclude that over time there was some improvements because the sentiment analysis improved slightly from session to session.

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