BUILDSPACE

Enabling Innovative Space-driven Services for Energy Efficient Buildings and Climate Resilient Cities

D2.2 Use cases and design of applications' dashboards

November 2023

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Abbreviations and acronyms

Acronym	Description
3D	3 dimensions
AI	Artificial Intellegence
AOI	Area of interest
API	Application programming interface
AR	Augmented Reality
BGI	Blue-Green Infrastructure
BIM	Building information modeling
BVC	Buildings Value Chain
CEST	Central European Summer Time
CET	Central European Time
CLMS	Copernicus Land Monitoring Service
CMIP6	Coupled Model Intercomparison Project Phase 6
CWS	CLIMNEG world simulation
D	Deliverable
DEM	Digital Elevation Model
DSM	Digital Surface Model
DT	Digital twin
EAFD	Expected annual flood damage
EC	European Commission
EGNSS	European Global Navigation Satellite System
ESC	Escape
EU	European Union
FDAM	Flood Damage Assessment Methodology
GDPR	General Data Protection Regulation
GDT	Geometric Digital Twin
GIS	Geographic Information Systems
GPS	Global Positioning System
IMZI	INSTITUT ZA MODRO-ZELENO INFRASTRUCTURO
IPCC	International Panel on Climate Change
KPI	Key Performance Index
kwh	Kilowatts per hour
LEED	Leadership in Energy and Environmental Design
LIDAR	Light Detection And Radar

M	Month
MaaS	Mobility as a service
MFH	multifamily home
MoP	Municipality of Piraeus
NDVI	Normalized Difference Vegetation Index
PV	Photovoltaic
RCP	Representative Concentration Pathways
RGB	Red, green and blue
RQ	User requirement
RTK	real time kinematics
SE	Service
SLAM	simultaneous localization and mapping
SLG	SingularLogic
SME	Small and Medium Enterprises
sqm	square meter
SSP	Shared Socioeconomic Pathways
T	Task
TR	Technical requirement
UAV	Unmanned Aerial Vehicle
UC	Use cases
UHE	Urban Heat Exposure
UHR	Urban Heat Risk
UHV	Urban Heat Vulnerability
UK	United Kingdom
UPM	Universidad Politécnica de Madrid
URL	uniform resource locator
US	User story
VR	Virtual Reality
WP	Work Package

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Executive summary

This document reports the progress that has been made in WP2 of the BUILDSPACE project. To get closer to the BUILDSPACE solution, the theoretical aspects that had been defined in previous deliverables have been converted into practical steps to start developing the different BUILDSPACE services. To ensure social engagement, co-creation sessions are held, to obtain feedback from the BUILDSPACE community. The first co-creation session was processed and is reported in the present document. It is used, together with user requirements and user stories, to define clear technical use cases for each service. Additionally, to visualise the services and to assist all service developers in creating the respective applications, a complete wireframe guide was created. This was done by creating user flows, as well as use the defined user stories and use cases. This framework will support the service developers to visually customise their service designs and make sure that BUILDSPACE users have common user interaction guidelines.

1. Introduction

1.1. Purpose of this document and relation to other documents

D2.2 – Use cases and design of applications' dashboards is produced within work package WP2 – BUILDSPACE requirements, co-creation, specifications and alignment with satellite services and it gathers the activities carried out in tasks T2.3 Social engagement for co-creating the BUILDSPACE use-cases and applications and T2.4 Co-design innovative user-friendly environments. This document follows on D2.1 – BUILDSPACE User requirements, where the theoretical foundation has been explained. The defined user requirements from D2.1, have been transformed into practical user cases and visual wireframes.

The activities of task T2.4, are largely reported in this deliverable, except for the creation of styled mock-ups. It was decided to not create a detailed mock-up guide as it is too service specific. Therefore, it is opted to only create some example mock-ups as well as some basic styling elements. These mock-ups and designs will also be aligned with the core platform, which is being addressed in task T3.1. Therefore, it has been decided to include the mock-ups in deliverable D2.3.

Secondly, it was decided to not include the activities done in T2.5 "BUILDSPACE Conceptual architecture built on existing resources of Copernicus and EGNSS", although initially planned, since the updates on this topic that were based mainly on the 1st co-creation session results (stakeholders' input), informed the architecture only partially. Those updates were presented during the 3rd quarterly online meeting. The next version of the architecture along with the Copernicus and EGNSS alignment details (Task2.2), will be delivered in D3.1 (February 2024) and will include all updates in the core platform, and in the services based on the 2nd co-creation session results. The final conceptual architecture is expected to be delivered in May 2024 (D2.3).

Therefore, this document will report on three main activities. Firstly, the social engagement process in the form of co-creation sessions. Secondly, the defined technical use cases and lastly the co-designed wireframes.

1.2. Structure of the document

The document is structured as follows: **Section 2** gives an update on the methodology that was already presented in D2.1 BUILDSPACE user requirements. Next, **Section 3** is about the social engagement via the 1st co-creation session, as well as the feedback received. **Section 4** portraits the definition of the technical use cases for all services based on the defined user requirements, user stories and feedback from the first co-creation session. **Section 5** contain user flows that were used to create a complete wireframing guide for the service developers and explains the process that was followed to create the designs. Lastly, a short conclusion is written in **Section 6.**

2. Methodology

Figure 1 shows the progress in the methodology that has been used in WP2. The methodology has been updated since deliverable D2.1, mainly for task T2.4. While originally it was planned to define personas and personas user stories in Task T2.4, these steps have been replaced by defining user flows. User stories were already defined in task T2.1, which also included a part about personas. Hence, it was not useful to redefine personas and user stories a second time in task T2.4. In replacement for these tasks, it was opted to define user flows as it was felt those would be more useful for both the designs of the wireframes as the definition of the services. The user flows, together with the user requirements defined in task T2.1, served as input for the technical use case.

Figure 1 shows that a lot of work has been complete in WP2. All subtasks with green check have been completed. All subtasks with a light green check are still in progress. The wireframes and mock-ups for visualisation, part of task T2.4 are still in progress, although it is nearing completion. For this task, a complete wireframing guide has been created, which can be consulted in Section 5. The only part remaining is adding a style guide and converting some wireframes into full designed mock-ups that can be used as an example for the service developers. Lastly, task T2.5 about the conceptual architecture is still ongoing and will be reported in D3.1, as discussed earlier.

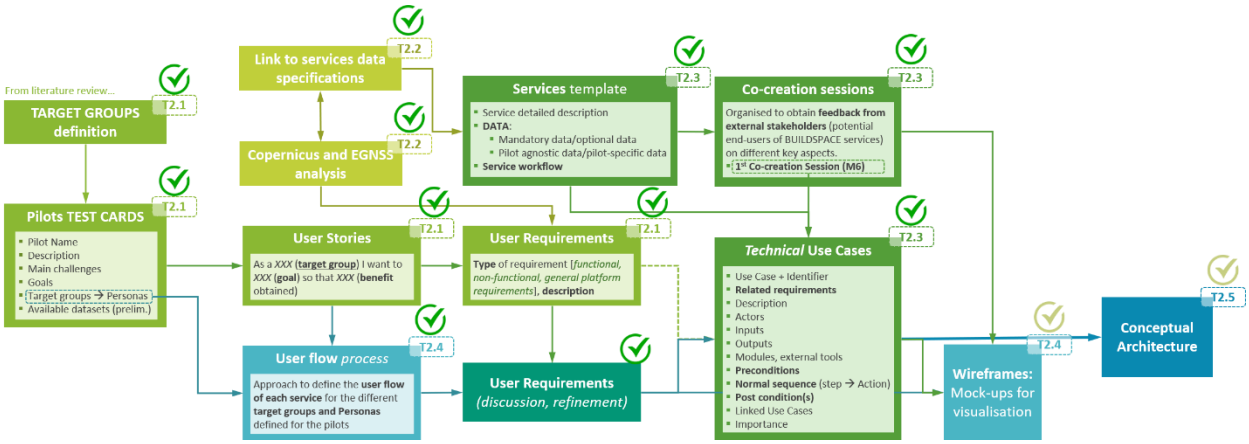

Figure 1. Progress in the methodology used through WP2 , subdivided into tasks.

3. Social engagement for co-creating BUILDSPACE use cases and applications

The definition of the use cases and applications in the BUILDSPACE project has been co-created with external stakeholders engaged during different sessions. The stakeholder engagement is a process that takes time and resources, allows individuals to build strong connections and it is mainly based on various existing and established trust relations. It follows an inclusive communication approach, in order to ensure that stakeholders are effectively included and can enjoy a positive, fair and equal experience for more effective interaction.

The co-creation sessions consist of several different steps, mainly for planning and managing the engagement process. The planning of the co-creation sessions follows the principles and procedure steps defined in Deliverable 2.1, consulting project partners to identify the needs for feedback they might need on their project tasks.

The sessions were decided to be condensed in the minimum possible number, so that stakeholders do not feel overwhelmed and provided enough valuable content and insights on the project. They were also developed in a joint way involving all pilots and services, in order to present the wider BUILDSPACE offer to all, creating synergies between the project and the stakeholders and finding possibilities to apply different functionalities. The sessions were held in English and in an online format.

For the co-creation sessions planning, a first consultation with different project partners was made, mainly to identify the needs for feedback on different project activities. Then, a first draft agenda is drafted to cover the different points raised. Also, internal discussions and decisions were made with respect to the stakeholders that need to be invited, as well as the setting of the date. At this point, the communication material was prepared, and once approved, the event started being promoted.

3.1. First co-creation session

The first co-creation session took place at M6, on 14th July 2023. It was open to broad audience, with each partner mobilising its network of possible or interested stakeholders or end-users through email (invitation letter template was prepared), as well as posts on social media that were shared during the two weeks before the session, both on the BUILDSPACE media accounts and on the different partners' accounts.

The level of participation was high, especially considering the date (summer period). A total of 142 participants were registered through the form, and 76 participants participated in the online session out of which approximately 80% were externals.

The objectives of the session were: 1) to present the BUILDSPACE project and services' offer, and attract stakeholders' attention; 2) to deepen knowledge on BUILDSPACE key concepts; 3) to understand potential

end-users or stakeholders' challenges and needs and 4) gather stakeholders' feedback on visualisations and additional services' functionalities.

The expected outcomes of the session were: 1) to make potential stakeholders interested in the project; 2) further understanding of users' needs and challenges to then build the technical use cases (considering the addition of more functionalities to the services); 3) to deep in stakeholders' current customer jobs and difficulties ("pains") they face to overcome the challenges (through the series of steps they take to address the defined challenges) and 4) and to present the BUILDSPACE services' offer, obtaining also feedback on additional functionalities that each service can have, as well as discuss how they would like to visualise the different solutions.

The session was held online, using Zoom platform and its duration was 2 hours in total with a 5-minute break. A Miro Board was used to gather feedback, to include the presentations and all interactions.

In the following Table 1, the main aspects of the planning and delivery of the first co-creation session are presented. Then, in the following subsections the different elements and feedback received are described in detail.

Table 1. First co-creation session planning in a nutshell

No.	**Date**	
#1	**M6.** 14th July 2023, 10:00 – 12:00 CEST	
Audience	**Invited**	Open to broad audience. Mobilisation of partners' networks of potential interested stakeholders and posts on the BUILDSPACE and partners' social media.
	Participation	142 participants registered, 76 participants connected to the session (around 80% externals)
Objectives	- To present the BUILDSPACE project and service and attract stakeholders' attention - To deepen the knowledge on BUILDSPACE key concepts - To understand potential end-users'/stakeholders' challenges and needs - To show stakeholders what BUILDSPACE can offer to them, and gather their feedback on visualizations and additional functionalities	
Expected outcome	- Make potential stakeholders interested in the project. - Further understanding of user's needs and challenges to then build the technical use cases (possibility to add more functionalities to the services). - Too deep in their current customer jobs and their current pains they face to overcome the challenges (through these steps in the customer jobs). - To present the BUILDSPACE service offer and obtain feedback on additional functionalities that the services can have and how they would like to visualise the different solutions.	

Type of interaction	Online session (through Zoom platform). The feedback, presentation and all interactions were done through a Miro Board.

3.1.1. Communication material

The communication material prepared for the session's promotion consisted of the agenda in a visual way, a flyer (see Figure 2), an invitation template (see Table 2) to share via email with the stakeholders that each partner contacted, as well as social media posts templates and pictures for the different social media posts (that were shared by the BUILDSPACE accounts and by other partners' media accounts).

Figure 2. Flyer for the promotion of the first co-creation session

Table 2. Invitation letter template to be shared by email with partners' networks of possible interested end-users

Invitation letter template
Dear [Representative's Name], I hope this email finds you well. I am writing to invite you and your company/organization to participate in **the first co-creation session of the BUILDSPACE project** that will take place online on **Friday, July 14th at 10:00 CEST.** I am contacting you, as I believe that BUILDSPACE could be interesting for you, considering your interest/great work/expertise in the [field of expertise]. **BUILDSPACE** is an ambitious project funded by the **Horizon programme** of the European Union, aimed at supporting the implementation of the **EU Green Deal** and focused on **energy efficiency**. Its main goal is to leverage terrestrial data from buildings, aerial imaging from thermal-equipped drones, and location-annotated data from satellite services to **deliver innovative services for buildings and urban stakeholders, as well as support informed**

decision-making towards energy-efficient buildings and climate-resilient cities. By integrating these heterogeneous data, the Platform will offer a range of **decision support tools to the Buildings Value Chain (BVC) stakeholders**.

In order to achieve these goals, the project wants to **collect and analyse the stakeholders' needs and inputs**, with a series of **co-creation sessions**. BUILDSPACE envisages the co-creation of knowledge among **people from several fields** - with different backgrounds crossing traditional boundaries between different disciplines; and **from different countries** in order to address various market situations and cultural contexts.

Being part of the co-creation sessions means not only being involved in the definition and design of innovative applications in **energy-efficient buildings and climate-resilient cities** through the integration of digital twins and at city scale providing decision-support services for energy demand prediction, urban heat and urban flood analysis, but also fostering valuable collaborations and connections among the stakeholders and with ongoing or upcoming projects.

The project is carried out by a consortium of 14 partners from 8 different countries: Space (Greece), SingularLogic (Greece), NTUA (Greece), CARTIF (Spain), Polytechnic University of Madrid (Spain), University of Cambridge (UK), European Centre for Medium-Range Weather Forecasts (UK), Nazka Mapps (Belgium), Mobics (Greece), ALDA (France), Mostostal Warszawa (Poland), Municipality of Piraeus (Greece), IMZI (Slovenia), Rigas Planosanas Regions (Latvia).

If you would like to know more about the project and your potential participation in it, do not miss the first co-creation session on July 14th. To confirm your participation, please register **here**.

I remain available for any further information and I thank you on behalf of the project for your time and attention

Additionally, an internal mapping of the stakeholders contacted by each partner was prepared to keep track of the invitations sent. According to it, around 185 stakeholders were invited via email, from different organisation types (research centres, universities, energy agencies, public authorities, consultancy, SME, construction companies, networks, municipal departments, etc.) and countries (Albania, Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Luxembourg, North Macedonia, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, Turkey and the UK).

3.1.2. Agenda

The agenda can be seen in the following Table 3, together with a description of each item and objective pursued for each part, which was prepared as organisational back up.

Table 3. First co-creation session agenda

Start	End	Duration	Topic	Chair	Description and objective pursued
10:00	10:10	10’	**Welcome and introduction** **Section 3.1.3.1**	CARTIF	To introduce the session and the agenda, and get participants to enter into participation and interaction mood through an ice breaker. The objectives of the session were also presented.
10.10	10.20	10’	**BUILDSPACE: scope and services** *[introductory presentation]* **Section 0**	SLG	Introduce the project and services, so that participants understand what the project is about, in which context will the services be developed, and how useful they could be.
10:20	10:40	20’	**Setting a common understanding: what do you mean by…?** *[interactive session]* **Section 3.1.3.3**	CARTIF	Engage with the audience with generic questions such as: what do you understand by digital twin? Then, a presentation of the “official” or agreed definitions on the different concepts was given.
10:40	11:10	30’	**What are your main challenges?** *[interactive session]* **Section 3.1.3.4**	CARTIF	Identify how stakeholders deal with specific challenges in their day to day undertakings. This feedback gathering session will contribute to identify some of the pains they are going through, and inform how we could tackle them in the project.
		5’	*BREAK*	-	
11:15	11:55	35’	**What can BUILDSPACE offer to you?: Potential features of the services** *[interactive session]* **Section 3.1.3.5**	NAZKA, CARTIF & UPM	To extract feedback from stakeholders on what the main benefits they can extract on the services proposed. Detect further functionalities or ways to present them (visualisations). A breakout room per each service. Final wrap up of each breakout room in the plenary.

Start	End	Duration	Topic	Chair	Description and objective pursued
11:55	12:00	5’	**Session wrap up and next steps** **Section 3.1.3.6**	CARTIF	To thank participants for their time and summarise the main bullets that have been tackled. Encourage people to follow BUILDSPACE in social media and stay tuned for next sessions.

3.1.3. Co-creation session development and feedback received

3.1.3.1. Topic 1: Welcome and introduction

A first frame in the Miro Board presented the session and the agenda (
Figure 3), followed by an ice-breaker to get participants enter into participation mode (
Figure 4).

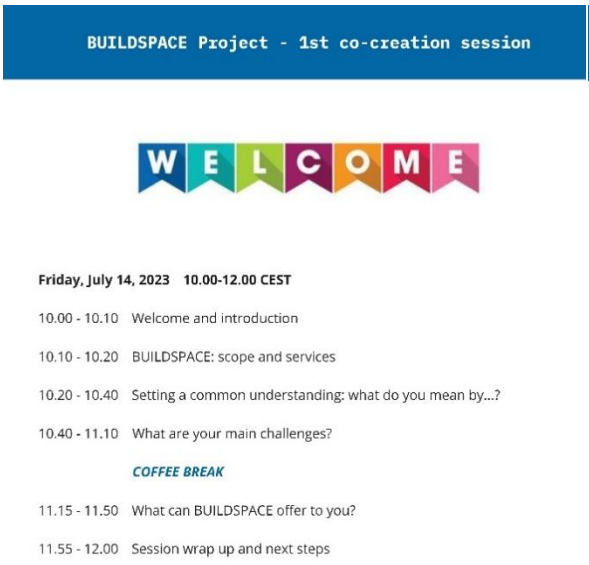

Figure 3. First frame in the Miro Board to welcome participants and present the session

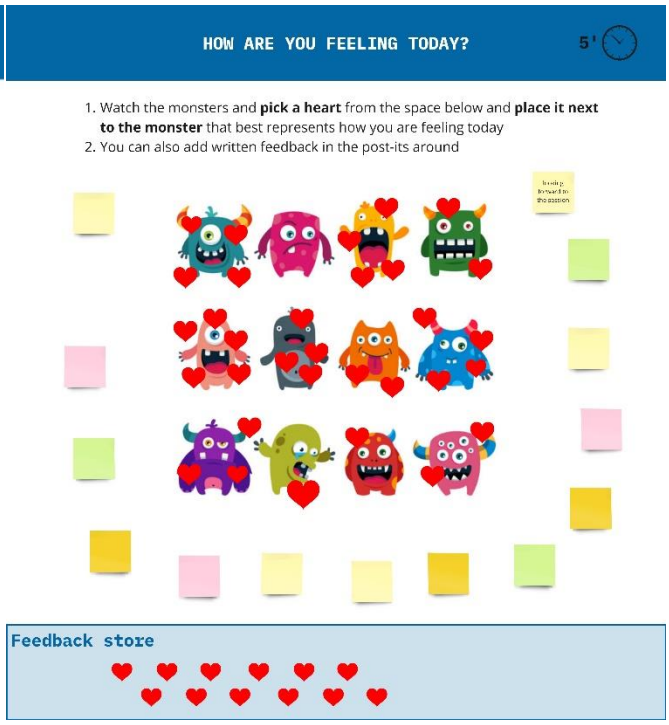

Figure 4. Second frame in the Miro Board with the ice-breaker

Then, the objectives of the session were presented (
Figure 5), and group pictures were taken (
Figure 6).

Figure 5. Third frame in the Miro Board with the session's objectives

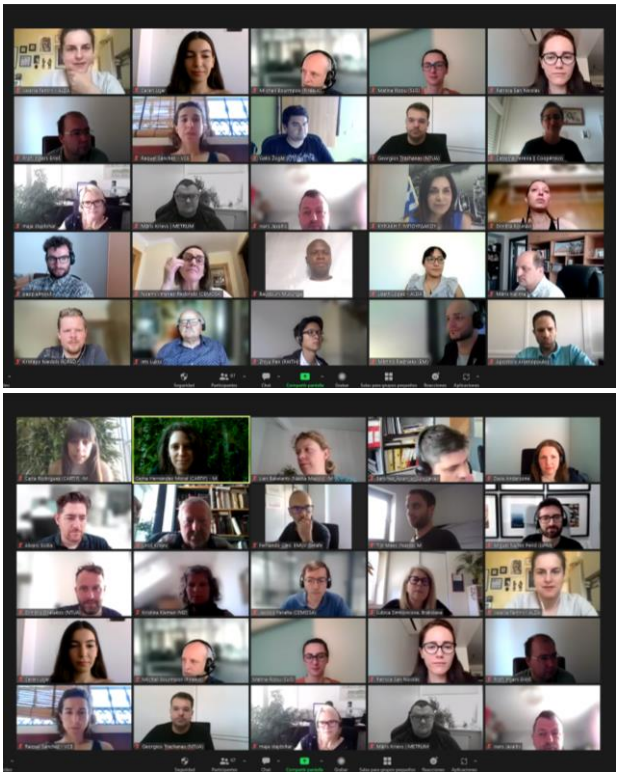

Figure 6. Pictures of the participants during the session

3.1.3.2. Topic 2: BUILDSPACE scope and services

A presentation was given by the project coordinator, which included an overview of the project with the items that can be seen in Figure 7.

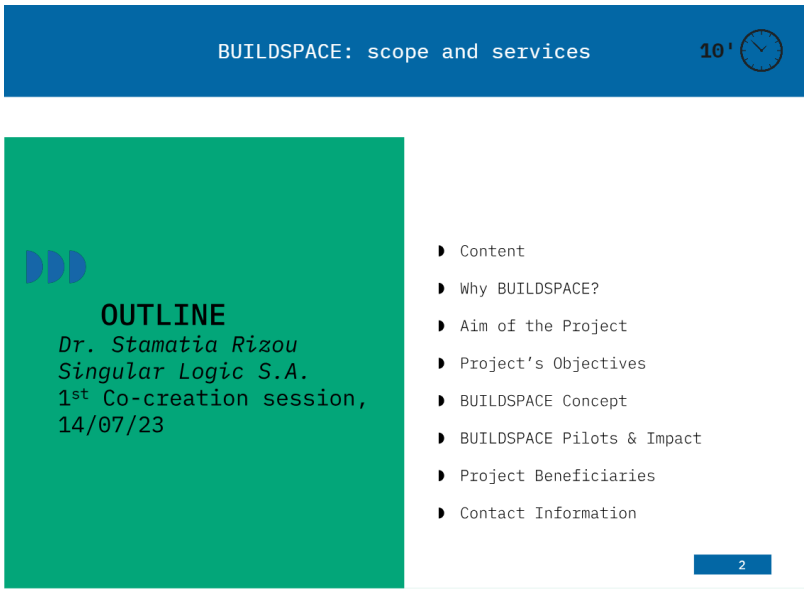

Figure 7. Fourth frame of the session including the BUILDSPACE presentation, where the content of the presentation given can be seen

3.1.3.3. Topic 3: Setting a common understanding: what do you mean by…?

The first part of this activity focused on making people think on the concepts of Building Digital Twin, Climate Resilient City, Urban Heat Island and Decision support for urban climate resilience. In this exercise participants wrote in notes (see Figure 8) what they understand by these concepts or things they think relate to these concepts. There were no wrong answers.

Figure 8. Fifth frame of the session to brainstorm on some concepts related to BUILDSPACE (including audience feedback)

Then, the agreed or "official" definitions of them were presented (Figure 9), to provide clarity on what we mean and have a common understanding for the upcoming activities.

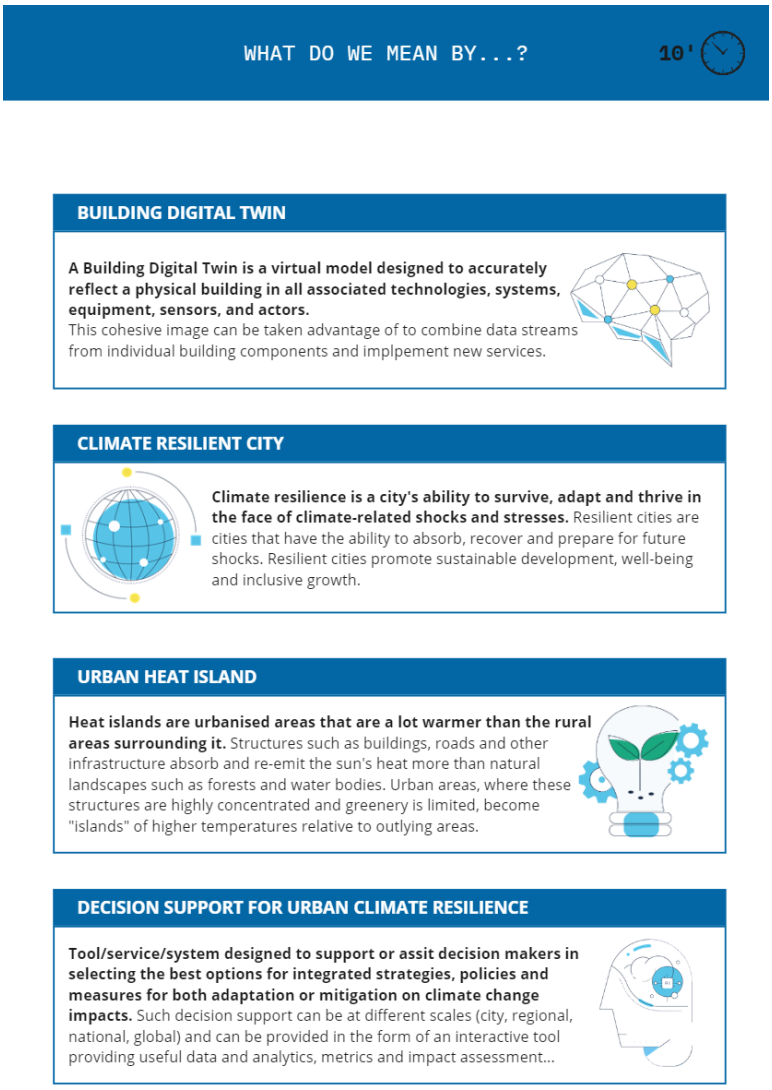

Figure 9. Sixth frame of the session to reveal the actual definitions for the presented concepts related to BUILDSPACE

3.1.3.4. Topic 4: What are your main challenges?

In this part of the session feedback from participants started to be collected as relevant for the project partners' activities. The session was formulated as a process based on the Value Proposition Canvas (Figure 10), mainly focusing on the Customer Profile part.

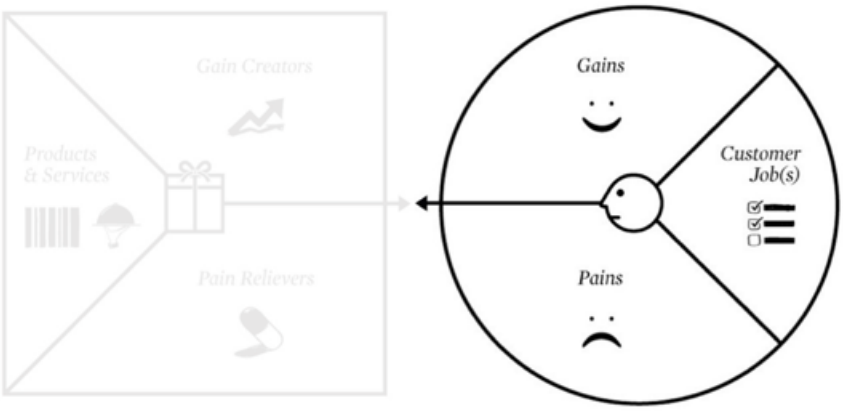

Figure 10. Value Proposition Canvas, Customer Profile part at the right

The activity was formulated as a process of three frames for participants' feedback (Figure 11). Starting with the participants identification on the challenges related with BUILDSPACE scope. Then, for the challenges identified (grouped in four groups to maintain the BUILDSPACE relation), the attendees defined the current steps they take in their day-to-day undertakings to address them (i.e. the customer jobs). As a next step, they had to add the difficulties (i.e. pains) they face to overcome them (difficulties found through the steps reported in customer jobs). At the end, the context of this exercise was provided, through the definition of the customer jobs and pains, to then move to the gains (i.e. what BUILDSPACE offers and how the services will help to overcome the challenges and pains).

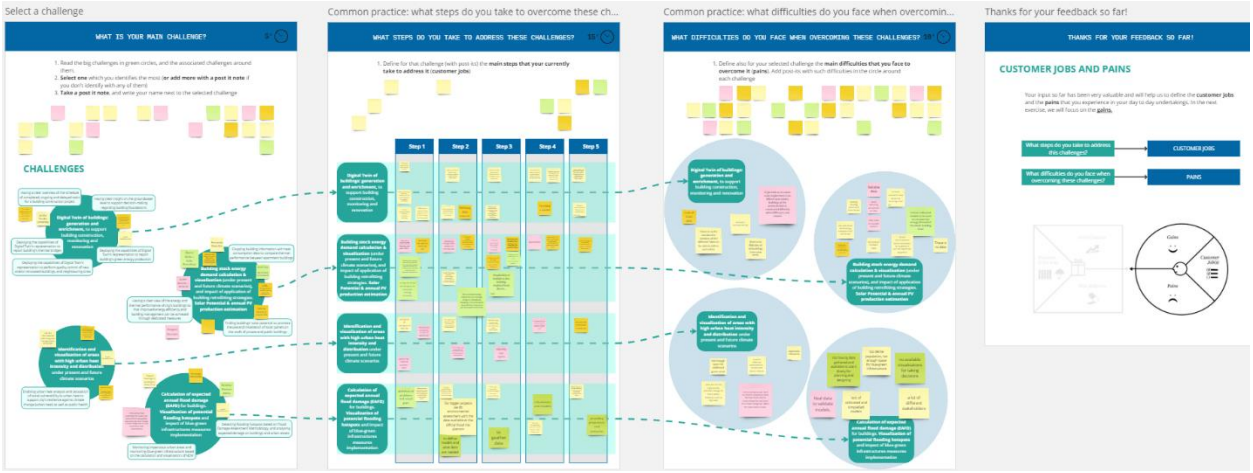

Figure 11. Overview of the four frames for the process activity of the identification of challenges and needs from users

Challenges identification

The challenges identification activity can be seen in Figure 12 below. At first, participants have to read the big challenges written in the rectangular boxes that are around the big circles with the BUILDSPACE services, in order not to lose the relation with the project and focus the identification of challenges, linked to the BUILDSPACE activities.

Figure 12. Seventh frame with interactive activity to identify participants' challenges

In the Table 4 below the feedback can be seen in detail, processed from the post-it's in the Miro Board.

Table 4. Feedback received from the activity: What is your main challenge?

Challenge	Feedback around the challenge (other than initially identified in the rectangular boxes)
Digital Twin of buildings: generation and enrichment, to support building construction, monitoring and renovation	- To create digital twins of all or a lot of buildings in the city - For the definition I would like to add one additional use of digital twin. Building maintenance is a very important use-case of digital twin in the building sector.
Building stock energy demand calculation & visualisation (under present and future climate scenarios), and impact of application building retrofitting strategies. **Solar potential & annual PV production estimation**	- Energy demand calculation/estimation of the building stock - Energy consumption data is hardly available to make detailed predictions in city/building level.
Identification and visualization of areas with high urban heat intensity and distribution under present and future climate scenarios	- Use this information to plan blue green infrastructure at city level - Availability of data on city/building level to make predictions and monitoring - Especially urban historical centres, more difficult to intervene in.
Calculation of expected annual flood damage (EAFD) for buildings. **Visualization of potential flooding hotspots** and impact blue-green infrastructures measures implementation	- I think actual flood predictions for Greece are quite difficult as available data does not seem to take climate change and current conditions under consideration - Prevent flooding in buildings

Customer jobs: steps definition to overcome the challenges

The customer jobs activity can be seen in Figure 13. They were already linked to the previous main challenges related to BUILDSPACE services, and participants had to add the different steps they currently take to address those challenges.

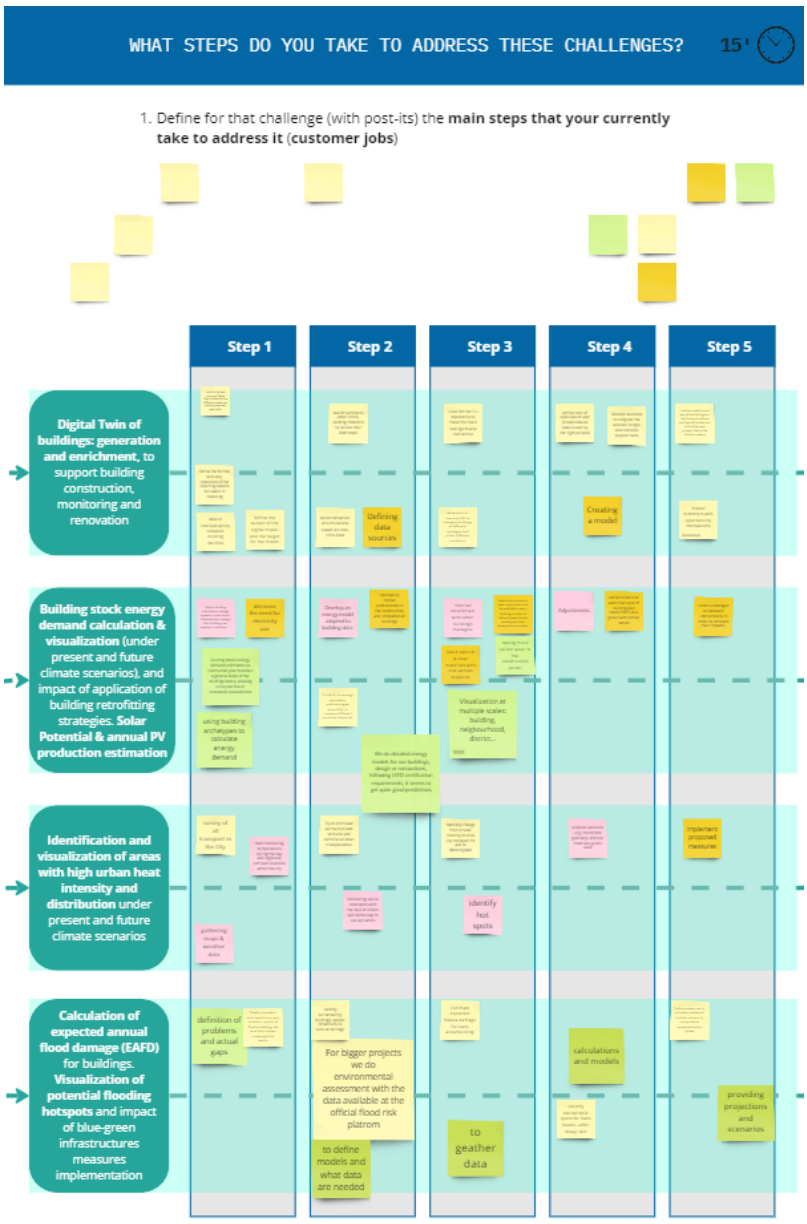

Figure 13. Eighth frame with interactive activity to define the attendees' customer jobs (steps they currently take) to address the identified challenges

In following Table 5 the feedback can be seen in detail, processed from the post-it's in the Miro Board.

Table 5. Feedback received from the activity: What steps do you take to address these challenges?

Challenge	Feedback around the steps				
	Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**
Digital Twin of buildings: generation and enrichment	- Look for the best common Digital Twin builders so the different models can communicate with each other - Define the format, accuracy, resolution of the incoming data to be usable in modelling - Assure interoperability between building facilities - Define the output of the digital model and the target for the model	- Ask for architects, existing modelers to receive their BIM model - Automatization of simulations based on real-time data - Defining data sources	- Look for the EU standards to make the twin intelligent and interactive - Generation of common KPI to compare buildings of different typologies and under different conditions	- set the level of open source and private data so data is used by the right persons - Develop solutions to integrate the services in high-level decision support tools - Creating a model	- Use the model to pre-test all the findings on the topics to reduce and ban all carbon out of the twin and present that to the decision makers - Protect customers with cybersecurity mechanisms
Building stock energy demand calculation & visualisation. Solar potential & annual PV production estimation	- Obtain building information: energy systems, construction characteristics, energy bills, building use, weather conditions, ... - Decrease the need for electricity use - Building stock's energy demands estimated via construction year to obtain a	- Develop an energy model adapted to building data. - Necessarily involve professionals in the construction and renovation of buildings - To clarify the energy calculation methodologies around	- Internal benchmark with other buildings managed. - Determine minimum data inputs that must be available in every building in order to allow at least an initial analysis and then iterate with more data.	- Adjustments - Define clusters of each main type of building and tackle them as a group with similar needs	- Create a catalogue of standard interventions in order to compare their impacts.

Challenge	Feedback around the steps				
	Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**
	general scope of the buildings' status, allowing us to plan future renovation plans/actions - using building archetypes to calculate energy demand	EU to compare different countries' demands. - We do detailed energy models for our buildings, design or renovations, following LEED certification requirements, it seems to get quite good predictions	- Value natural & local materials with less carbon footprint - Having more skilled labour in the construction sector - Visualization at multiple scales: building, neighbourhood, district...		
Identification and visualization of areas with high urban heat intensity and distribution	- Survey of all transport in the city - Start monitoring temperatures during the day and night and compare locations within the city - Gathering maps & weather data	- Try to eliminate as much private vehicles and combine all other transportation - Monitoring can be developed with the help of citizen and some easy-to-use application	- Radically change from private mobility to small city transport EV and to M(obility)aaS - Identify hot spots	- Propose solutions - e.g. much more greenery, different materials, green roofs	- Implement proposed measures
Calculation of expected annual flood damage (EAFD) for buildings. Visualization of potential	- Definition of problems and actual gaps - Clearly represent and visualize current situation, results of flood modelling. Be sure that citizens understand the results.	- Identify vulnerability: buildings, people, infrastructure, cultural heritage - For bigger projects we do environmental assessment with the data	- Estimate expected flood damage for each area/building - To gather data	- Calculations and models - Identify vulnerable spots for flash floods - after heavy rain	- Define measures to increase resilience, include citizens to cooperate at

Challenge	Feedback around the steps				
	Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**
flooding hotspots		available at the official flood risk platform - To define models and what data are needed			implementation phase - Providing projections and scenarios

Pains identification: difficulties found when overcoming the challenges

The pains identification activity can be seen in Figure 14. It was also linked with previous steps, mainly with the BUILDSPACE main challenges related to the services, and participants had to add the main difficulties they face to overcome the challenges, with post-it's in the circles around the challenges.

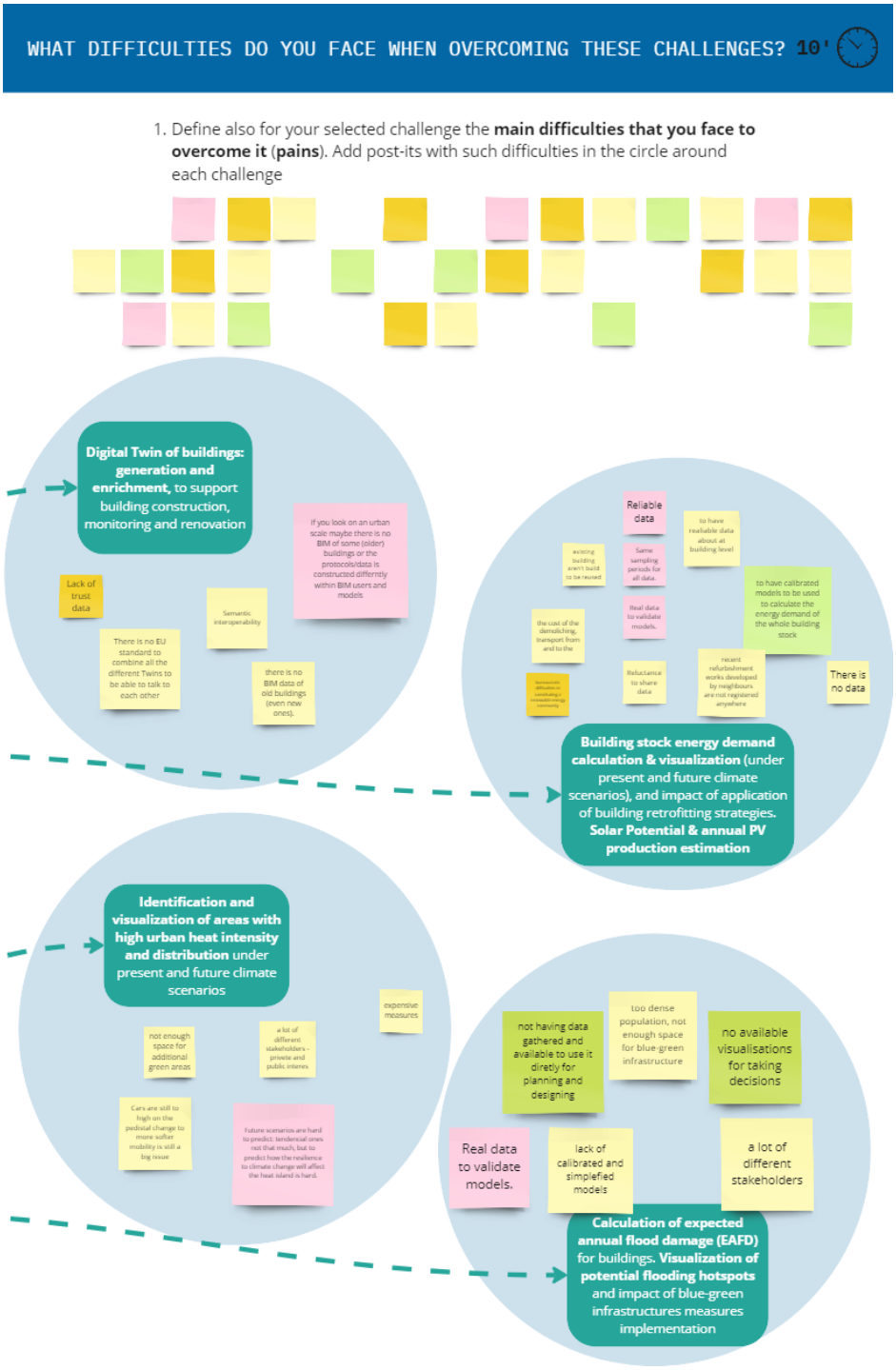

Figure 14. Ninth frame with interactive activity to define the pains (difficulties found) when overcoming the challenges

The Table 6 includes the feedback in detail, processed from the post-it's in the Miro Board.

Table 6. Feedback received from the activity: What difficulties do you face when overcoming these challenges?

Challenge	Feedback on the pains/ difficulties when overcoming the challenges
Digital Twin of buildings: generation and enrichment	- If you look on an urban scale maybe there is no BIM of some (older) buildings or the protocols/data is constructed differently within BIM users and models - Semantic interoperability - Lack of trust data - There is no EU standard to combine all the different twins to be able to talk to each other - There is no BIM data of old buildings (even new ones)
Building stock energy demand calculation & visualisation. Solar potential & annual PV production estimation	- To have calibrated models to be used to calculate the energy demand of the whole building stock - To have reliable data about a building level - Reliable data - Same sampling periods for all data - Existing building aren't built to be reused - The cost of demolishing, transport from and to the building - Bureaucratic difficulties in constituting a renewable energy community - Real data to validate models - Reluctance to share data - Recent refurbishment works developed by neighbours that are not registered anywhere - There is no data
Identification and visualization of areas with high urban heat intensity and distribution	- Not enough space for additional green areas - A lot of different stakeholders - private and public interest - Expensive measures - Cars are still too high on the pedestal change to softer - mobility is still a big issue - Future scenarios are hard to predict: tendential ones not that much, but to predict how the resilience to climate change will affect the heat island is hard.
Calculation of expected annual flood damage (EAFD) for	- Not having data gathered and available to use it directly for planning and designing - Too dense population, not enough space for blue-green infrastructure

Challenge	Feedback on the pains/ difficulties when overcoming the challenges
buildings. **Visualization of potential flooding hotspots**	- No available visualisations for taking decisions - A lot of different stakeholders - Lack of calibrated and simplified models - Real data to validate models

3.1.3.5. Topic 5: What can BUILDSPACE offer to you?

This part was presented as the link to the previous Customer Profile, where the challenges identified, and the customer jobs and pains provided by the participants can be solved through the BUILDSPACE services. Participants were invited to join at the service breakout room of outmost interest for them (more related with the previous challenges and pains they identified in previous activity).

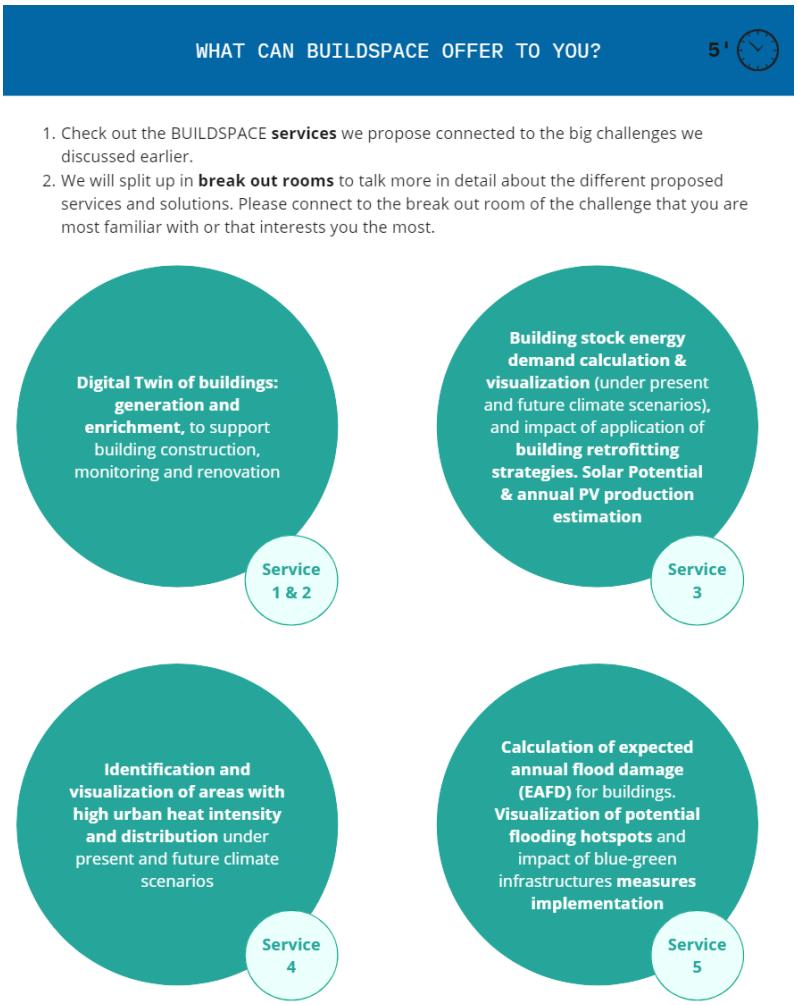

Figure 15. Tenth frame with the presentation of the interactive activity on the BUILDSPACE offer (services), prior to the breakout rooms on each service

In the breakout rooms, each service was presented more in detail through the solutions proposed for the service (functionalities already planned in BUILDSPACE, but in a rather general way, in order not to provide too many details that prevent participants to have their own ideas). Then, participants of the room were invited to add further ideas or functionalities they would like to obtain and are of added value for the service. Finally, they were also asked to add in which way they would like to visualise such information/function (e.g. in a map, in a graph, in a table, other…).

Next, the feedback received at each breakout room is depicted.

Breakout room 1: Services 1 & 2

The first breakout room was related to the two services of BUILDSPACE related to Buildings Digital Twin (Figure 16).

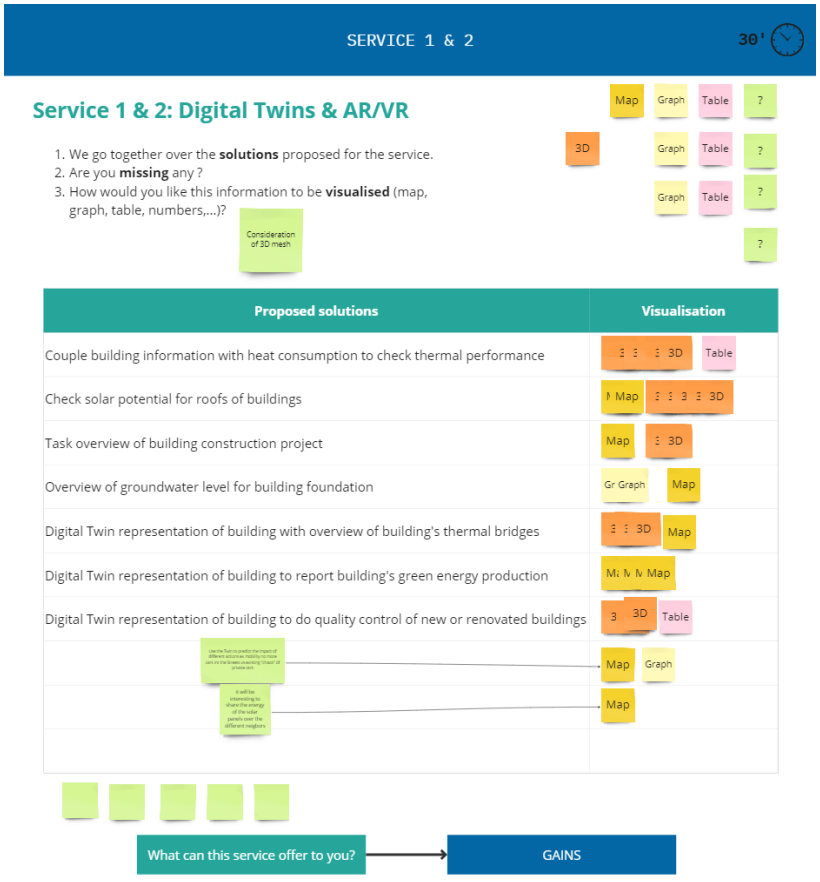

Figure 16. Joint breakout room for services 1 & 2 feedback on functionalities and visualization

In the Table 7 the feedback can be seen in detail, processed from the post-it's in the Miro Board.

Table 7. Feedback received from the activity: What can BUILDSPACE offer to you? In breakout room for service 1 & 2

Proposed solutions	Feedback on visualisation
Couple building information with heat consumption to check thermal performance	- Majority of 3D visualisation - Table visualisation
Check solar potential for roofs of building	- Majority of 3D visualisation - Map visualisation
Task overview of building construction projects	- Majority of 3D visualisation - Map visualisation
Overview of groundwater level for building foundation	- Graph visualisation - Map visualisation
Digital Twin representation of building with overview of building's thermal bridges	- Majority of 3D visualisation - Map visualisation
Digital Twin representation of building to report building's green energy production	- Majority of map visualisation
Digital Twin representation of building to do quality control of new or renovated buildings	- Majority of 3D visualisation - Table visualisation
Feedback to additional solutions	**Feedback on visualisations**
Consideration of 3D mesh	-
Use the twin to predict the impact of different actions ex mobility no more cars int the Streets vs existing "chaos" of private cars	- Map visualisation - Table visualisation
It will be interesting to share the energy of the solar panels over the different neighbours	- Map visualisation

Breakout room 2: Service 3

In the same way, the second breakout room was devoted for the BUILDSPACE service related to the Building Stock Energy Demand (Figure 17).

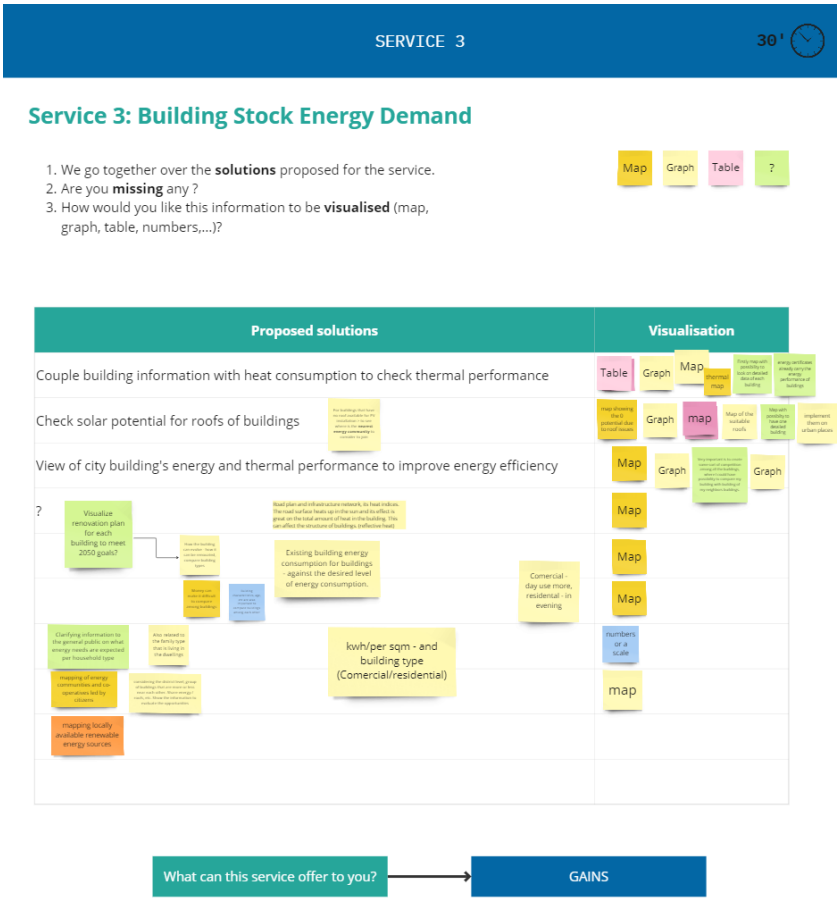

Figure 17. Breakout room for service 3 feedback on functionalities and visualization

The Table 8 shows the feedback provided in detail, processed from the post-it's in the Miro Board.

Table 8. Feedback received from the activity: What can BUILDSPACE offer to you? In breakout room for service 3

Proposed solutions	Feedback on visualisation
Couple building information with heat consumption to check thermal performance	- Several feedback for Table visualisation - Graph visualisation - Map (and thermal map) visualisation - Firstly, map with possibility to look on detailed data of each building - Energy certificates already carry the energy performance of buildings
Check solar potential for roofs of building	- Several map visualisations, and with details: o Map showing the zero-potential due to roof issues o Map of the suitable roofs o Map with possibility to have one detailed building

	- Graph visualisation - Implement them on urban places
View of city buildings' energy and thermal performance to improve energy efficiency	- Several graph visualisations - Map visualisation - Very important is to create some sort of competition among all the buildings, where I could have possibility to compare my building with building of my neighbours' buildings.

Feedback to additional solutions	Feedback on visualisations
For buildings that have no roof available for PV installation > to see where is the **nearest energy community** to consider to join	- Map visualisation
Mapping of energy communities and co-operatives led by citizens	- Map visualisation
Road plan and infrastructure network, its heat indices. The road surface heats up in the sun and its effect is great on the total amount of heat in the building. This can affect the structure of buildings. (reflective heat)	- Map visualisation
Visualize renovation plan for each building to meet 2050 goals?	- Map visualisation
How the building can evolve - how it can be renovated, compare building types	- Map visualisation
Existing building energy consumption for buildings - against the desired level of energy consumption.	- Map visualisation
kwh/per sqm - and building type (commercial/residential)	- Numbers or a scale visualisation
Commercial - day use more, residential - in evening	- Map visualisation
Money can make it difficult to compare among buildings	- Map visualisation
Building characteristics, age, etc are also important to compare buildings among each other	- Map visualisation
Clarifying information to the general public on what energy needs are expected per household type	- Map visualisation
Also related to the family type that is living in the dwellings	- Map visualisation
Considering the district level, group of buildings that are more or less near each other. Share energy / roofs, etc. Show the information to evaluate the opportunities	- Map visualisation
Mapping locally available renewable energy sources	- Map visualisation

Breakout room 3: Service 4

The third breakout room was dedicated to the BUILDSPACE service related to Urban Heat Resilience (Figure 18).

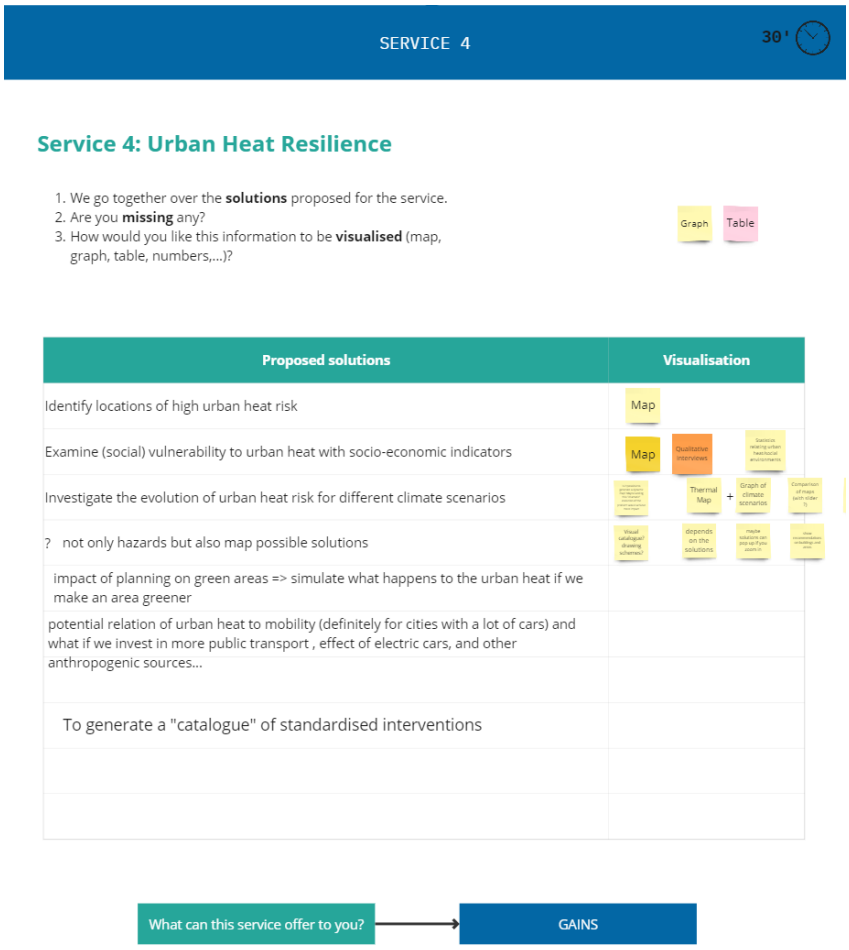

Figure 18. Breakout room for service 4 feedback on functionalities and visualization

The Table 9 depicts the detailed feedback provided, processed from the post-it's in the Miro Board.

Table 9. Feedback received from the activity: What can BUILDSPACE offer to you? In breakout room for service 4

Proposed solutions	Feedback on visualisation
Identify solutions of high urban heat risks	- Map o Enriched map with some more information? that is the vision

Examine (social) vulnerability to urban heat with socio-economic indicators	- Map
	  o Maybe in combination with the one above
	- Qualitative interviews
	  o Compare interview information with the objective heat risk
	- Statistics relating urban heat/ social environments

Investigate the evolution of urban heat risk for different climate scenarios	- Is it possible to generate a dynamic map? Maybe adding this "dramatic" evolution of the problem would achieve more impact - Thermal map + graph of climate scenarios - Comparison of maps (with slider?) - Mark areas with high urban heat risk no matter what scenario

Feedback to additional solutions	Feedback on visualisations
Not only hazards but also map possible solutions	- Visual catalogue? drawing schemes? - Depends on the solutions - Maybe solutions can pop up if you zoom in - Show recommendations on buildings and areas
Impact of planning on green areas => simulate what happens to the urban heat if we make an area greener	-
Potential relation of urban heat to mobility (definitely for cities with a lot of cars) and what if we invest in more public transport, effect of electric cars, and other anthropogenic sources...	-
To generate a "catalogue" of standardised interventions	-

Breakout room 4: Service 5

Lastly, the fourth breakout room focused on the BUILDSPACE service related to Flood Resilience (Figure 19).

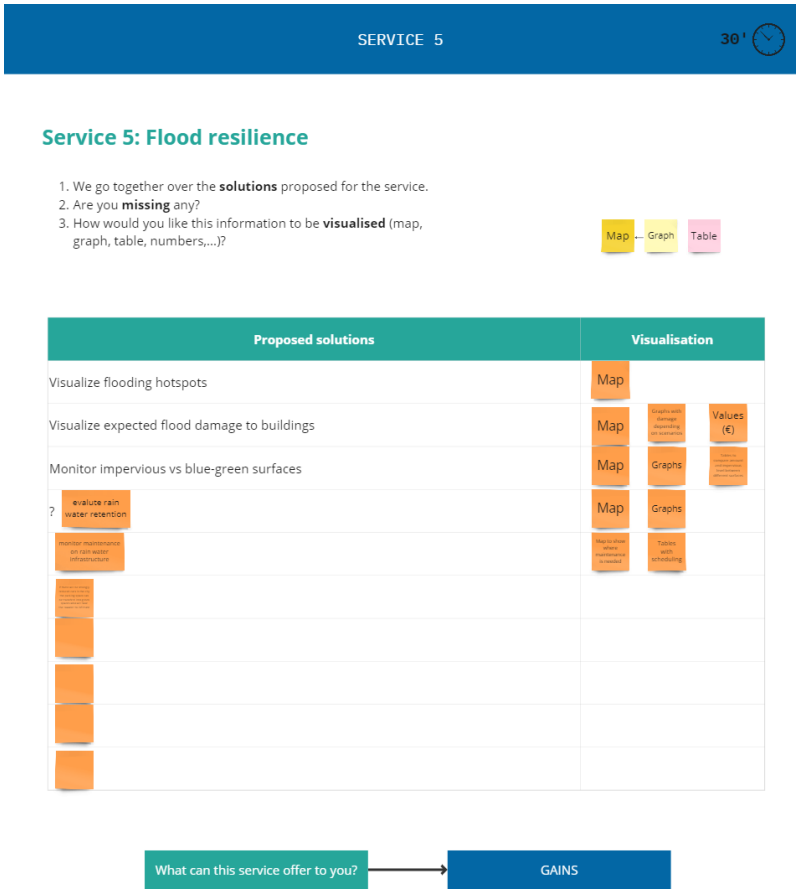

Figure 19. Breakout room for service 5 feedback on functionalities and visualization

In the following Table 10, the feedback can be seen in detail, processed from the post-it's in the Miro Board.

Table 10. Feedback received from the activity: What can BUILDSPACE offer to you? In breakout room for service 5

Proposed solutions	Feedback on visualisation
Visualise flooding hotspots	- Map visualisation
Visualise expect flood damage to buildings	- Map visualisation - Graphs with damage depending on scenarios - Values (€)
Monitor impervious vs blue-green surfaces	- Map visualisation - Graphs visualisation - Tables to compare amount and impervious level between different surfaces

Feedback to additional solutions	Feedback on visualisations
Evaluate rain water retention	- Map visualisation - Graphs visualisation
Monitor maintenance on rain water infrastructure	- Map to show where maintenance is needed - Tables with scheduling
If there will be strongly reduced cars in the city the parking spaces can be transferred into green spaces who will take the rainwater to infiltrate	

3.1.3.6. Topic 6: Session wrap up and next steps

Finally, the service leader that guided each breakout room provided in plenary a couple of highlights from the discussion in their group with main topics covered, and then the session ended thanking the participants and encouraging them to follow the project on social media and to stay tuned for the following events and sessions (Figure 20).

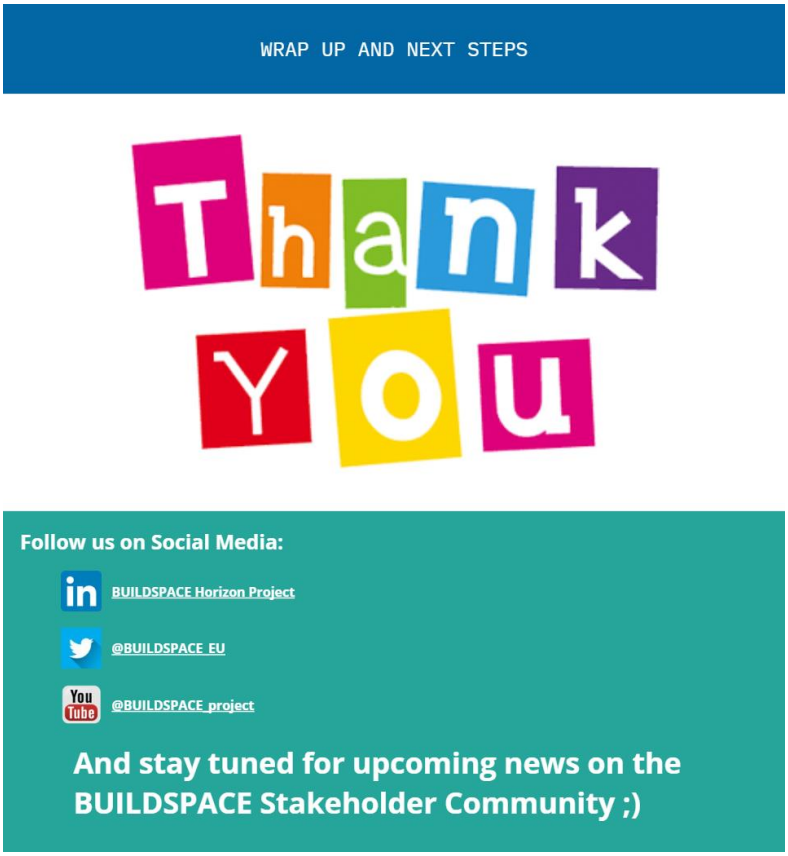

Figure 20. Last frame in the Miro Board to thank participants

3.2. Second co-creation session

The second co-creation session was conducted on the 24th November 2023. It was decided to maintain it on Friday, as the first one to establish some continuity and for coherence. As happened for the first session, it is open again to broad audience: the participants that were registered for the first session received an email from the BUILDSPACE email address inviting them to this second co-creation session. Additionally, a special focus was put in mobilising pilots' related key stakeholders, to make an early engagement of those that will be involved in the project during the pilot implementation testing phase (WP4) and at different stages of the services development (technology releases, WP3).

The objectives of this second session are: 1) to refresh (or present for the participants that didn't attend the first session) the BUILDSPACE project, its scope and objectives; 2) to present the services through its description, functionalities and visualisation, together with the feedback received in the first co-creation session; 3) to show the services workflow on a simple diagram and obtain feedback from participants interested in the services, as well as on key aspects of the services (e.g. visualisation aspects, comparable

elements, and other key questions around the service potential use that are relevant to each service leader) and 4) and to find synergies of the BUILDSPACE project and services with other EU projects and initiatives in which the participants are involved or linked.

The expected outcomes of the session are: 1) making potential stakeholders interested in the project, especially targeted potential end-users from each pilot environment; 2) further understanding of how the potential end-users of the services would use the different functionalities, and their interest on the more concrete ones; 3) better knowledge on how the different visualisations can support the user to obtain the information they need from the services and 4) and to gather several EU projects and initiatives to which the BUILDSPACE project can establish links and relations for potential collaboration and synergies.

The session format was online, planned in a 2-hour Zoom meeting, with a 5-minute break. The feedback, presentation and all interactions will be hosted on a Miro Board, similar to the first session.

In the following Table 11, the main aspects of the second co-creation session's planning are presented.

Table 11. Second co-creation session planning in a nutshell

No.	**Date**	
#2	**M10.** 24th November 2023, 11:00 – 13:00 CET	
Audience	**Invited**	Open to broad audience. Invitation to all stakeholders registered for the first co-creation session and mobilisation of pilots' networks of potential interested stakeholders related to the four BUILDSPACE pilots. Posts on the BUILDSPACE and partners' social media.
Objectives	- To refresh (or present for new participants) the BUILDSPACE project, with scope and objectives - To present the services through its description, functionalities and visualisation. Link with the feedback received during the first co-creation session (on additional functionalities mainly) - To show the workflow of the services and obtain feedback on key aspects, visualisation, comparable elements and key questions to support the service developers - To find synergies between the project and services with other EU projects and initiatives	
Expected outcome	- Make potential stakeholders interested in the project (special target on Pilot-related stakeholders) - Further understanding of how potential end-users of the services would use the different functionalities, and their interest on specific ones (that help them in their work on in a concrete need)	

	- To obtain a better knowledge on how the different visualisation can support the user to obtain the information they need - To gather several EU projects and initiatives to establish collaboration
Type of interaction	The session is online (through Zoom platform). The feedback, presentation and all interactions will be hosted on a Miro Board.

4. Technical Use Cases

In this section, the first version of the BUILDSPACE Use cases is presented. They have been developed as part of Task T2.3, building on the outputs of Task T2.1 and on the feedback gathered during the first co-creation session with external stakeholders.

The process is explained in next section 4.1, while the use cases of each service are included in the following sections 4.2 to 4.6.

4.1. Process for use cases definition

The process for the use cases generation (Figure 21) started with the service description that was already reported in D2.1, where each service included details on the scope and objectives, a short description, input requirements, service operation, service output, and the definition of the service workflow (through different steps). The template provided for the service description, also included a first identification of the data requirements, separating the data non-dependent from the pilots from the pilot-dependent data, for clarification purposes.

Then, considering the user stories, the user requirements and the technical requirements already reported in D2.1 “BUILDSPACE User Requirements”, the service leaders were invited to provide feedback. A template was used to guide the process.

Finally, the template already presented in D2.1 was sent to the service leaders to complete the use cases. The feedback received from the first co-creation session activities was considered as well, for which purpose, all documentation of the processed feedback had already been prepared (included in the current section 3.1.3).

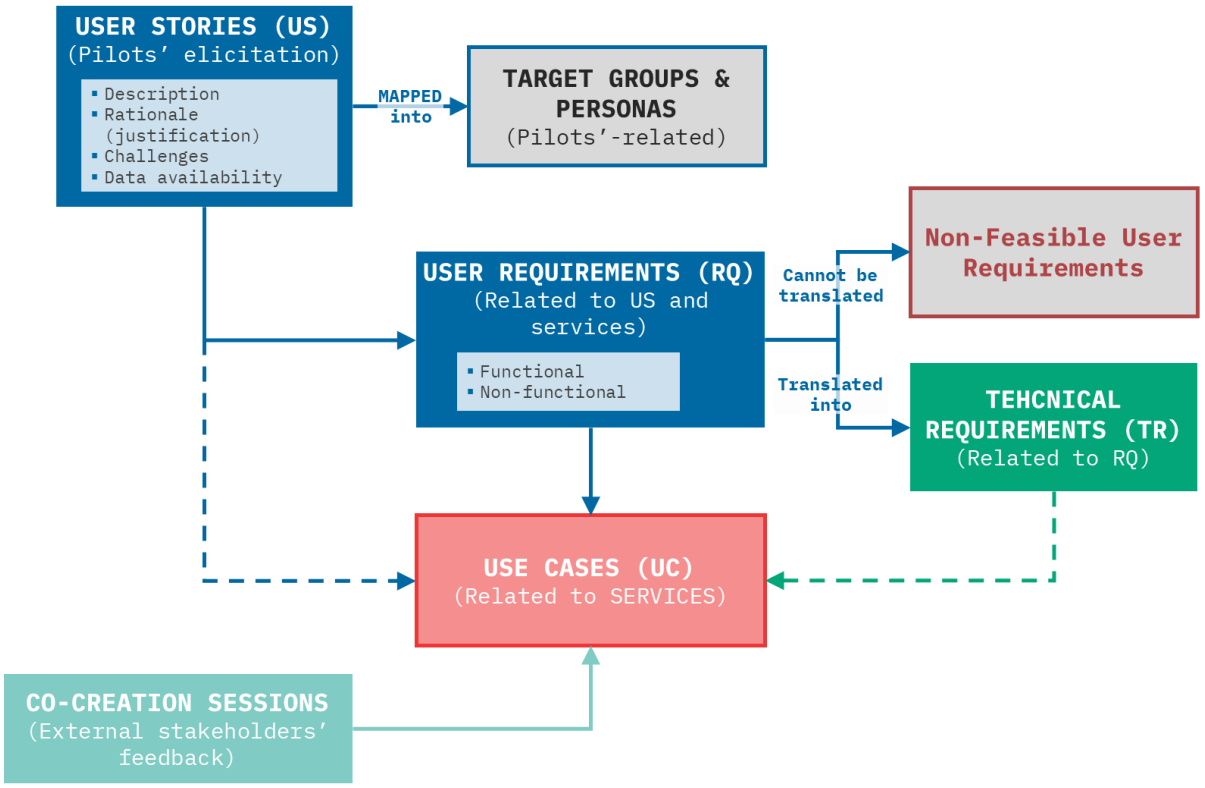

Figure 21. Process for the generation of the use cases

The template was organised as a process (Figure 22) in which service developers had to go through each user story, user requirement and technical requirement that was initially foreseen as linked to the service and provide input on the actual match (Yes / No) and how or why this match happen or not, justifying it with the planned service functionalities.

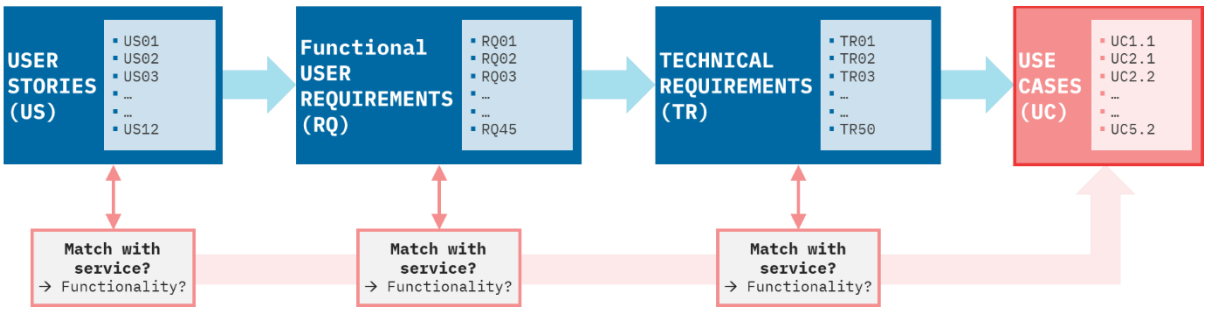

Figure 22. Process for the feedback to the different requirements by the services prior the definition of the Use Cases

In the following Table 12, the matches between the services and user stories is provided as summary.

Table 12. User stories (US) relation with services

US ID	Brief description	SE identified	Match?
US01	As a municipality, I want to use building information and couple it with heat consumption data so that to compare the thermal performance between apartment buildings.	**SE1**	Yes (partially)
		SE3	Yes
US02	As a municipality, I want to record heat energy consumption along the city and, in particular, to create a "Register of Chimneys" (provides information on air pollution) so that to implement activities to improve air quality at city level.	**SE3**	No
US03	As a municipality, I want to create an online tool where owners can find out buildings' solar potential so that to promote the use and installation of solar panels on the roofs of private and public buildings.	**SE1**	Yes (partially)
		SE3	Yes
US04	As a construction company, I want to have a clear overview of the schedule of completed, ongoing, and delayed tasks for a building construction project.	**SE2**	No
US07	As a construction company, I want to deploy the capabilities of building's DT representation so that to have clear overview on building's thermal bridges.	**SE1**	Yes (partially)
		SE2	Yes (partially)
US08	As a construction company, I want to deploy the capabilities of building's DT representation so that to perform quality control (e.g., cracks, etc.) of new and/or renovated buildings, as well as neighbouring ones that in close proximity to the construction site.	**SE2**	Yes (partially)
US09	As a municipality, I want to have a clear view of the energy and thermal performance of city's buildings so that measures that improve energy efficiency and other aspects of building management can be applied.	**SE1**	Yes (partially)
		SE2	Yes (partially)
		SE4	No
US10	As a municipality, I want to enable urban heat analysis and calculate social vulnerability to urban heat so that to support city´s resilience against climate change (urban heat) as well as public health.	**SE4**	Yes (partially)

US ID	Brief description	SE identified	Match?
US11	As a research institution, I want to use an online application, based on the Flood Damage Assessment Methodology (FDAM), so that flooding hotspots can be visualized and the expected damage on buildings and other urban assets can be addressed.	**SE5**	Yes
US12	As a research institution, I want to deploy a simplified online tool where urban stakeholders can find out the potential of Blue-Green Infrastructure (BGI) to impact flood vulnerability and resilience to promote BGI measures implementation on the building and neighbourhood level.	**SE5**	Yes

User requirements, that were initially captured through the elicitation process of deliverable D2.1, are re-evaluated. The main aim of this part is to update and align user requirements with the services that are going to be developed through BUILDSPACE project. This connection is reflected in the elicitation process of Task T2.1.

The present exercise relies on the combination of (1) the outcomes of the 1st BUILDSPACE co-creation session that was held in July 2023, 14th; (2) Services detailing and (3) Use cases definition of the present section (in the following sub-sections 4.2 to 4.6), as presented in Figure 23.

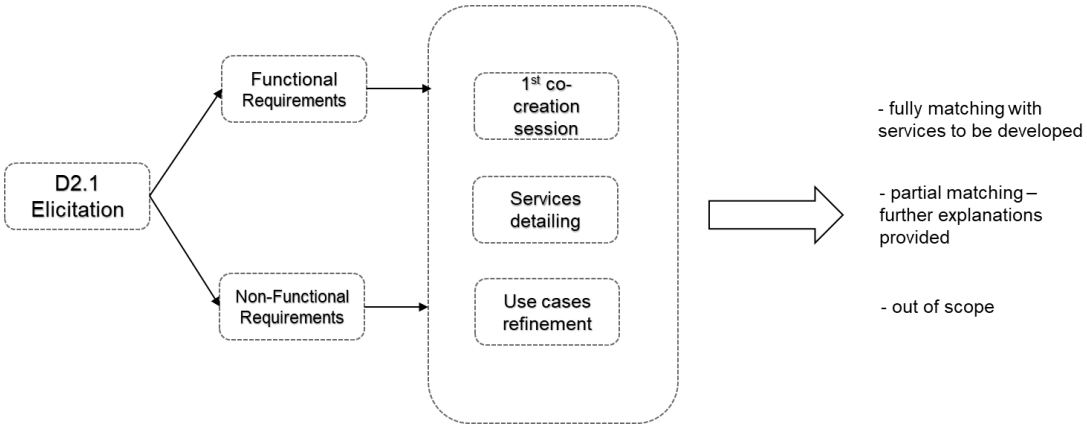

Figure 23. User Requirements update process (from D2.1 at M4 to present D2.2 at M10)

In particular, based on the level they match with the five services of BUILDSPACE project, the functional requirements are classified into: (i) fully matching, (ii) partially matching, (iii) out-of-scope.

In case (i), there is at least one BUILDSPACE service that matches directly with the aim and scope of the particular requirement. In case (ii), a user requirement may be partially matching with one or more services. This doesn't mean that the requirement is out of project's scope. Instead, it means that additional functionalities need to be implemented towards the complete matching (e.g. additional captures by cameras, further data integration, etc.) that probably could not be treated within the umbrella of BUILDSPACE so far (in terms of timeline and pilot capabilities). In this context, to be more complete, specific suggestions are also provided for the potential exploitation of the partially matching user requirements, as presented in Table 13 and Table 14.

By analysing the results, 25 user requirements are found to be fully addressed (~55%), 9 user requirements are partially addressed (20%), and 11 user requirements have been characterized as out of scope of the BUILDSPACE services (~24%).

Regarding n*on-functional requirements*, only minor modifications emerged at the re-evaluation process. In particular, RQ46 and RQ47 of D2.1 (also included in Table 15 for reference) are now described as "Secure stored information" and "Support time-efficient data collection", respectively, to better reflect BUILDSPACE platform non-functional requirements.

Table 13. Functional User Requirements (RQ) relation with Services

RQ ID	Brief description	SE identified	Match?
RQ01	Connect district heating consumption data in apartment buildings with available building information (e.g., area, volume, etc.)	**SE1**	Yes (partially)
		SE3	Yes
RQ02	Calculate energy efficiency rating of buildings that are connected to the district heating network	**SE2**	No
		SE3	Yes
RQ03	Visualise building's energy efficiency rating	**SE1**	No
		SE3	Yes
RQ04	Link "bad" energy efficiency rating buildings with recommended solutions	**SE1**	No
		SE3	Yes
RQ05	Identify all chimneys by using satellite thermography images	**SE2**	Yes
		SE3	No
RQ06	Connect every "hot" chimney to building and heated area data	**SE2**	No

RQ ID	Brief description	SE identified	Match?
		SE3	No
RQ07	Connect every "hot" or used chimney to heat source used in the building	SE2	No
		SE3	No
RQ08	Create a list of heated buildings and used heat source	SE2	No
		SE3	Yes
RQ09	Calculate building's heat consumption	SE2	No
		SE3	Yes
RQ10	Calculate air pollution for each heat source	SE2	No
		SE3	No
RQ11	Measure the roof area that is available for solar energy generation	SE1	Yes (partially)
		SE3	Yes
RQ12	Measure the shaded roof area	SE1	Yes (partially)
		SE3	Yes
RQ13	Calculate the yearly output of solar panels	SE2	No
		SE3	Yes
RQ14	Calculate the available amount of solar energy (solar energy potential of the building)	SE2	No
		SE3	Yes
RQ15	Visual representation of the progress of construction works on daily/weekly basis	SE1	No
		SE2	Yes (partially)
RQ16	Identify quickly and accurately hazards that are associated with groundwater levels, taking also into account the weather changes	SE1	No
		SE2	No

RQ ID	Brief description	SE identified	Match?
RQ17	Visual representation of green energy production and related savings	**SE1**	No
		SE2	No
RQ18	Visual identification of thermal bridges of the buildings	**SE1**	Yes (partially)
		SE2	Yes (partially)
RQ19	Detect cracks in the building structure or displacement of the building or surrounding buildings	**SE1**	No
		SE2	Yes (partially)
RQ20	Provide a baseline indicator value for the energy performance of municipal buildings, as well as a procedure to replicate on more municipal or other buildings	**SE1**	No
		SE2	Yes (partially)
		SE4	No
RQ21	Provide a baseline indicator value for the thermal performance, as well as a procedure to replicate on more municipal or other buildings	**SE1**	No
		SE2	Yes (partially)
		SE4	No
RQ22	Measure the impact of interventions at building scale	**SE1**	Yes (partially)
		SE2	Yes (partially)
		SE4	No
RQ23	Measure the impact of interventions at city scale	**SE1**	Yes (partially)
		SE2	No
		SE4	No
RQ24	Provide a baseline indicator value for the social vulnerability to urban heat	**SE1**	No
		SE2	No
		SE4	Yes

RQ ID	Brief description	SE identified	Match?
RQ25	Measure relevant heat indicator values at any time	**SE1**	No
		SE2	No
		SE4	Yes (partially)
RQ26	Acquire necessary expertise and equipment to perform building and city level heat analysis at any time, at any building	**SE1**	No
		SE2	Yes
		SE4	No
RQ27	Identify specific areas where urban heat is significantly higher than the rest of the city	**SE1**	No
		SE2	No
		SE4	Yes
RQ28	Measure the impact of interventions at the city level regarding urban heat and social vulnerability	**SE1**	No
		SE2	No
		SE4	No
RQ29	Develop an online version of the already existing Flood Damage Assessment Methodology (FDAM) tool	**SE5**	Yes
RQ30	Upgrade FDAM to address the expected damage in urban flooding caused by short-term extreme rainfall events, while also allowing engagement of end-users	**SE5**	Yes (partially)
RQ31	Make the upgraded FDAM more user-friendly in terms of eliminating the needs for GIS and requiring programming skills by the end-users	**SE5**	Yes
RQ32	Visualise flooding hotspots by combining available off-line flooding altitude data, satellite urban floods images and satellite terrestrial altitude data.	**SE5**	No
RQ33	Calculate the flood damage per m2 of urban area	**SE5**	Yes
RQ34	Calculate the flood damage per m of urban infrastructure	**SE5**	Yes

RQ ID	Brief description	SE identified	Match?
RQ35	Calculate the flood damage per building	**SE1**	No
		SE5	Yes
RQ36	Build evidence of urban planning events by enabling to make individual georeferenced inputs by the end users	**SE5**	No
RQ37	Calculate the terrestrial altitude from satellite LIDAR DEM model with open source software: QGIS, LAStools, FUSION, SAGA and make a kind of intersection of them	**SE5**	No
RQ38	Calculate the average Normalized Difference Vegetation Index (NDVI) per buildings or buildings‘ plots	**SE1**	No
		SE5	Yes
RQ39	Assess how blue-green is a building or a building's plot	**SE1**	No
		SE5	Yes
RQ40	Identify where are the critical points in view of high urban flooding risk	**SE5**	Yes
RQ41	Create NDVI trends over seasons and years	**SE5**	Yes
RQ42	Monitor existing blue-green infrastructure measures by attaching photos and writing some connected text/descriptions	**SE5**	Yes
RQ43	Calculate the terrestrial altitude from satellite LIDAR DEM model with open source software: QGIS, LAStools, FUSION, SAGA	**SE5**	No
RQ44	Combine available terrestrial with satellite data to identify potential flooding hotspots	**SE5**	Yes
RQ45	Analyse the effects of blue-green infrastructure (BGI) measures on flooding resilience of buildings	**SE1**	No
		SE5	Yes

Based on the feedback “matches” of services to the user requirements (as main element related to use cases definition), in the table below there is an update of the reported requirements in D2.1 (part of the continuous updating of Task 2.1 “User requirements elicitation”).

For the services that partially cover some of the user requirements, a potential exploitation that may be needed is added in the following table.

Table 14. Service potential exploitation for User requirements (RQ) partial coverage

RQ ID	Brief description	SE	SE potential coverage
RQ01	Connect district heating consumption data in apartment buildings with available building information (e.g., area, volume, etc.)	**SE1**	Generated geometric digital twin model will contain the information about the building layout, orientation, area and orientation of windows to support the thermal performance comparison. However, the non-geometric information, such as construction material information and insulation level will not be provided in the initial generated digital twin.
RQ18	Visual identification of thermal bridges of the buildings	**SE1** **SE2**	The 3D point cloud of the external envelop could contain thermal information as well as RGB. Information could be used to diagnose heat anomalies such as thermal bridges, cracks, infiltration of water/air. This information will depend on how many times the building is captured. SE2 will obtain the 3D point cloud, RGB and thermal data, and another SE should develop the visual representations.
RQ19	Detect cracks in the building structure or displacement of the building or surrounding buildings	**SE2**	The 3D point cloud provides metric information about the state of the building or the construction process. This information will depend on how many times the building is captured. SE2 will obtain the 3D point cloud, RGB and thermal data, and another SE should develop the visual representations. The resolution of the camera has to be considered because it may not detect fine cracks or small anomalies.
RQ20	Provide a baseline indicator value for the energy performance of municipal buildings, as well as a procedure to	**SE2**	The 3D point cloud of the external envelop could contain thermal information as well as RGB. Information could be used to diagnose heat

RQ ID	Brief description	SE	SE potential coverage
	replicate on more municipal or other buildings		anomalies such as thermal bridges, cracks, infiltration of water/air. This information will depend on how many times the building is captured. SE2 will obtain the 3D point cloud, RGB and thermal data, and another SE should develop the visual representations.
RQ21	Provide a baseline indicator value for the thermal performance, as well as a procedure to replicate on more municipal or other buildings	**SE2**	
RQ22	Measure the impact of interventions at building scale	**SE1**	The 3D point cloud of the external envelop could contain thermal information as well as RGB. Information could be used to compare different situations of the building, pre and post intervention.
		SE2	
RQ23	Measure the impact of interventions at city scale	**SE1**	The generated digital twin will be integrated with the EGNSS data and has the capability to be merged in a city-scale model. However, the specific impact from should be further analysed and it is beyond the scope of SE1.
RQ25	Measure relevant heat indicator values at any time	**SE4**	The Urban Heat Exposure will be calculated based on a time series climate data collected from CWS, reference weather stations and ERA5 data. A specific time period will be established for this analysis (not real time data)
RQ30	Upgrade FDAM to address the expected damage in urban flooding caused by short-term extreme rainfall events, while also allowing engagement of end-users	**SE5**	The service won't provide upgrading by addressing the expected damage in urban flooding caused by short-term extreme rainfall events due to the out-of-the-service scope. Still, it will enable users to contribute inputs of flood extension information via geolocated uploading photos and text inputs.

In the following Table 15, the Non-functional requirements (RQ) are also included from those reported in D2.1 for reference in the following use cases.

Table 15. Non-Functional User requirements (RQ), the application of them to concrete use cases is reported in next sections

RQ ID	Brief description
RQ46	Guarantee the security of stored information
RQ47	Support real time data collection
RQ48	Provide time-efficient analytics methods
RQ49	Support different authorisation access level for different users
RQ50	Support error protection methods for user input fields
RQ51	Enable easy user navigation through the platform
RQ52	Prevent users from inserting invalid input
RQ53	Allow extensibility and easy implementation of new functionalities

4.2. Technical use cases for SE1

Table 16. Use case 1.1 related to SE1 Digital Twin Generation

Use case	**UC1.1 – Digital twin generation**	
Related user requirements	**Functional**	RQ01, RQ11, RQ12, RQ18, RQ22, RQ23
	Non-functional	RQ46, RQ48, RQ51, RQ52, RQ53
Description	The UC1.1 is about to generate a geometric digital twin (DT) model with EGNSS data integrated based on a point cloud dataset (with XYZRGBt information). The generate DT will support the further energy analytics of the building and city level.	
Actors	The actors will be the owners of the building or the municipalities	
Inputs	The point cloud dataset (with XYZRGBt information)	

Outputs	The geometric digital twin model	
Modules / External tools	Software for DT visualization: Revit, online IFC viewer tool, Unity, Unreal Engine 5.1 Hardware for DT visualization using MR device: Computer with Graphics Cards TRX min 3060.	
Preconditions	Accurate and registered point cloud dataset that containing the XYZ (geolocation), RGB (image) and t (thermal imaging) information.	
Normal sequence	**Step**	**Action**
	1	Convert the input point cloud dataset into mesh model
	2	Convert mesh model to geometric digital twin (DT) model
	3	Integrate the .ifc model with geo location (EGNSS) data
	4	Present the thermal information to DT model or light weight model for visualization
	5	Visualize the DT model under the Mix Reality environment
Post conditions	The visualization of the generated of geometric digital twin requires the specific software or the ifc online viewer module in the DT platform.	
Exceptions	**Related step**	**Action**
	1	The comprehensiveness of the input point cloud dataset will affect the DT output directly.
Linked use cases	The input point cloud dataset is generated from the SE2 (UC2.1 &UC2.2)	
Importance	High	

4.3. Technical use cases for SE2

Table 17. Use case 2.1 related to SE2 Digital Twin Semantic Enrichment

Use case	**UC2.1 – Mostostal quality control of a new building**	
Related user requirements	**Functional**	RQ05, RQ15, RQ18, RQ19, RQ20, RQ21, RQ22
	Non-functional	RQ46, RQ47, RQ48, RQ49, RQ50
Description	The use case corresponds to pilot 1, Mostostal The use case is related to the quality control of a new (newly constructed) building for the identification of critical areas in the thermal envelope. (cracks, thermal bridges, etc)	
Actors	The construction company	
Inputs	-	
Outputs	3D point cloud data, RGB images of the exterior and interior envelope, thermal images of the exterior envelope and identification of critical areas of the envelope	
Modules / External tools	Hardware: Drone equipped with thermal and RGB camera (UAV) and GPS rtk (georeferenced) for the external envelope and mobile mapping (SLAM) and GPS (rtk georeferenced) for the inner envelop Software: Pix4D, Agisoft Metashape, CloudCompare, Reality Capture or Drone Deploy. Manufacture SLAM software.	
Preconditions	Legal issues (depending on the region), weather.	
Normal sequence	**Step**	**Action**
	1	A date and time are set, considering the weather, flight permits are requested, and legal issues are resolved (UAV and SLAM)
	2	The place is visited to see if there are any inconveniences when flying. Busy roads, vegetation, electric cables or elements that may interrupt the flight outside. And the best flight path is studied and programmed. (UAV and SLAM)
	3	The drone is flown to capture the point cloud, thermal and RGB images. (UAV) The mobile mapping moves through the interior of the building capturing it. (SLAM)

	4	The information obtained is processed by software and manually. (UAV and SLAM) A point cloud is obtained with an RGB and thermal model of the outdoor, which have to be overlaid. (UAV) A point cloud is obtained with RGB information of the inner envelop (SLAM)
	5	This information will be used to generate the digital twin (SE1).
	6	Detection of critical areas and building quality through AI
Post conditions	The resolution of the thermal camera is lower than the resolution of the RGB camera, so some details or small elements of the images could be lost in the processing of the model.	
Exceptions	**Related step**	**Action**
	3	In case of the drone does not have thermal camera, the information contained in the 3D point cloud will be RGB and XYZ
	3	In case of the mobile mapping does not have RGB information, the information contained in the 3D point cloud will be XYZ
Linked use cases	UC1.1 (that will use the information from this UC)	
Importance	High	

Table 18. Use case 2.2 related to SE2 Digital Twin Semantic Enrichment

Use case	**UC2.2 – Piraeus intervention areas of a municipal building**	
Related user requirements	**Functional**	RQ05, RQ15, RQ18, RQ19, RQ20, RQ21, RQ22
	Non-functional	RQ46, RQ47, RQ48, RQ49, RQ50
Description	The use case corresponds to pilot 3, MoP	
Actors	Municipalities	
Inputs	-	
Outputs	3D point cloud data, RGB and thermal images of the interior and exterior	

Modules / External tools	Hardware: Drone equipped with thermal and RGB camera (UAV) and GPS (georeferenced) for the external envelope and mobile mapping (SLAM) and GPS (georeferenced) for the inner envelop Software: Pix4D, Agisoft Metashape, Reality Capture or Drone Deploy. Manufacture SLAM software.	
Preconditions	Legal issues (depending on the region), weather.	
Normal sequence	**Step**	**Action**
	1	A date and time are set, considering the weather, flight permits are requested, and legal issues are resolved (UAV and SLAM)
	2	The place is visited to see if there are any inconveniences when flying. Busy roads, vegetation, electric cables or elements that may interrupt the flight outside. And the best flight path is studied and programmed. (UAV and SLAM)
	3	The drone is flown to capture the point cloud, thermal and RGB images. (UAV) The mobile mapping moves through the interior of the building capturing it. (SLAM)
	4	The information obtained is processed by software and manually. (UAV and SLAM) A point cloud is obtained with an RGB and thermal model of the outdoor, which have to be overlaid. (UAV) A point cloud is obtained with RGB information of the inner envelop (SLAM)
	5	This information will be used to generate the digital twin (SE1).
	6	Detection of critical and intervention areas through AI
Post conditions	The resolution of the thermal camera is lower than the resolution of the RGB camera, so some details or small elements of the images could be lost in the processing of the model.	
Exceptions	**Related step**	**Action**
	3	In case of the drone does not have thermal camera, the information contained in the 3D point cloud will be RGB and XYZ
	3	In case of the mobile mapping does not have RGB information, the information contained in the 3D point cloud will be XYZ

Linked use cases	UC1.1 (that will use the information from this UC)
Importance	High

4.4. Technical use cases for SE3

Table 19. Use case 3.1 related to SE3 Building Environment Climate Scenarios

Use case	**UC3.1 – Assessment of energy demand and consumption**	
Related user requirements	**Functional**	RQ01, RQ02, RQ03, RQ08, RQ09.
	Non-functional	RQ46, RQ48, RQ49, RQ50, RQ51, RQ52, RQ53
Description	This use case corresponds to the calculation and estimation of the energy demand and consumption of the building stock, based on buildings' data (year of construction, geometry, height, use/typology, and other characteristics). It will also calculate the energy demand and consumption in the future according to different climate change scenarios: standard accepted CMIP6 scenarios (SSPs and RCPs) through the downscaling of climate data and their bias-correction with historical data from weather stations.	
Actors	Urban stakeholders (urban planners, real estate and construction companies, policy makers…)	
Inputs	Data inputs: on buildings' data (cadastral data, real consumption data…), historical weather data, future climate data (from models and scenarios), energy use profiles…	
Outputs	Tool to show the calculation and visualisation of energy demand and consumption data of the pilot building stock focused in residential (specially MFH) but other buildings use would be considered, such us public buildings. Assessment of the evolution of the energy demand and consumption in the future taking into account climate change scenarios.	
Preconditions	Data inputs are available. Data related to buildings is collected and categorised according to different building characteristics.	

	Building stock energy performance (energy demand and consumption) is calculated or estimated according to previous processed data and calibrated taking into account real consumption data. Standard CMIP6 scenarios (SSPs-RCPs) climate data are downscaled through bias-correction with historical climate data. Building stock energy performance is calculated according to climate scenarios with different time horizon: short term (in 3-6 years), medium term (in 20-30 years) and long term (year 2100).	
Normal sequence	**Step**	**Action**
	1	A map of the pilot area is shown and user defines the geographical area of interest (selection in the map).
	2	Precalculated (by default) building energy performance (energy demand and consumption) of building(s) of the area of interest will be shown based on colours on the map.
	3	User selects a future scenario (from several options precalculated) to compare how the energy demand of the building stock changes.
	4	The service combines the information of the current energy demand with the climate change scenario selected.
	5	The service provides comparable information (data and visualization) of the current and future (climate scenario selected) energy performance of the buildings.
Post conditions	Rating of energy performance estimation of pilot building stock. Rating of energy performance forecasting of pilot building stock in future scenarios (considering climate change).	
Exceptions	**Related step**	**Action**
	2.1	User can modify the parameters/characteristics of selected buildings by default (e.g. year of construction, energy systems, etc.)
Linked use cases	UC3.2 and UC3.3 need of this UC operative to be executed.	
Importance	High	

Table 20. Use case 3.2 related to SE3 Building Environment Climate Scenarios

Use case	**UC3.2 – Assessment of retrofitting strategies**	
Related user requirements	**Functional**	RQ04.
	Non-functional	RQ46, RQ48, RQ49, RQ50, RQ51, RQ52, RQ53.
Description	This use case corresponds to the calculation of KPIs to retrofitting strategy gains, based on retrofitting measures defined, as well as its modelling according to climate change scenarios in future. A specific retrofitting scenario will be covered using UC3.3 for the heating and cooling demand, through PV deployment.	
Actors	Urban stakeholders (urban planners, real estate and construction companies, policy makers…)	
Inputs	UC3.1 is executed. Data inputs: building retrofitting measures defined	
Outputs	Tool to show the changes in buildings energy demand and consumption with the application of different retrofitting measures. It shows also the change in future energy demand and consumption with the application of retrofitting strategies according to the climate change scenarios.	
Preconditions	UC3.1 and UC3.3 is available. Building retrofitting measures are defined.	
Normal sequence	**Step**	**Action**
	1	Defined area of interest in step 1 of UC3.1 is shown.
	2	User selects a package of retrofitting measures to apply to the building(s) from available list of predefined packages.
	3	The service combines the outcome information of the UC3.1 with that of the retrofitting measures selected, and provides the calculation of how the building(s) energy performance changes.

	4	The service provides comparable information (data and visualization) of the current and future (climate scenario selected) energy performance of the buildings (UC3.1) and with the application of retrofitting strategies.
Post conditions	KPIs on retrofitting gains are calculated to see how the energy demand and consumption of buildings changes after application of retrofitting measures. KPIs on retrofitting gains calculation for energy performance of buildings change in future scenarios (considering climate change).	
Linked use cases	UC3.1 needs to be executed previously so this UC can be executed. For some scenarios UC3.3 could be need	
Importance	Medium	

Table 21. Use case 3.3 related to SE3 Building Environment Climate Scenarios

Use case	**UC3.3 – Assessment of solar PV potential**	
Related user requirements	**Functional**	RQ11, RQ12, RQ13, RQ14.
	Non-functional	RQ46, RQ48, RQ49, RQ51, RQ53
Description	This use case corresponds to the estimation of solar radiation potential, on daily/hourly output, of available rooftop areas and, through a suitability analysis, calculates the rooftop PV installation potential. The general process is based on building footprint data and Digital Elevation Model of the area of interest.	
Actors	Urban stakeholders (urban planners, real estate and construction companies, municipalities, policy makers, citizens, tenants and owners, utilities, facility managers).	
Inputs	Digital Surface Model (DSM) of the area of interest and building footprint of AOI	
Outputs	Shapefile including suitable rooftops, solar radiation daily with potential 1-hour interval, potential PV energy production daily with potential 1-hour interval, MtCO2 per rooftop per year averred, payback period.	
Modules / External tools	ArcGIS Pro 3.1 by ESRI	
Preconditions	Building footprint and Digital Surface Model of 1m resolution file of the area of interest are available as open-source data of the Municipality of Riga, Latvia.	

Normal sequence	**Step**	**Action**
	1	Input data of Digital Elevation Model of the area
	2	Input building footprint to exclude other surfaces than rooftops from further analysis
	3	Combination of both inputs to the solar radiation tool, producing the solar radiation map of the available rooftops
	4	Performing suitability analysis excluding unsuitable rooftops from further analysis
Post conditions	Performance of available solar radiation of rooftops of building stocks. Performance of potential energy production of potential PV installations.	
Exceptions	**Related step**	**Action**
	1.1	In case we do not use the DSM file provided by Riga/Latvia, we will have to access DSM data of high accuracy via the Copernicus program
	2.1	In case we do not use the building footprint provided by Riga/Latvia, we will have to implement high accuracy raster images of the area of interest via the Copernicus program or drone flights and implement a deep learning tool to extract the rooftop area.
Linked use cases	It will be used as input for some retrofitting scenarios (UC3.2)	
Importance	Medium	

4.5. Technical Use Cases for SE4

Table 22. Use case 4.1 related to SE4 Urban Heat Analysis and Resilience

Use case	**UC4.1 – Urban heat risk analysis**	
Related user requirements	**Functional**	RQ24, RQ25, RQ27
	Non-functional	RQ48, RQ49, RQ51

Description	This use case corresponds to the calculation of the Urban Heat Risk (UHR) which is estimated by overlaying information on heat exposure and vulnerability. This will be calculated for the present and future climate scenarios from the IPCC report (SSPs-RCPs).	
Actors	• Citizens • Urban stakeholders • Public administration • Academia	
Inputs	Building´s footprint, urban heat exposure data, urban heat vulnerability data	
Outputs	A georeferenced map with the urban heat risk calculated for the selected area. Identification of urban heat hotspots. A tool will be available to make a comparison between different climate scenarios (present and future).	
Preconditions	Uploading the data with the calculated georeferenced maps and corresponding metadata	
Normal sequence	**Step**	**Action**
	1	An overall map is displayed in the web platform and the user selects the area of interest (either typing, zooming)
	2	In the selected area, the urban heat risk is visualized along with a colour palette associated with different levels of urban heat risk in the city.
	3	User can select different climate scenarios and compare them
	4	Comparison and information from the urban heat risk can be shared via hyperlinks on social networks. Also, a generic report with basic data can be generated.
Post conditions	Files compatible with GIS software available for downloading as well as a detailed and complete urban heat risk analysis report (for the paid version)	
Exceptions	**Related step**	**Action**
	2.1	If it is a paid user profile after selecting the area of interest, to access the payment features, the logger option will appear.

	3.1	User can select different climate scenarios and download georeferenced data and metadata available
Linked use cases	This use case is needed to execute UC4.2 and UC4.3	
Importance	High	

Table 23. Use case 4.2 related to SE4 Urban Heat Analysis and Resilience

Use case	**UC4.2 – Urban heat exposure**	
Related user requirements	**Functional**	RQ25, RQ27
	Non-functional	RQ48, RQ49, RQ51
Description	This use case is the calculation of the Urban Heat Exposure (UHE) based on the present and future climate scenarios and most importantly considering the effect of urban heat. Building characteristics are also considered, such as year of construction, energy performance, etc. The information is displayed in a map with a colour palette.	
Actors	• Public administrations • Academia • Private sector	
Inputs	UC4.1 is executed. Urban climate zones map, weather files for each urban climate zone and for different future climate scenarios.	
Outputs	Georeferenced map according to the selection of the user (e.g. present/future climate scenarios), this will update also the Urban Heat Risk map. Layer with building stock information. Hotspots with the most exposed areas to urban heat. Baseline indicator for building´s energy performance that can be compared with another layer with the same information but considering the impact of urban heat.	
Preconditions	The user must be logged in.	
Normal sequence	**Step**	**Action**
	1	Defined area of interest in step UC4.1 is shown

	2	User logs in with credentials
	3	User can select to display the Urban Heat Exposure map and compare different climate scenarios (e.g. future/present). A baseline indicator is shown with a colour palette which enables a comparison of the impact of urban heat on the cooling demand of the building stock.
Post conditions	Baseline indicator for the increase in cooling demand of buildings due to urban heat. Weather files available for downloading. Georeferenced map with hotspots within the city.	
Exceptions	**Related step**	**Action**
	3.1	User can select to display the urban climate zones from the area of interest
	3.2	By hovering the mouse over the urban climate zones, and clicking in one of them, the option to download climate files is activated
Linked use cases	UC4.2 is linked to UC4.1 and UC4.3	
Importance	High	

Table 24. Use case 4.3 related to SE4 Urban Heat Analysis and Resilience

Use case	**UC4.3 – Urban heat vulnerability**	
Related user requirements	**Functional**	RQ24
	Non-functional	RQ46, RQ48, RQ49, RQ51
Description	This use case is the calculation of the Urban Heat Vulnerability (UHV) based on demographic and socio-economic indicators. Also, it calculates the capacity to adapt depending on the possibilities for intervention in the city.	
Actors	• Public administrations • Academia • Private sector	
Inputs	UC4.1 is executed.	

	Socio-economic and demographic layer indicators, proposal for adaptation and mitigation measures.	
Outputs	Georeferenced map with the Urban Heat Vulnerability and hotspots identifying the most vulnerable areas within the city, information obtained from the indicators used and comparison results, recommendations for adaptation and mitigation measures that can be implemented in the hotspots.	
Preconditions	UC4.1 is available	
Normal sequence	**Step**	**Action**
	1	Defined area of interest in step UC4.1 is shown
	2	User logs in with credentials.
	3	User can select to display the Urban Heat Vulnerability map and compare different climate scenarios (e.g. future/present). In the same map, hotspots with the most vulnerable areas are shown.
	4	Through the interface user can select different indicators and display a series of graphs to allow comparison between different areas of the city.
	5	By hovering the mouse over the identified hotspots, information about adaptation and mitigation measures will pop up.
Post conditions	Baseline for the vulnerability indicator. Georeferenced map with hotspots within the city.	
Linked use Cases	UC4.1 is executed first. This use case is linked also with the UC4.2 since depending on climate scenarios, vulnerability hotspots may vary.	
Importance	High	

4.6. Technical use cases for SE5

Table 25. Use case 5.1 related to SE5 Urban Flood Analysis and Resilience

Use case	**UC5.1 – Flood damage hotspots**	
	Functional	RQ29, RQ31, RQ32, RQ33, RQ34, RG35.

Related user requirements	**Non-functional**	RQ46, RQ47, RQ48, RQ49, RQ50, RQ51, RQ52, RQ53
Description	This use case is the calculation expected flood damage for buildings due to fluvial floods with online application-based visualisations. The damage per building or building plot will be assessed by FDAM methodology by overlying flooding map, calculated terrestrial altitude and georeferenced users' inputs. This will be visualised for different rainfall scenarios.	
Actors	Civil protection, infrastructure providers and public authorities, urban water managers, real estate and construction companies, landowners and building owners and citizens, insurances	
Inputs	• Buildings and consolidated cadastre of public infrastructure, flood maps, flood damage values, current land use, planned land use, registry of spatial units • Floods extend	
Outputs	Expected flood damage per building or building plot for the selected area on a georeferenced map. A tool will be available to make a comparison between different rainfall scenarios.	
Modules / External tools	Calculated terrestrial altitude from LIDAR	
Preconditions	Uploading the data with the calculated georeferenced maps and corresponding metadata. The user must be logged in to access the reporting features.	
Normal sequence	**Step**	**Action**
	1	An overall map is displayed in the web platform and the user can select the Flood Damage Analysis Module.
	2	The flood damage hotspots map of all pilot area is displayed; the expected annual flood damage hotspots are visualized in red colour scale according to the value of flood damage.
	3	The user can select the area of interest either by uploading own data (e.g. shapefile or geojson) or to draw it directly in the application by a drawing tool.
	4	On the map appears the building stock with data result from model calculations with attributes to selected buildings.

	5	Scenarios menu appears. User can select different flood scenarios (Q10, Q50, Q100, Q500, depth at Q100) and adaptation by non-structural measures scenarios (e.g., buildings without basements, buildings with non-living basements, non-living ground floor), and compare them.
	6	A generic report with information and comparison about the expected annual flood damage can be generated.
Post conditions	Shapefile available for downloading as well as a detailed expected flood damage analysis report in PDF and table or graph can be generated.	
Exceptions	**Related step**	**Action**
	4.1	By hovering the mouse over the targeted buildings, and clicking in one of them, the option to download report file for this building is activated.
Linked use cases	Linked to UC5.2, but independent (not needed to be UC5.1 executed).	
Importance	High; failed execution of UC5.1 it wouldn't block the execution of a following step (UC5.2), but it is a key functionality for the service.	

Table 26. Use case 5.2 related to SE5 Urban Flood Analysis and Resilience

Use case	**UC5.2 – Blue-green infrastructure impact**	
Related user requirements	**Functional**	RQ38, RQ39, RQ40, RQ41, RQ42, RQ44, RQ45
	Non-functional	RQ46, RQ47, RQ48, RQ49, RQ50, RQ51, RQ52, RQ53
Description	This use case corresponds to assessment of the potential of BGI to impact flood vulnerability and resilience to promote BGI measures implementation on the building and neighbourhood level.	
Actors	• Infrastructure providers and public authorities • Potential investors, land developers, landowners and building owners • Urban planners, Urban water managers	
Inputs	Planned land use, Blue-green factor map, map of soil hydrological groups, weather (precipitation) data, NDVI map, catalogue of different BGI measures with condition instructions for building renovations	

Outputs	Runoff volumes hotspots and Blue-green factor per land use unit visualized on a georeferenced map, both with the application of some BGI measures, in the present and in different climate change scenarios. Both results can be compared with another area of interest.	
Preconditions	Uploading the data with the calculated georeferenced maps and corresponding metadata: • NDVI map from Sentinel 2 data, • Blue-green factor map from CLMS high resolution products (Imperviousness Grassland, Tree Cover Density, Small Woody Features), • Different climate change scenarios	
Normal sequence	**Step**	**Action**
	1	A standard (orthophoto) map appears in the web platform, showing the pilot area (Ljubljana metropolitan area) and the user chooses a topic layer "Flood vulnerability hotspots"
	2	By the selected topic, an interactive-colored is displayed with a green color scale according to the Blue-green factor, an assessment of the blue-green infrastructure implementation impact with attributes to building plots, as an indices of building flood resilience.
	3	The user selects the area of interest (either typing, zooming, by uploading own data, e.g., shapefile or geojson, drawing it directly in the application by a drawing tool)
	3	On the map appears the building stock with data result from model calculations with runoff volumes hotspots in blue colour scale according to the value of runoff volumes.
	4	If the user clicks on one building or area, there is shown a value of Blue-green factor and runoff visualisation diagrams (a runoff volume, precipitation high, runoff hydrogram).
	5	When the user has received the information, he can choose to compare certain information. There are three options for this: 1: Compare the statistics with another area. For this, the process from identifying an area of interest until receiving extra info about the area will need to be done again. 2: Select different measures: A list of possible measures will be present. A user can select a measure. If a measure has been selected, the model needs to be ran again to calculate the new results.

		3: Select different climate scenarios. Same as option 2, but with different climate scenarios. Also, for this option, the model will need to run again.
	6	User can input georeferenced photo or comments about existing BGI measures.
	7	A generic report with information and comparison about a value of Blue-green factor and runoff can be generated.
Post conditions	Shapefile available for downloading as well as a detailed flood resilience analysis report in PDF and table can be generated.	
Linked se cases	Linked to UC5.1, but independent (not needed to be UC5.2 executed).	
Importance	High; failed execution of UC5.2 it wouldn't block the execution of a following step (UC5.1), but it is a key functionality for the service.	

4.7. Feedback from the first co-creation session included in the use cases

As previously mentioned, the feedback received during the first co-creation session was relevant for the services' further definition and functionalities, especially for the elaboration of the use cases (included in the previous sections) for each service. In the following table an overview of the initially planned functionalities per use case and the added ones as input from the external stakeholders is presented.

Table 27. Main feedback from the 1st co-creation session considered for the use cases definition

SE	Use case	Challenges and pain points that will be addressed by the services	Feedback incorporated to service functionalities
SE1	**UC1.1** Digital Twin generation	▪ Schedule of construction project ▪ DT representation to show the context buildings ▪ Thermal bridge representation ▪ Provision of info for building's green energy production	▪ Geometric Digital Twin (GDT) visualisation with various data collection time stamp in VR/AR environment ▪ Geometric information is presented in object-based ▪ DT integrating with the ENGSS and images (RGB/Thermal) ▪ Potential of integrating DT to city scale platform/map

SE	Use case	Challenges and pain points that will be addressed by the services	Feedback incorporated to service functionalities
SE2	**UC2.1** Mostostal – Quality control of a new building	▪ Lack of trust data ▪ Monitoring of construction works	▪ Possibility of capturing information from all types of buildings using drones and SLAM ▪ Capture information during construction
	UC2.2 Piraeus – Intervention areas of a municipal building	▪ Lack of trust data ▪ There is no BIM data of buildings	▪ Data capturing with drone and SLAM ▪ A mesh with thermal information of the envelop is provided. In addition, critical areas will be marked on the model
SE3	**UC3.1** Assessment of energy demand and consumption	▪ Data availability ▪ Reliable data ▪ Calculation/estimation of the energy demand of building stock ▪ Calibrated models to be used to calculate energy demand of the whole building stock ▪ Energy consumption data is hardly available to make detailed predictions at city/building level ▪ Obtain building information ▪ Visualisation at multiple scales (building, district…)	▪ Possibility to see one building in detail ▪ Existing building energy consumption vs desired level of energy consumption ▪ Building characteristics to compare (and create a sort of competition for residents to be able to compare their building with their neighbours' buildings)
	UC3.2 Assessment of retrofitting strategies	▪ Create a catalogue on standard interventions to compare impacts	▪ Building characteristics to compare ▪ How the building can evolve – how it can be renovated ▪ Compare building types

SE	Use case	Challenges and pain points that will be addressed by the services	Feedback incorporated to service functionalities
	UC3.3 Assessment of solar PV potential	▪ Data availability ▪ Reliable data	▪ Possibility to see one building in detail ▪ Mapping suitable roofs for solar energy
SE4	**UC4.1** Urban heat risk analysis	▪ Use this information to plan blue-green infrastructure at city level ▪ Identification and visualisation of areas with high urban heat intensity and distribution ▪ Urban historical centres: more difficult to intervene in	▪ Propose solutions – e.g. more greenery, different materials, green roofs
	UC4.2 Urban heat exposure	▪ Availability of data on city/building level to make predictions and monitoring	▪ Identify hotspots ▪ Monitoring can be developed with the help of citizens and some easy-to-use application ▪ Gathering maps and weather data ▪ Identify hotspots ▪ Gathering maps and weather data
	UC4.3 Urban heat vulnerability	▪ Identification and visualisation of areas with high urban heat intensity and distribution ▪ Availability of data on city/building level to make predictions and monitoring ▪ Enabling urban heat analysis and calculation of social vulnerability to urban heat	
SE5	**UC5.1** Flood damage hotspots	▪ Data gathering, availability ▪ Many different stakeholders	▪ Depending on climate and measures scenarios ▪ Visualisations by maps & graphs

SE	Use case	Challenges and pain points that will be addressed by the services	Feedback incorporated to service functionalities
	UC5.2 Blue-green infrastructure impact	▪ Data gathering, availability ▪ Climate changes not under consideration ▪ Validated & simplified models ▪ Missing visualisations for decision making	▪ Evidence greenness of urban surfaces ▪ Depending on climate and measures scenarios ▪ Catalogue of standard measures to compare impacts ▪ Visualisations by maps & graphs

5. Co-design innovative user-friendly environments

In this section, the progress of task T2.4 Co-design innovative user-friendly environments will be explained. In Section 5.1, the followed methodology will be explained. This chapter focusses on the user flow definitions, the creation of the first wireframes and the feedback sessions that were held in during the physical consortium session held in Valladolid in M8. Section 5.2 focusses on the result in form of a wireframe guide.

5.1. Methodology

The goal of this task is to create a wireframing framework that is useful for all services. Each service will be developed separately by different partners and will have service-specific features. However, we want BUILDSPACE users that use multiple services to have a good and uniform user experience. Therefore, it is vital that all services have a similar design and UI so that user can easily navigate through all applications.

To make sure that a useful framework is designed, an iterative process was implemented where wireframes were created, and the feedback was gathered and processed before starting a new version of the wireframes. The final product is a wireframe guide to be used as guideline for all service developers.

5.1.1. User flow definitions

Before starting blindly with the wireframes and mock-ups, it was important to get a better idea of the functionalities that will be offered in the different services. Which ones are common and which ones are specific for certain services? To learn more about this, sessions were organised with all relevant and involved partners to discuss about the services in detail. The goal of these sessions was to create a user flow for each application. A user flow describes the different steps a user has to take to reach a certain goal and is visualised by a theoretical example in Figure 24.

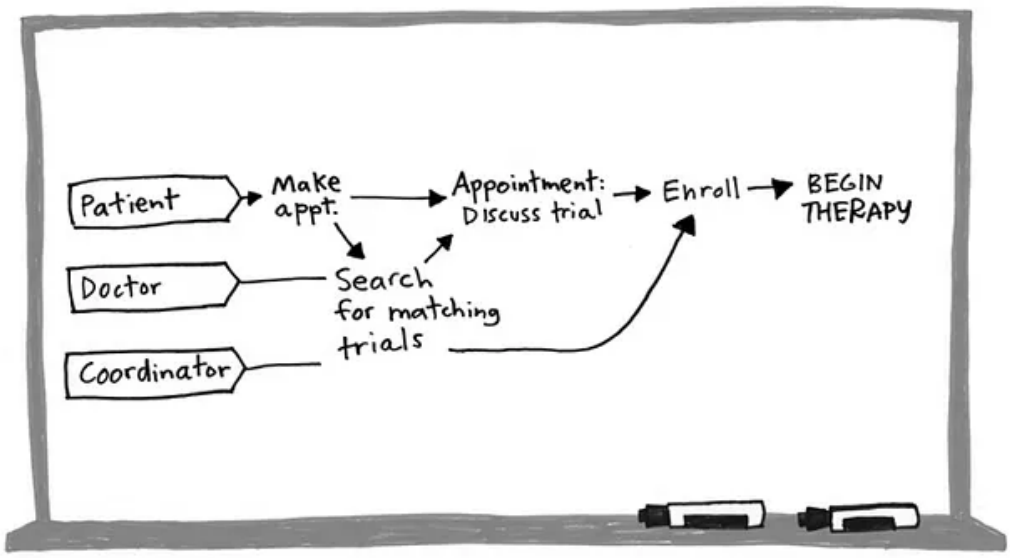

Figure 24. Example of a user flow (Jake Knapp, 2016)

To create a user flow, the starting point is to list the target users for each service on the left side of the diagram. In the next step, it is thought why the user would want to use the BUILDSPACE service? And what does the user ultimately want to accomplish by using it? Finally, the steps in between are filled in to go from the start point to the end point, trying to limit this to a maximum of 10 high level steps. This exercise was done by organising individual calls per service where both service developers and relevant pilots were present. An open discussion followed, and the user flows were designed in consensus between participants.

Below an explanation of the user flows for each service can be found. A better resolution of the images have been added in the annex in Figure 56 to Figure 59. The user flow exercise helped also the service developers to better define and organise their respective services. It is important to note that the flows depicted here a first version, designed under the process explained above, and are subject to changes.

5.1.1.1. Service 1 & 2

The user flow of Service 1 and 2 is visualised in Figure 25 and more enlarged in the annex. It was decided to merge the discussions for Service 1 and 2 together as they will operate within the same application. The target users of service 1 and 2 are defined as **facility managers** and **construction companies & designers.**

Construction companies & designers need to know the current 3D situation to have an idea of the progress in the construction of a building. They will open a project file as the first step in the application

and choose a mode of operation: VR, AR or web application. They will be mainly interested in a specific phase of the construction process and may want to compare planned and completed tasks. Their goal would be to increase the efficiency in construction planning and management and assist during the warranty period of a construction project.

The flow of **facility managers** is very similar. They also need to know the current 3D situation but will focus on navigating the projects in 3D to extend the information they have on an asset.

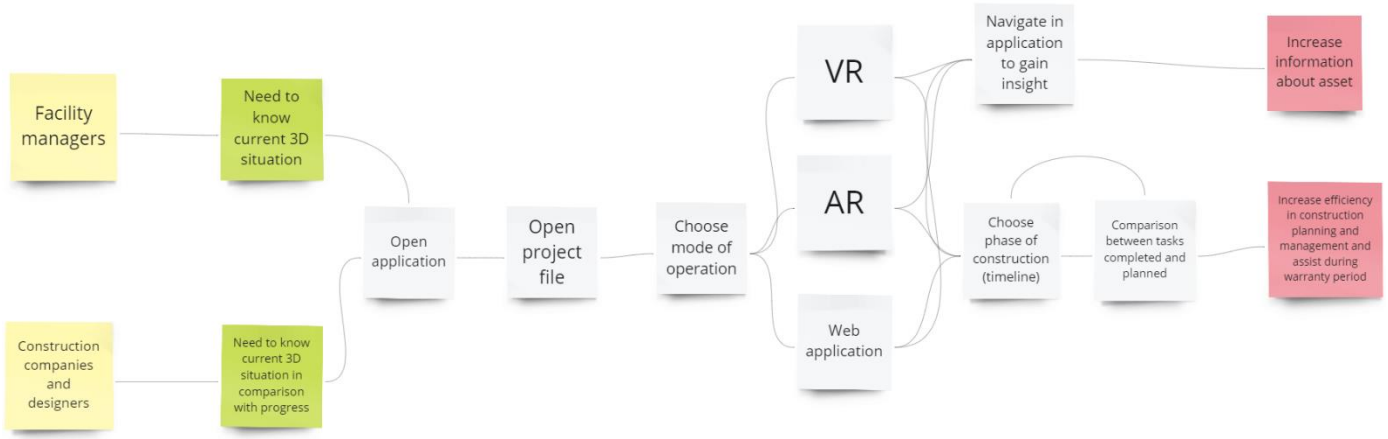

Figure 25. User flow for Service 1 & 2

5.1.1.2. Service 3

For the user flow of Service 3 (Figure 26), two main user groups were defined: **urban stakeholders** (urban planners, the real estate sector and policy makers) and **citizens & homeowners**.

Both user groups have the same starting point namely an interest in building energy performance, retrofitting scenarios and solar potential. They will be able to select a geographical area of interest and level of detail (city level, neighbourhood level, etc...). After that, they will see a map with baseline energy performance for the building(s) in the area. The user can compare energy performance with baseline values by selecting and comparing improvement measures (solar potential and renovations) or by comparing different climate scenarios. These settings can be saved and potentially even used in other services. The results can be exported to the user's device.

As a result, **urban stakeholders** can define building retrofitting and solar energy strategies and action plans to reduce CO2 emissions. **Citizens** can ask offers to renovating companies to reduce energy usage.

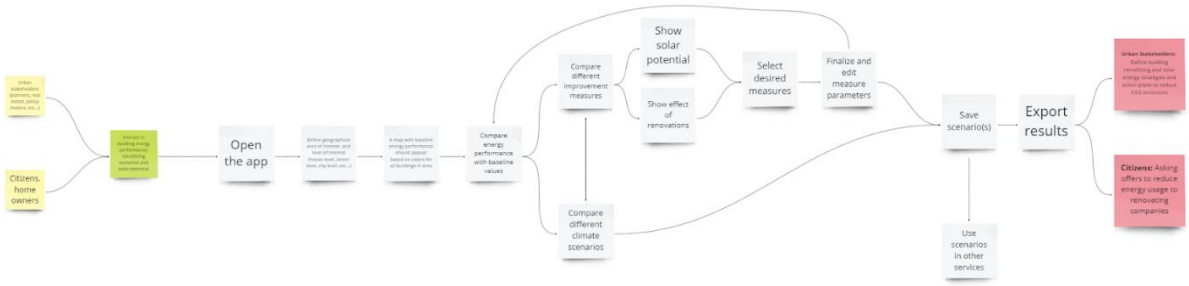

Figure 26. User flow for Service 3

5.1.1.3. Service 4

The user flow of Service 4 (Figure 27) shows three user groups: **the general public** (citizens), **advanced users** (academia, public administration, public sector) and **super-users** (access to all available input, e.g. pilot).

Out of curiosity for the theme of urban heat the **public (and advanced users)** can search for an area of interest in the app and explore the urban heat risk. They can compare the urban heat risk based on different climate scenarios. Afterwards they can generate a basic report or share the results via social networks through URLs. In the end, this will increase their understanding of urban heat risk.

Advanced users and **super users** on the other hand, will be looking also for specific information about urban heat. So, additionally, to the earlier mentioned features, they can compare two urban heat metrics: urban heat exposure and vulnerability. Urban heat exposure can vary by comparing different climate scenarios which will affect the urban heat risk. Urban heat risk hotspots are updated and possible measures to decrease the risk in the hotspots are proposed. Finally, users can generate a summary report or download the results (e.g. GIS data), and also metadata is available. By means of the urban heat exposure, it is also possible to define urban climate zones that can be used to create urban weather files. These contain more accurate weather information that can be downloaded and used in e.g. the other services. This way super users can execute a complete urban heat case study for a certain city.

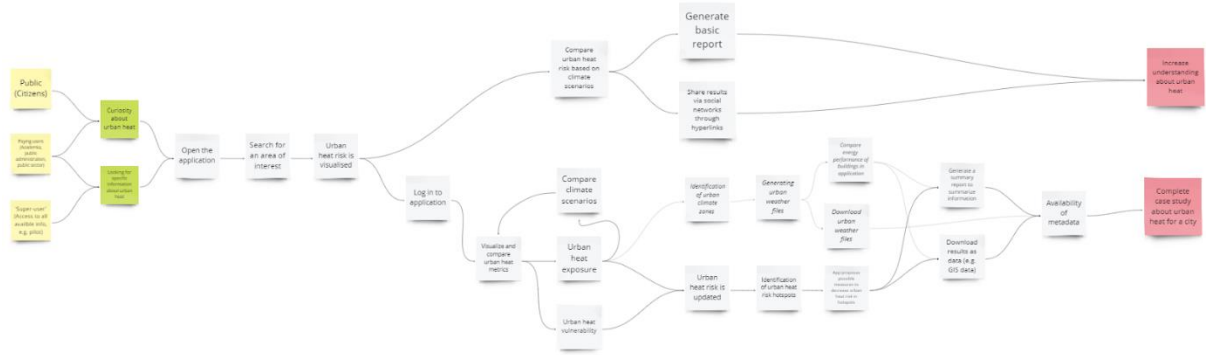

Figure 27. User flow for service 4

5.1.1.4. Service 5

Lastly, in the user flow exercise for Service 5 (Figure 28) two user groups were defined: **urban planners & policy makers** and **citizens, building owners & tenants.**

Citizens, building owners & tenants are curious about building flood damages, benefits and measures. In the Service 5 application they can explore the predefined flood damage areas. They can also identify an area of interest and receive extra information about flood damages. They can compare the results of different climate scenarios and different measures. Furthermore, they can select an additional area of interest to compare it with the first selection. All these results can be exported to start discussions and plan and implement measures to reduce flood damage.

Urban planners & policy makers are not only curious about but also interested in building flood damages, benefits and measures. They can not only visualise predefined flood damage areas but also import their own data (if they have more detailed data about predictions of future land use) and run the flood damage model. They can then use all the other features with the results from their custom data.

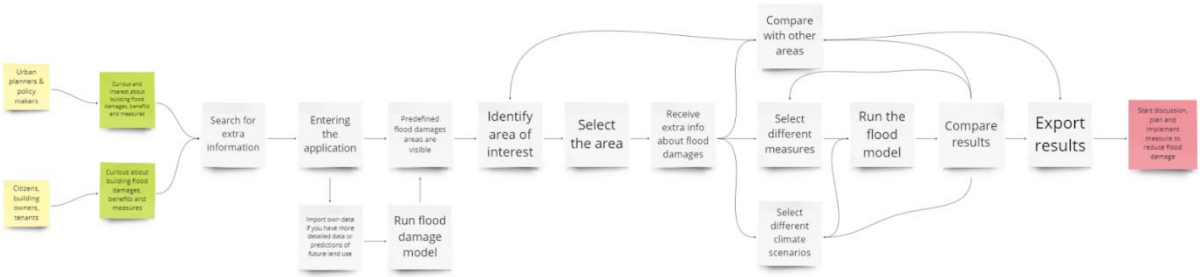

Figure 28. User flow for Service 5

5.1.2. Development of first wireframes

Wireframes are a black and white representation that make it easier to talk about ideas and visualise them without getting distracted by the design, colours and interactions. They are a draft version of the design that can be easily discarded and remade without wasting time. They are the perfect tool for the job at this phase in the project, as multiple iterations are needed and services will still have the opportunity to implement their own design and styling, within a common design framework.

The first input for the wireframes came from the first co-creation session with the stakeholders. During that session we discussed how we wanted to visualise different types of data in breakout rooms for the different sessions.

The map is an important part of the interface, as a lot of information has a spatial component. A section for displaying data on a graph or a table is also needed. Service 1 & 2 were a special case, since a lot of the information is going to be visualised in 3D, which is hard to visualise as a wireframe.

A second source of information are the user flows. Common elements in the flows that could act as building blocks for the user interface of the different services were looked for. A first list of interesting overlaps was created:

- Selection of area of interest
- Comparison of
    - Climate scenarios
    - Measures
    - Areas
- Export or share results
- Visualize layer on a map

Some common building blocks of user interfaces (with a map) were also added to that list:

- Background map
- Map tools (zoom, panning (moving the map with the mouse),...)
- Navigation
- BUILDSPACE background information
- Authentication/user profile

Inspiration and best practices for these design elements were looked for. In the next step, the first sketches and iterations on the designs were created to make sure to end up with robust design elements.

The first wireframes are focused on these common building blocks, and an example was also added for service 5 to make them a bit more concrete. To gather feedback by the partners on the first wireframes, a feedback session was organised during the next physical consortium meeting in Valladolid, Spain.

5.1.3. Feedback session Valladolid

The wireframes feedback session was organised by Nazka Mapps on the first day of the physical meeting in Valladolid on September 19 2023. The workshop was organised in a hybrid way to accommodate all partners, remote participants could follow via video call and give feedback on a digital whiteboard.

5.1.3.1. Workshop

The workshop was organised in the spirit of design critiques, using an adequate facilitation method to foster positive and constructive feedback (Gibbons, 2016). The workshop fosters co-creation by using post-its and a round robin approach with four “stations” (tables) to encourage collaboration. Each “station” consisted of three wireframe screens, post-it’s in four different colours and a grid to stick them on. The participants were divided into four groups, each starting at one of the stations. The members of each group were purposefully selected to have diverse backgrounds and services. Every 15 minutes the groups shift to the next station, until they have completed them all. Feedback was asked in four different categories:

- What did you like?
- What can we improve?
- Questions
- Ideas

The wireframes were shown with a minimal amount of explanation (only a title), to check what was clear at first glance and what was confusing. Furthermore, some extra common features were proposed in the wireframes to have a glimpse of the support for these ideas (as listed above). This way, the co-creation of a common framework for the interfaces of the services could be initiated.

The four stations and wireframes are listed below (the designs themselves are available in the annex):

- General station
    - Starting page
    - Select area
    - Service launcher
- Onboarding station
    - Landing page
    - Login page
    - User profile
- Compare station

    - Switch climate scenarios
    - Compare measures
    - Compare climate scenarios
- Example station
    - Service 5 map
    - Compare areas
    - Link to SE1&2

5.1.3.2. Results

After the feedback gathering, a discussion was moderated to go over the post-its and make sure all of them were clear. Participants could add more input and there was room for questions. This was followed by some final remarks and conclusions. This was done by inputting all feedback in a Miro board, to assure that partners that were not physically present could still participate. Below the gathered feedback is listed for each station briefly in Table 28 to Table 31.

General station

Table 28. Results feedback session Valladolid for the 'General station'

Feedback category	Feedback provided by partners
What we like…	• Combination of graphs and map • Possibility of multiple layers • Scale of Europe as starting point • Simplicity
What can be improved…	• Pilot locations should be marked on the map • Region opened on the map should be linked to service • Only show pilot countries
Questions	• Usefulness of service launcher • Which help info do we include? • Which info is presented in the lower panel? • Can we select an area freely? • Do we need the map button?
Ideas	• Add satellite image background layer • Add icons for each service to service launcher

	• Add a home tab • Could we have predefined areas? • Need for landing page

Onboarding station

Table 29. Results feedback session Valladolid for the 'Onboarding station'

Feedback category	Feedback provided by partners
What we like…	• Services “catalog” • Landing page • User profile + tabs • User friendliness
What can be improved…	• Elaborate on user profile editing • Need for GDPR information • Add language selector in user profile • Tabs should be moved to top of the screen • Service details instead of user details
Questions	• Who is the user? Partner or end user? • Are GDPR regulations covered? • What info to present on landing page vs user profile (services)? • Do we add different user roles? • Do users always need an account? Some things should be available without login?
Ideas	• Give users the possibility to connect with each other • Add easy navigation to BUILDSPACE website • Links to projects social media and websites • Bulletin board with brief description and demo videos • Translations • List of pilots instead of services • Limited access without signing in should be possible

Compare station

Table 30. Results feedback session Valladolid for the 'Compare station'

Feedback category	Feedback provided by partners
What we like…	• Both compare measures and scenarios • Compare scenarios is the easiest to understand • Map slider comparison
What can be improved…	• Slider also for comparison of measures • Clarify export, share, … buttons • Compare and switch scenarios could be combined
Questions	• What happens (to the slider) if you select more than two scenarios? • What does the measure “bar” indicate?
Ideas	• In general add more description of the different sections (info buttons) • Measures should not be separate of scenarios, users should first select a scenario and then a measure • Add tooltips • Collapsible right panel for graphs

Example station

Table 31. Results feedback session Valladolid for the 'Example station'

Feedback category	Feedback provided by partners
What we like…	• Clear and simple • Graph comparison • Compare areas and plots is clear and intuitive • Clear how you can select 3D building view
What can be improved…	• Make building 3D points more clear • Integrate two comparison graphs in one graph • Make scenario/measure selection menu collapsible • Integrate export, share,… in one button with dropdown • Make it more clear where the two areas are located • Where do we use radio buttons and where do we use checkboxes?

Questions	• What does the map button do? • How do we change the base map layer? • Only show pilot area service 5 on the map? • Can we compare between more than two areas? • Link between city services and building services relevant? • No screens about Digital Twin without a map? • Can users import their own datasets and indicators? • Can datasets be exported?
Ideas	• Automatically focus the map on the area the user is located (country level?) • Make more space for the map with smaller panels • Visualise 3D building before and after flood damages • Zoom in to building and change to building view on the map • Use radio buttons in layer panel if only one layer can be selected

The wireframes and pictures of the results of the post-it exercise can be found in the annex.

5.2. Wireframe guide

5.2.1. Methodology and second version of wireframes

The feedback that was gathered during the workshop in Valladolid, was processed and used to make a second version of the wireframes. It was decided to focus more on individual elements and less on complete screens as was done in the first round of wireframing. The screens that were created for the 'Onboarding station', as well as the feedback gathered, were transferred to SLG as leaders for task 3.1 BUILDSPACE Core platform implementation, as those screens were more related to the core platform and less to the services.

After creating the second version of the wireframes, all partners were asked to provide some last feedback. The wireframe elements were placed in a Miro-board with some explanation. Each partner was free to provide feedback via post-its. This feedback was processed for a last time to create a final version.

In order for all service developers to correctly use the wireframes, it was decided to construct a wireframe guide. This guide shows all wireframes and explains what is in them and why certain decisions have been made. This way, the services can be developed as much as possible in the framework provided in the wireframe guide.

In the guide, only wireframes are used and not mock-ups. The wireframe guide will be updated with some styling and style elements. However, it has been decided to not include this in the deliverable as there is still need for discussion to decide what kind of style elements would be useful for service developers. Although there are mutual elements, all services do differ substantially, and this raises the question if it is useful to create a detailed style guide as well or to limit it to some style suggestions.

5.2.2. General map

5.2.2.1. General layout of the map

The wireframe in Figure 29 shows the general layout of the application. All applications, with the exception of service 1 & 2, are map-focussed. Therefore, the map should be the most prevalent item. The map can be automatically positioned and zoomed to the most desired location. On top, a navigation bar is present. The map has several necessary elements. In the top right corner, the map controls are present. On the left top, a search bar can be incorporated. Underneath the search bar, a layer panel or selector is needed. Each map should have a scale bar on the bottom left corner. In the right bottom corner, there is room for controls related to area selection. If a legend would be visible on the map (depending on the selection of layers), the area selection tools can move to the left to fit in the legend.

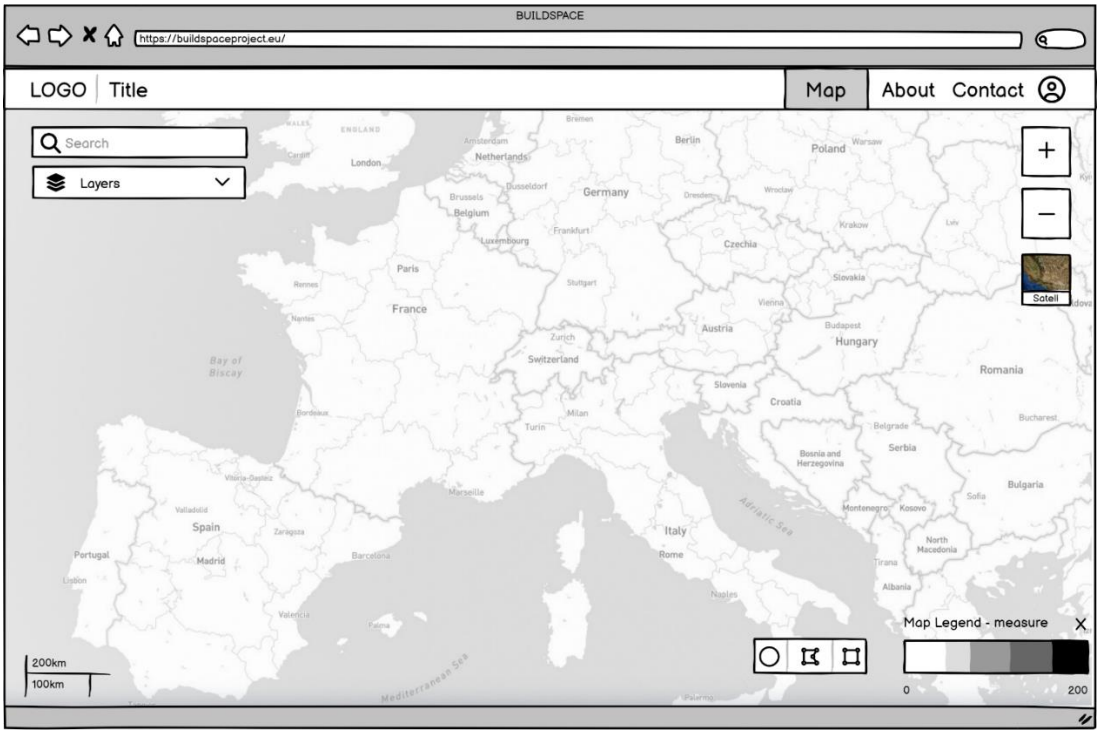

Figure 29. Wireframes: General layout of the map

5.2.2.2. Zoom buttons and background selector

Figure 30 shows the zoom and background buttons. The zoom buttons have a very simple design. The buttons should be a square and show a plus-symbol for zooming in and a minus-symbol for zooming out. The zooming in button should be placed above the zooming out button. Zooming can also be made possible by scrolling.

If it is useful for the service to change the standard background layer of the map, a background selector could be placed below the zooming controls. The button should show a preview of the possible background. If only one alternative is present, a user can just click the button and the background changes. At the same time, the preview in the button should change to the other, at that moment not selected, alternative.

If more than one alternative exists, the button can open to the left as shown in the wireframe. All options can be shown in one row and can be named. If more than three options are available, a second row might be necessary. It is not advised to create more than two rows. Each option should show a preview in the button. When clicking on one of the options, the background is selected, and the menu closes again.

An info button could be added if more explanation is needed for the end users. Hoovering the info button can open a tooltip with some explanation. Clicking the info button can redirect the user to an external website or to an about page with more information.

Figure 30. Wireframes: Zoom buttons and background selector

5.2.2.3. Legend

As legends can be very layer-specific, they can be designed and developed to own interpretation. As shown in Figure 31, It is important though to create clear labels. A legend should be made closable by an 'X' in the top right corner. The legend will then disappear and transform into a small clickable box that shows the word 'Legend' and has an upwards facing arrow next to the name. When a user clicks the box or the arrow, the legend can slide open.

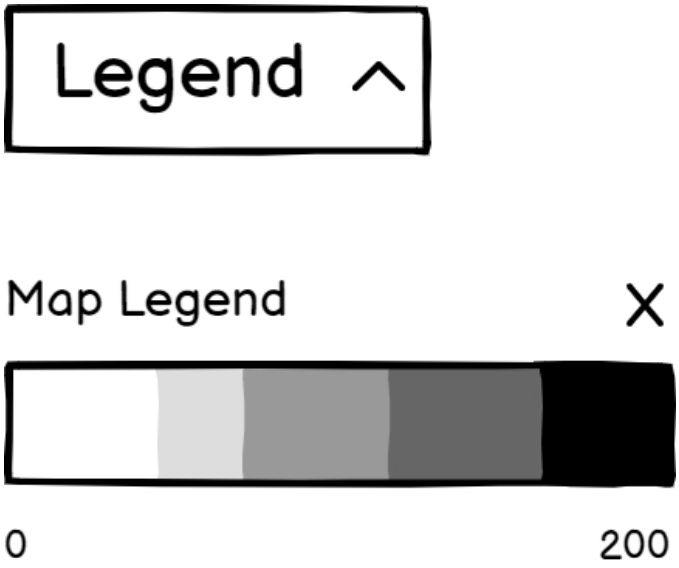

Figure 31. Wireframes: Legend

5.2.2.4. Layer selector

The layer selector (Figure 32) is downwards collapsible by clicking the arrow on the right. When the layer selector is collapsed, the arrow faces upwards instead of downwards. When a user clicks this arrow, the selector closes again. A standard layer symbol (the three stacked squares) can be placed in the left corner.

Layers are service-specific. Layers can be grouped if needed if multiple layers have a common characteristic. There are two types of possible selections: toggle buttons or radio buttons. With toggle buttons, the user can select multiple layers at once, with radio buttons, only one can be chosen, and the user has to pick one of the options. Both options can be combined in a layer selector, although it is advised to keep consistency within grouped layers. Hovering over info buttons can open a pop-up with extra information or redirect to the about page. If the number of layers is large, a scroll bar can be added.

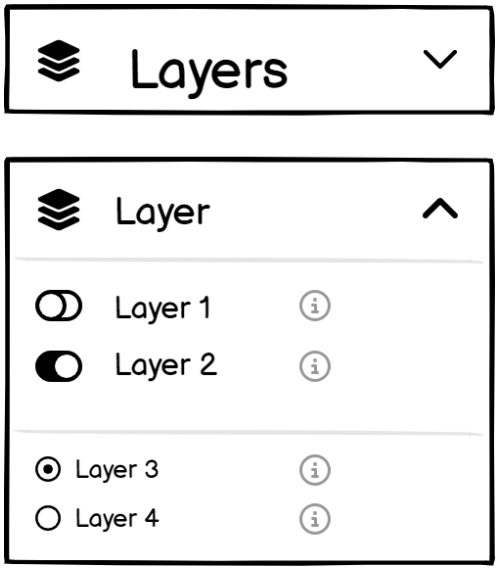

Figure 32. Wireframes: Layer selector

5.2.2.5. Search component

The search bar can be used to search for both addresses (e.g. via Google API) or in datafiles. The search bar should be a text box with the word 'Search' in it and a magnifying glass next to it. When a user starts typing, results should automatically appear. It is suggested that at least three characters are required as input before providing search results. This way, a user gets more relevant results, and this also limits the number of needed API calls. A user can click the X-icon to delete their input. It is also suggested to limit the number of shown search results to three, but a scroll bar could be added if you want to visualise more results.

For search addresses (left side of Figure 33), the Google API is recommended. This API allows a user to search not only on addresses but also on POI's.

If searching in datafiles is possible (example on the right of Figure 33), the data source or type should be mentioned next to it. This way a user gets all required information.

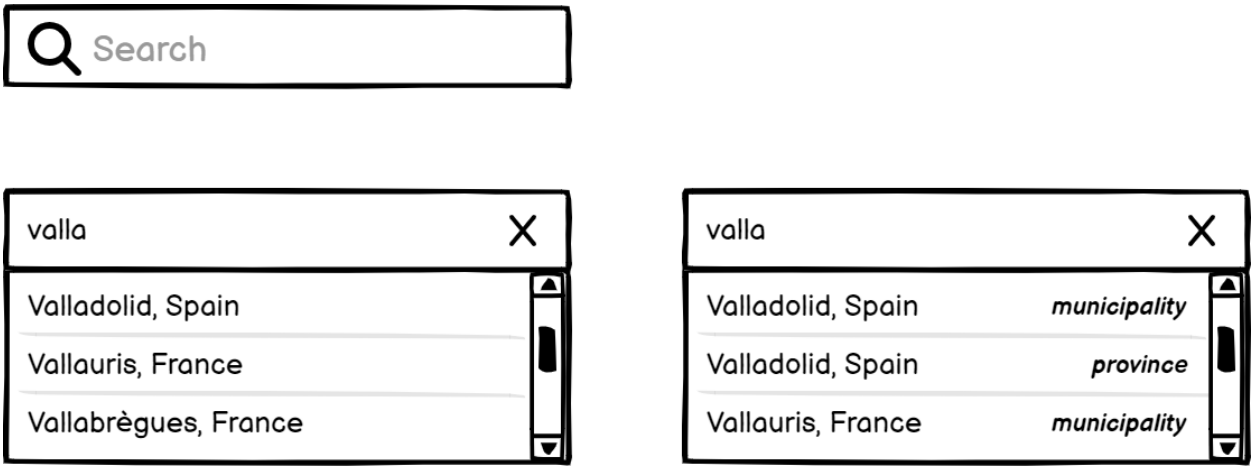

Figure 33. Wireframes: Search component

5.2.2.6. Selecting an area of interest

Selecting an area of interest on the map is done by using the area controls (Figure 34). They are grouped in a box and consist of the three possible methods. A user can select an area by drawing a radius, a rectangle or draw a free hand drawing. When hoovering over one of the options, a small tooltip should appear that explains the user what drawing option he is about to select. When an option is selected, the user will go into drawing mode immediately and the button will have a darker colour to show the user which option has been selected. The drawings should all be semi-transparent to ensure that a user can still see the map below the drawing.

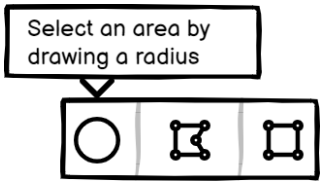

Figure 34. Wireframes: Controls for selecting an area of interest

To use a radius to select an area of interest, the user needs to click on the map to select a centre point for the circle. Then the user can move the pointer and the circle appears. The location of the pointer is the circumference of the circle. When the user is pleased with the radius, they can click again and the circle locks into position. This process is visualized in Figure 35.

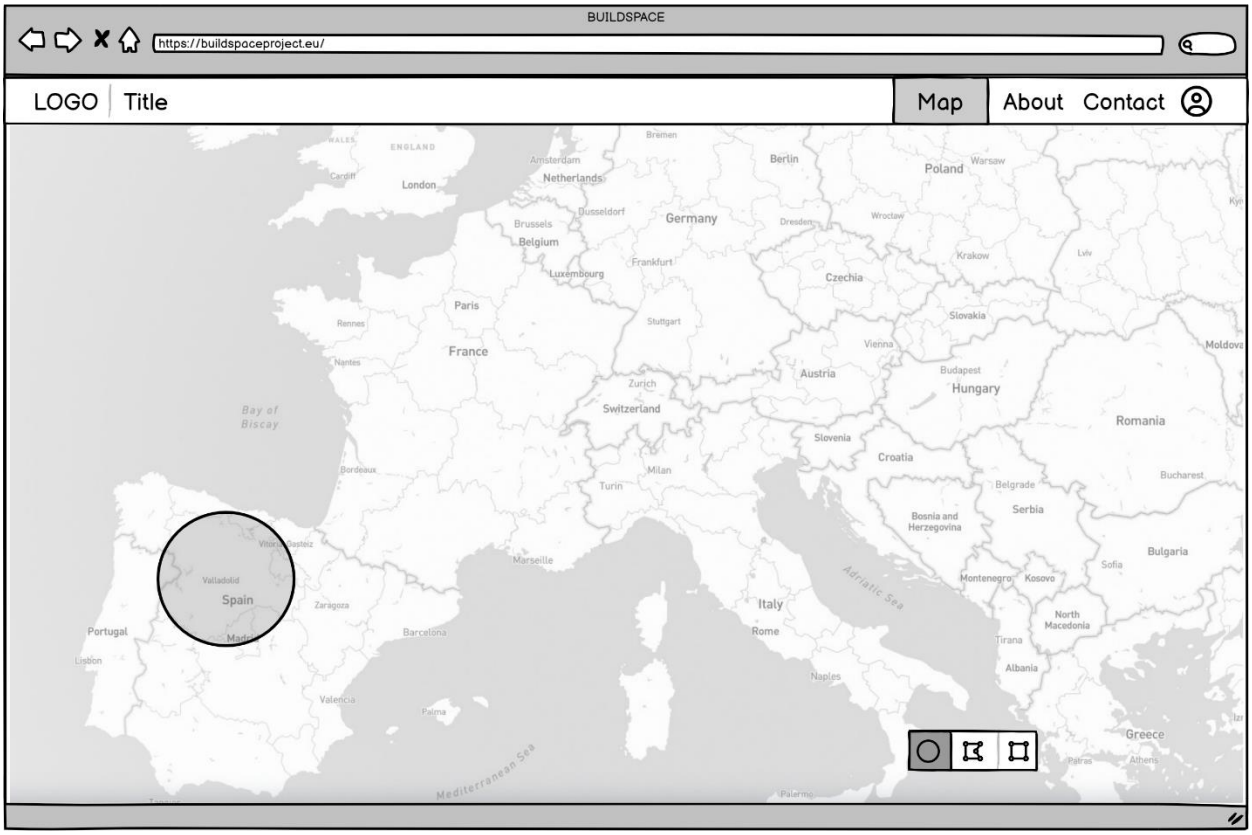

Figure 35. Wireframes: Using a circle to select an area of interest

When a user wants to use a rectangle to select an area of interest, they first need to click on the map to lock in the first vertex. Similar to the radius, when the user moves the pointer, the rectangle appears. The point will be the opposite vertex of the already locked in vertex on the map. When the user is pleased, they can click on the map and the opposite vertex is also locked in. This process is visualized in Figure 36.

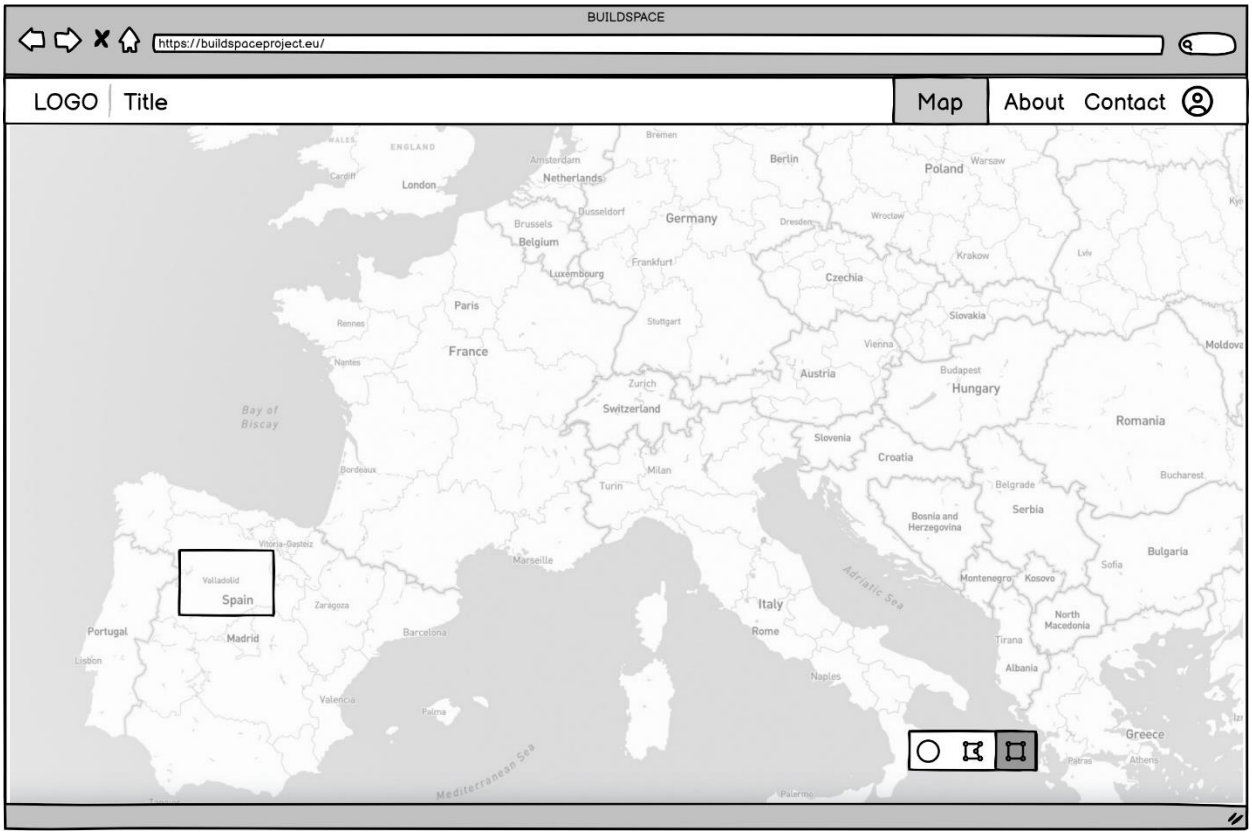

Figure 36. Wireframes: Using a rectangle to select an area of interest

Lastly, a user can make a free drawing if a regular shape is not sufficient to select an area of interest. A user can click on the map to set a vertex. When two vertices are set, a line will appear, starting from three vertices, a shape will appear. A user can put as many vertices as necessary. When the user is pleased, they can end the drawing and exit the drawing mode by either clicking the first vertex again or by using the ESC-button on their device. This process is visualized in Figure 37.

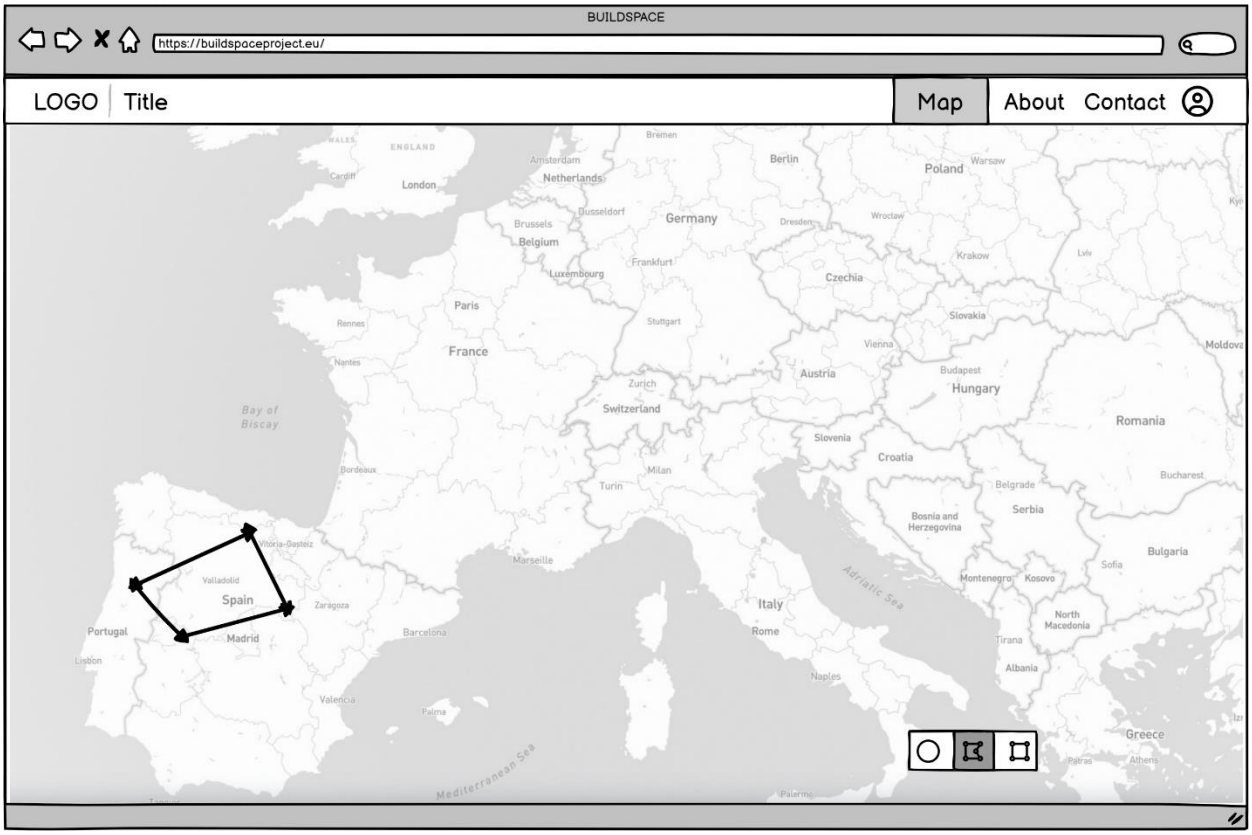

Figure 37. Wireframes: Using a free drawing to select an area of interest

5.2.2.7. Toast messages

There are three options for toast messages (Figure 38), each with their own symbol: Information, Success or Warning/Fail. Messages can be for anything and can be chosen by the service developers, examples are made for a data export. Messages should pop up in the bottom right corner and can be closed by clicking the cross.

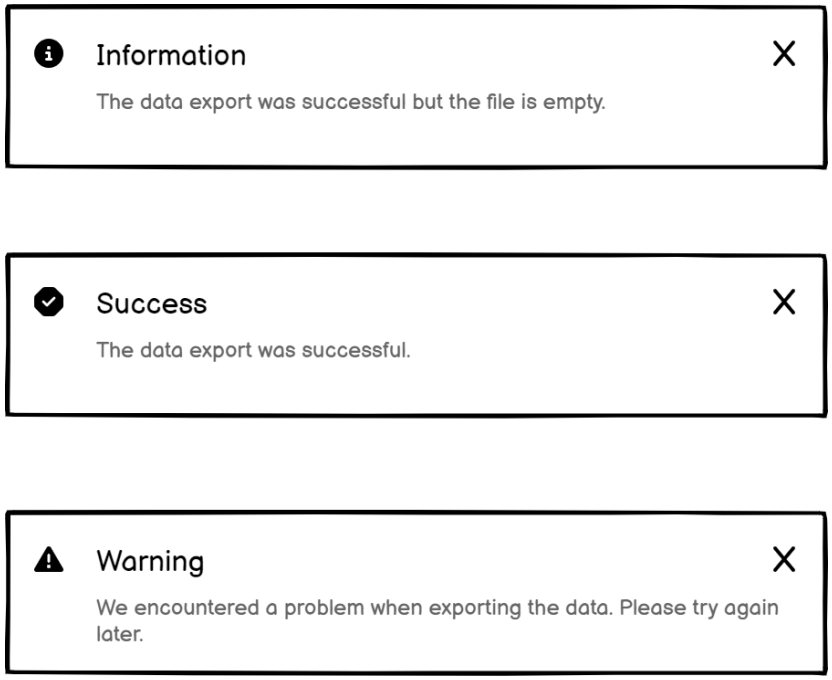

Figure 38. Wireframes: Toast messages

5.2.3. Data panels

For the data panels, it was opted to have two versions. One where the data panel is more horizontal and located at the bottom of the screen and one where the panel is vertical and located on the side. The wireframes show the panel at the left, but this can also be located at the right. The map controls should move aside, and the map needs to rescale when the panel opens. It is recommended the horizontal design, but depending on the data used in the service, a vertical design might be more applicable.

5.2.3.1. Standard data panel

This panel will be used when the user has selected an area of interest. It will open with relevant information. The content of the panel will be service specific.

When a user selected an area or a feature and information needs to be shown, the information panel can open from below for the horizontal orientation (Figure 39). The map is still shown at the top. The bottom panel has some general information on the left. This can be any attributes that are needed. On the right, there is room for graphs or tables. Each graph should have a clear title and axis names. The three dots next to the graphs can be used to give the user some control on what is visualised in the graphs. There is room for controls on the top right such as export, save and share. On the top left, there are controls to

start a comparison of scenarios or areas. The panel is closable by clicking the downwards facing arrow. The panel could also be made scalable or scrollable if more space is needed.

The logic is the same for the vertical design (Figure 40). Here the general attributes are on top, and the graphs are located below. The compare buttons are still on top, but the extra controls are now located at the bottom and use symbols instead of text. The panel is closable by clicking the arrow. This design is more appropriate when a lot of information needs to be shown in the side panel and the role of the map is less important.

Figure 39. Wireframes: Standard data panel in horizontal orientation

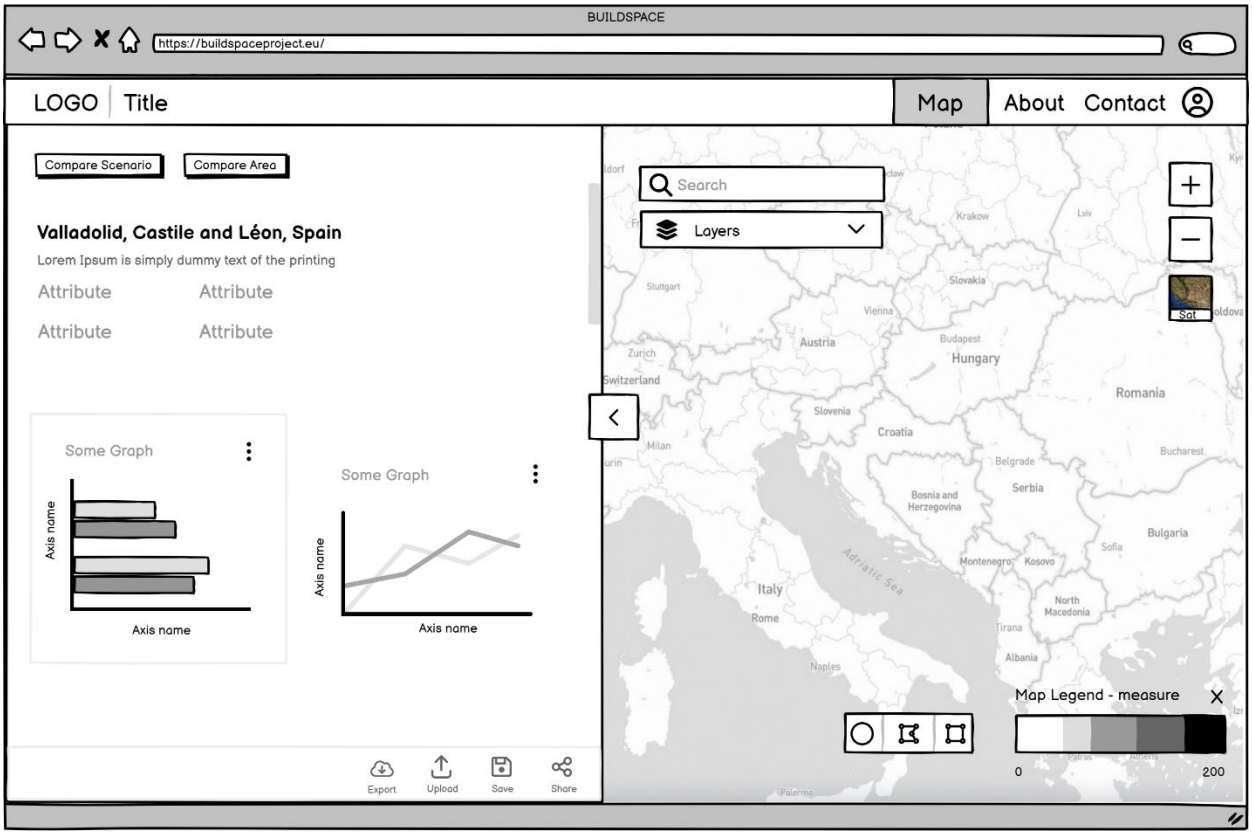

Figure 40. Wireframes: Standard data panel in vertical position

5.2.3.2. Starting a climate scenario comparison

The wireframe in Figure 41 shows how a user can activate the comparison mode to compare climate scenarios and possible measures. The wireframe shows the horizontal version, but the vertical version is identical.

When the user clicks the 'Compare scenarios' button, a pop-up opens. In this pop-up, the user needs to select two scenarios. A scenario can consist of two parts. The first are predefined climate change scenarios such as the IPCC-scenarios. They can be selected by using a drop-down menu. If it is applicable, the application can give the user the possibility to also add measures that have an effect on the chosen climate scenario. The user needs to do this two times to be able to start a comparison. If a user already had to select a climate scenario and/or measures in a previous step (e.g. via the layer panel), the first scenario could be filled in standardly based on the previous selection.

The panel is closable by using the X-symbol. This will cancel the comparison and the user exits the comparison mode. Info buttons can open tooltips when hoovered if that would be needed. A user can

then reset their selection or continue by clicking ‘Run model’. If running a model would not be necessary, this button can be replaced by an ‘Execute’ button.

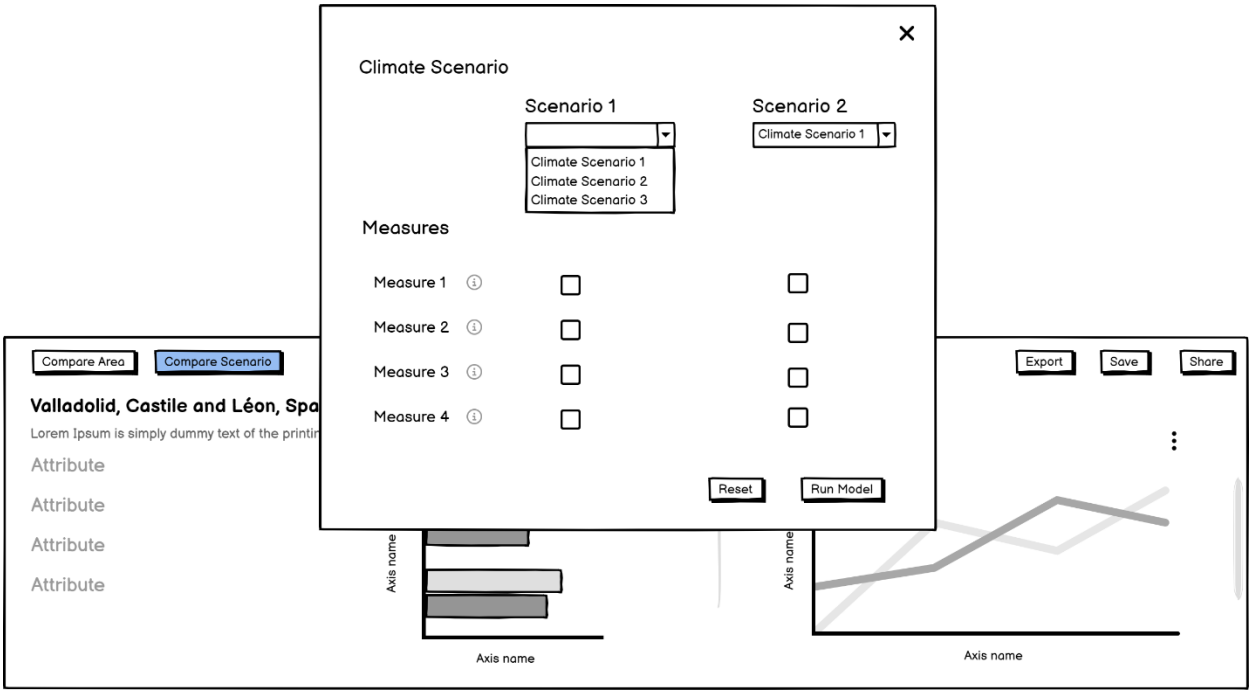

Figure 41. Wireframes: Starting a climate scenario comparison

5.2.3.3. Comparing climate scenarios

When the user has clicked the ‘Run model’ or ‘Execute’ button, the comparison will be visualised in the application and the data panel will change. The visualisation is similar for the horizontal (Figure 42) and vertical orientation (Figure 43). There is a box which shows the selected comparison. It shows a legend and gives a show summary of the selected climate scenario and measures. There is a pencil-symbol on top that will give the user the possibility to edit the parameters entered for the comparison. This will open the pop-up from the previous screen again. By clicking the X-symbol, the user will delete one of the comparisons. This will cause the user to exit the comparison mode and the remaining scenario will be the selected scenario. A user can also decide to cancel the visualization on the map if needed.

Next to (horizontal) or below (vertical) the information box, there is room for graphs, tables and data to compare the two scenarios. This can be filled in depending on the needs for each service. A user can also choose to click the button that says: ‘Cancel scenario comparison’. This will cause the user to exit the comparison mode and return to the previous screen.

On the map, it is suggested the use of a map slider if there are different visualisations possible on the map. The map slider can be dragged left to right to show the differences. Each visualisation should have a distinct colour that returns in the comparison scenario box.

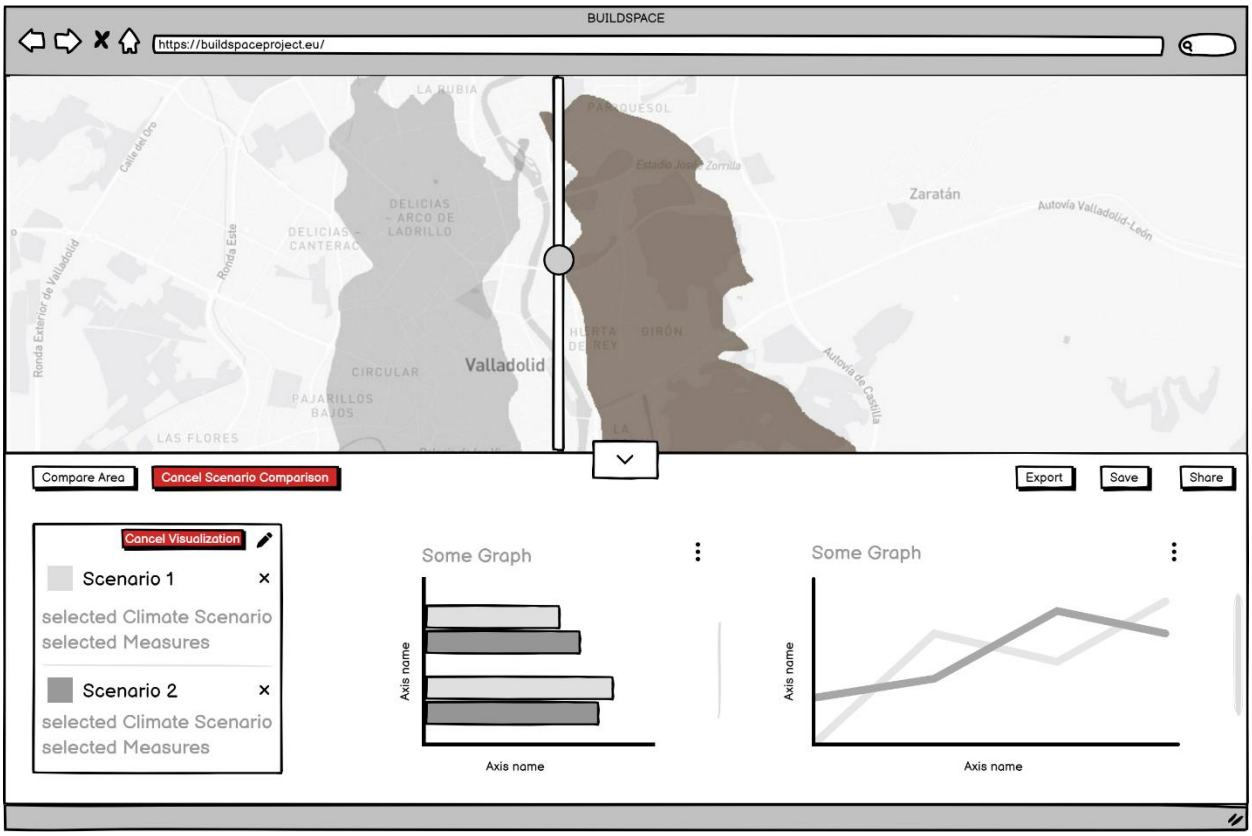

Figure 42. Wireframes: Comparing climate scenarios in horizontal orientation

Figure 43. Wireframes: Comparing climate scenarios in vertical orientation

5.2.3.4. Comparing areas

When a user clicks the 'Compare area' button in the data panel, the panel closes, and the user is forced to draw a new area (Figure 44). This can be done by using the standard drawing tools. When the user has finished their drawing, a comparison can be made between the original area of interest and the new drawn area.

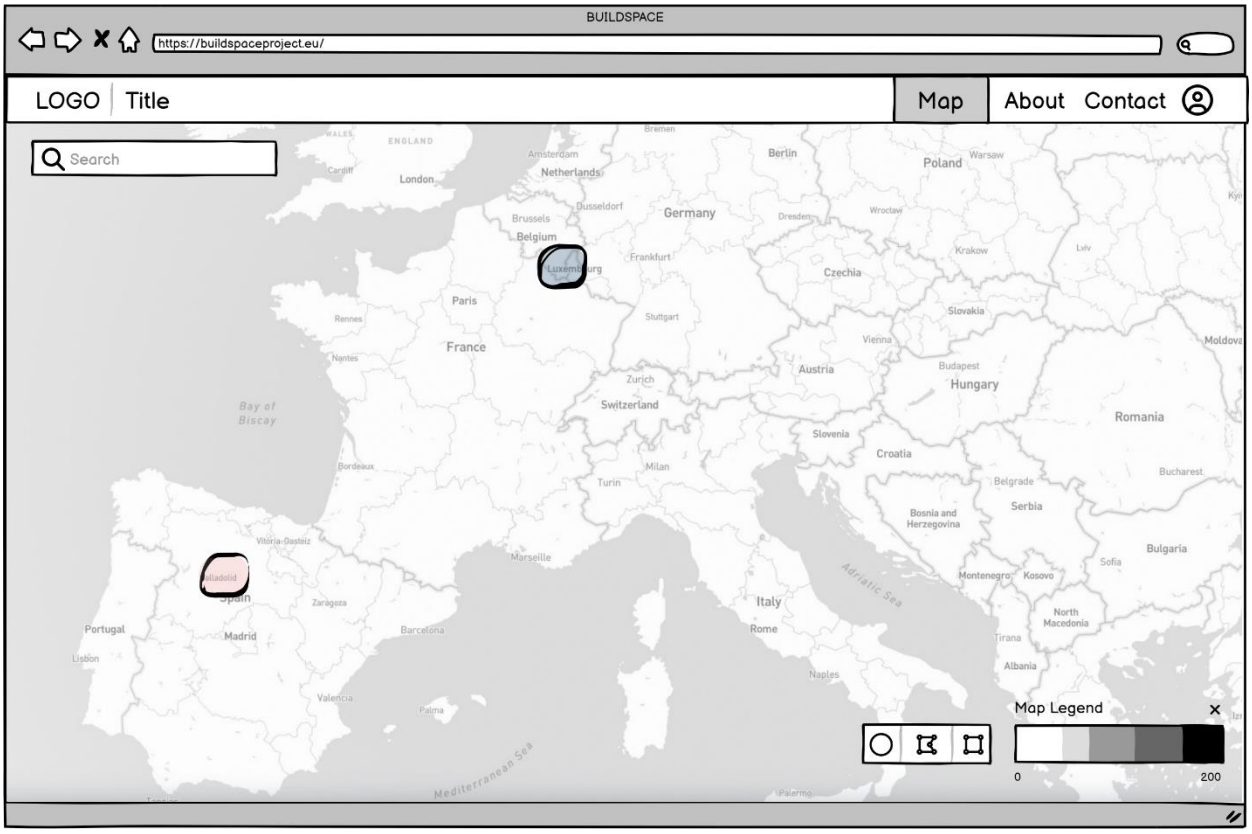

Figure 44. Wireframes: Starting an area comparison

The data panel will have a similar look than the scenario comparison panel, as can be seen in Figure 45 and Figure 46. On the right (or top in the vertical orientation), the user can find an information box with the two areas and some information. The name of the areas could be given a name based on their geolocation. Next to the box, there is room for tables, graphs and attributes. This can be filled in by the services. A user can cancel the comparison by clicking the 'Cancel area comparison' button. This will let the user to exit the comparison mode and return to the previous page. A user can delete an area by clicking the X next to it. This will delete the area and let the user to continue working with the remaining area.

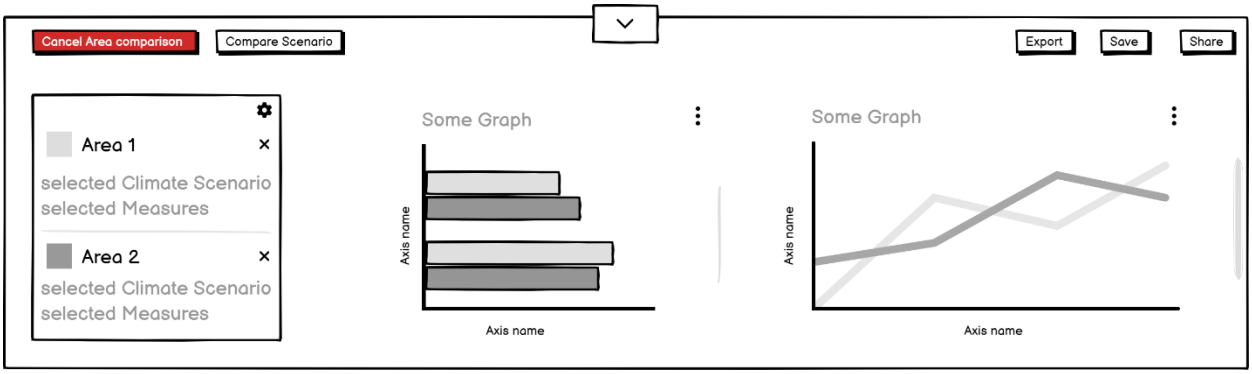

Figure 45. Wireframes: Data panel to compare areas in horizontal orientation

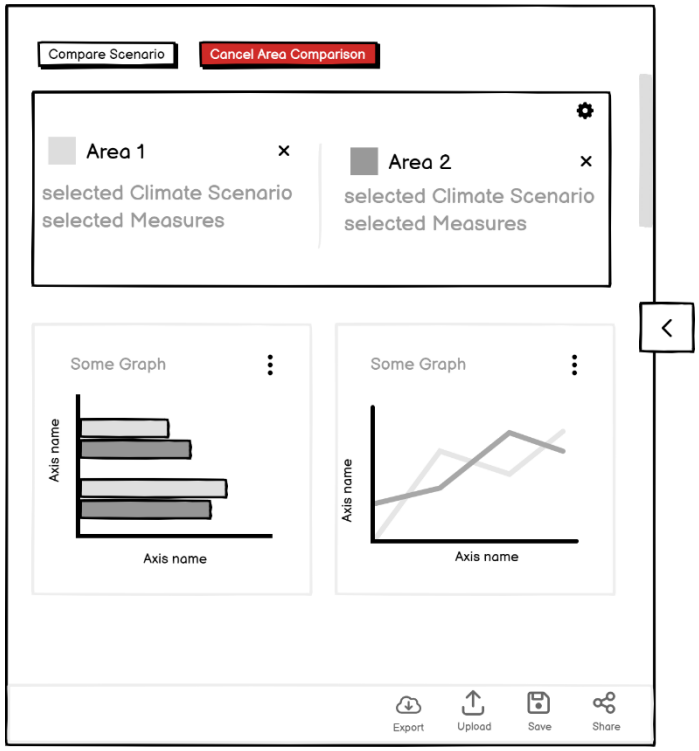

Figure 46. Wireframes: Data panel when comparing areas in vertical orientation

The area comparison box has a little settings symbol in the top right corner. This can be used to edit the selected climate scenario and measures. Clicking this results in opening a pop-up window as can be seen in Figure 47. This will allow the user to select a climate scenario and add measures if needed. The pop-up uses the same logic as the pop-up when comparing scenarios. The only major difference is that only one scenario can be chosen and not two. This way, a user can change the scenario and compare how the different areas would evolve.

This pop-up could also be used for certain services where it is needed to always select a climate scenario and add measures. For example, in the layer selector, a climate picker like this could be incorporated to allow the user to select a climate scenario. This could then impact the layers that are visible on the map and effect the choice of area of interest.

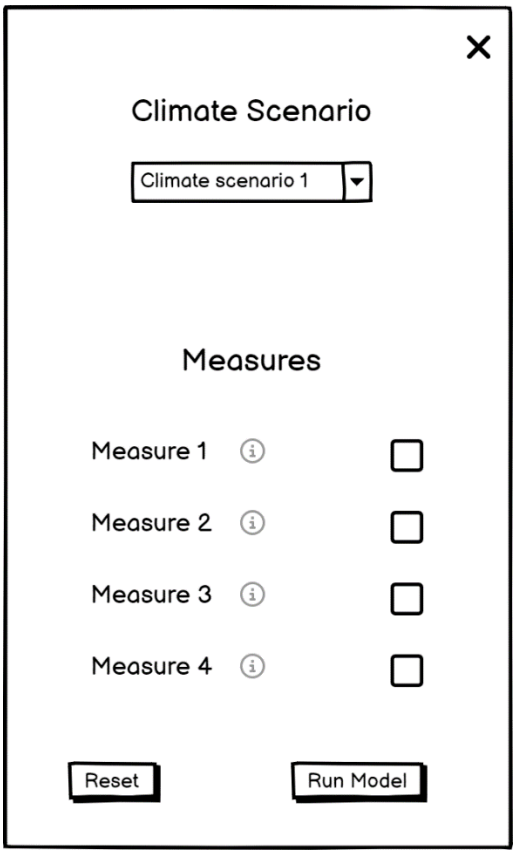

Figure 47. Wireframes: Changing the climate scenario when comparing areas.

5.2.3.5. Export function

The export function opens a side tab (Figure 48). The content is dependent on the different services. But there will be the need for some checkboxes to select e.g. which layers need to be exported or in which file format. The goal here is to allow the user to export data and results and process it further in another external application. It might also be desirable to include some kind of export report here. The design is similar for the vertical orientation, but here the panel opens at the bottom.

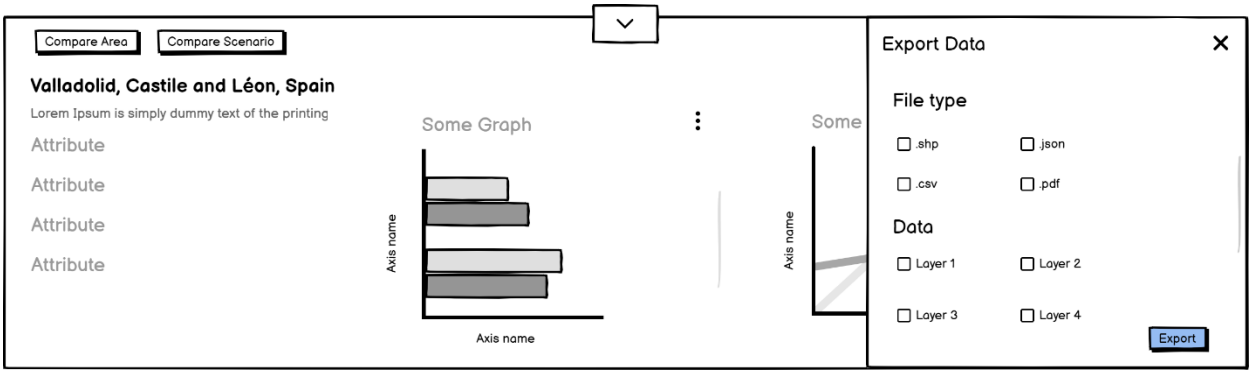

Figure 48. Wireframes: Export function

5.2.3.6. Save function

As can be seen in Figure 49, the save function will allow the users to connect back to the core platform and save certain aspects in their cloud environment. This part still needs to be further examined. Some things that might be considered to include are e.g. defined areas and scenarios, weather files or just the general project to continue their project later. If this will be incorporated, there will also be a need to have some kind of upload functionality to allow users to import their data again.

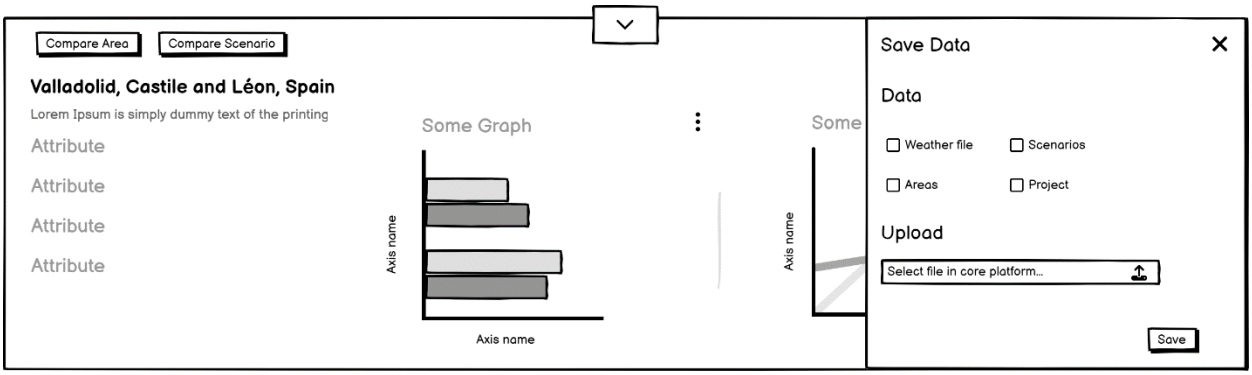

Figure 49. Wireframes: Save function

5.2.3.7. Share function

The share function (Figure 50) allows users to share a part of the project on social media. This would be a good functionality for dissemination purposes. The functionality will create a shareable URL that can either be directly shared on social media platforms like Facebook or LinkedIn, or can be copied to the users' clipboard by clicking the 'Copy' button.

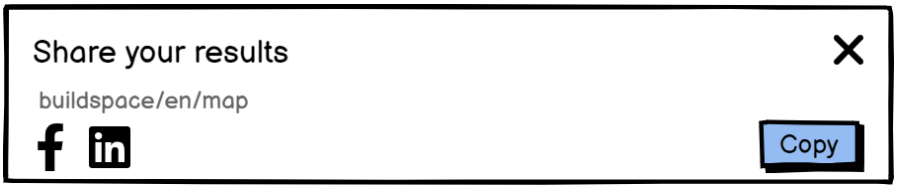

Figure 50. Wireframes: Share function

5.2.4. Navigation bar and related pages

5.2.4.1. Navigation bar

The navigation bar (Figure 51) consist of a service title and an EC logo on the left. On the right, standardly 'Map' is selected but it is possible to navigate to an 'About'-page or a 'Contact'-page. On the far right, there is a user symbol with some basic information of the logged in user.

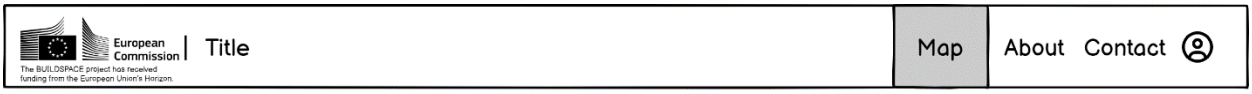

Figure 51. Wireframes: Navigation bar

5.2.4.2. About page

It is suggested that an "about" page is constructed for each service (Figure 52). This page can hold specific information for a service like methods and formulas used or information about specific features in the service. The page can be divided in tabs that can be clicked or scrolled through. The content can be completely decided by the service developers. On top, a service-related banner can be shown.

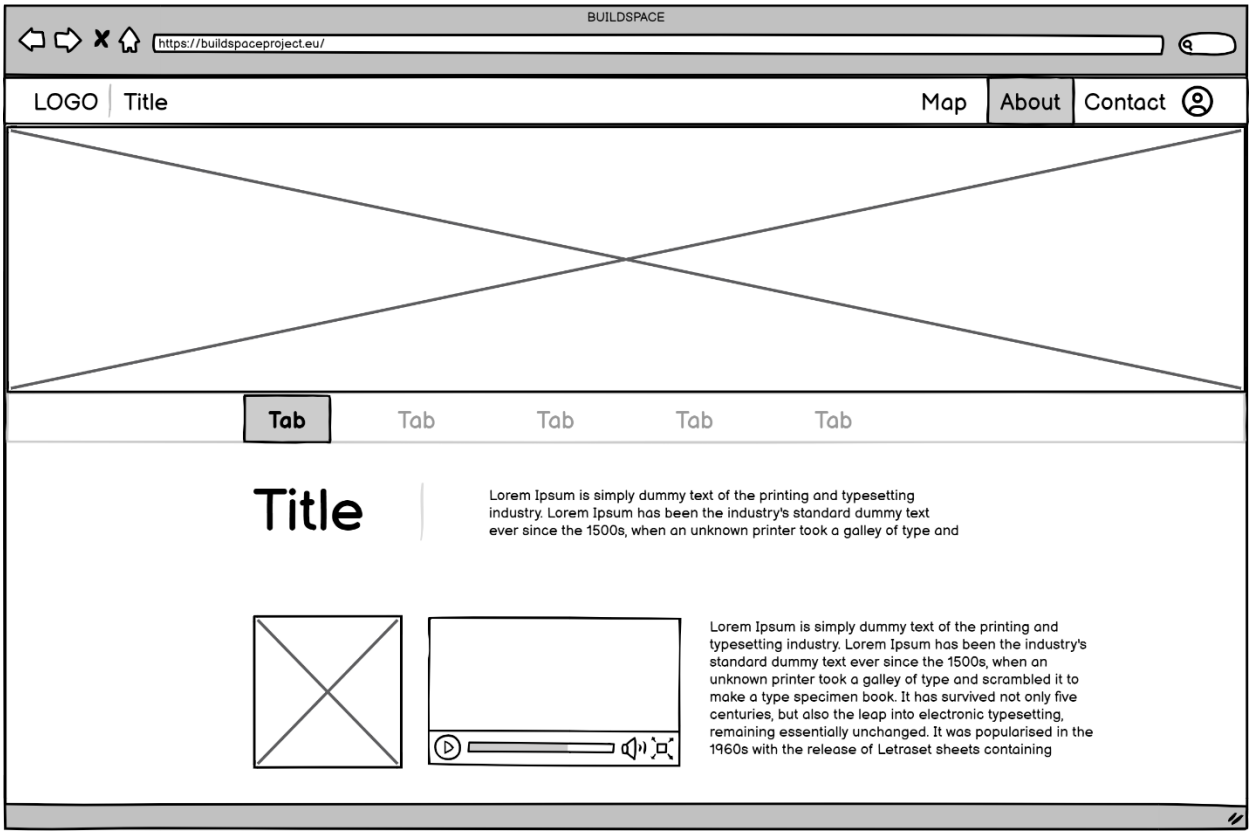

Figure 52. Wireframes: About page

5.2.4.3. Contact page

A “contact” page can be constructed so a user can contact the service provider for e.g. technical questions (Figure 53). The contact page has a very basic message design on the right. The user can send a message via the message box. It is required to leave a name and an email address to be able to contact the user in question. A link back to the general BUILDSPACE contact could be built in here. It should be made clear that this is a service contact page and not the general BUILDSPACE contact page.

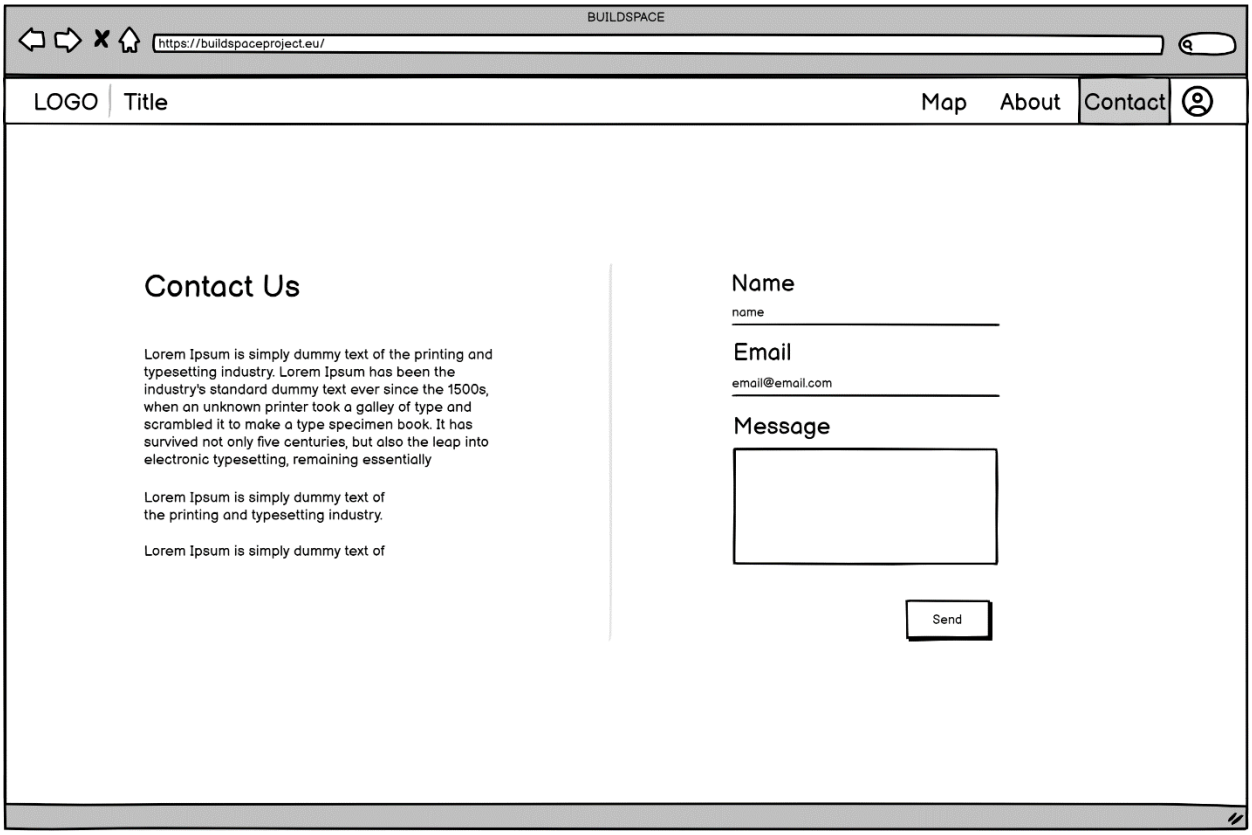

Figure 53. Wireframes: Contact page

5.2.5. Link to DT services

As service 1 & 2 are based on DT generation and will be shown more in VR and AR, it has been decided to not include detailed wireframes for these services. However, it is important to connect the DT services with the city services. Therefore, two possible wireframes were made to achieve this.

For services that also have geolocated 3D buildings, the wireframe in Figure 54 has been designed. A button could be incorporated that allows the user to check if any 3D buildings are in the area. They could be visualised by a yellow dot. They could also be shown together with relevant layers to see which 3D buildings might be more interesting to further examine. By clicking a yellow dot, the user can be redirected to a separate 3D environment.

If a more complete 3D city model would be available, it could be incorporated to create a 3D mode where all buildings can be visualised, together with relevant layers. When a user selects a building, they can be redirected to a 3D environment about the specific building. This is shown in Figure 55.

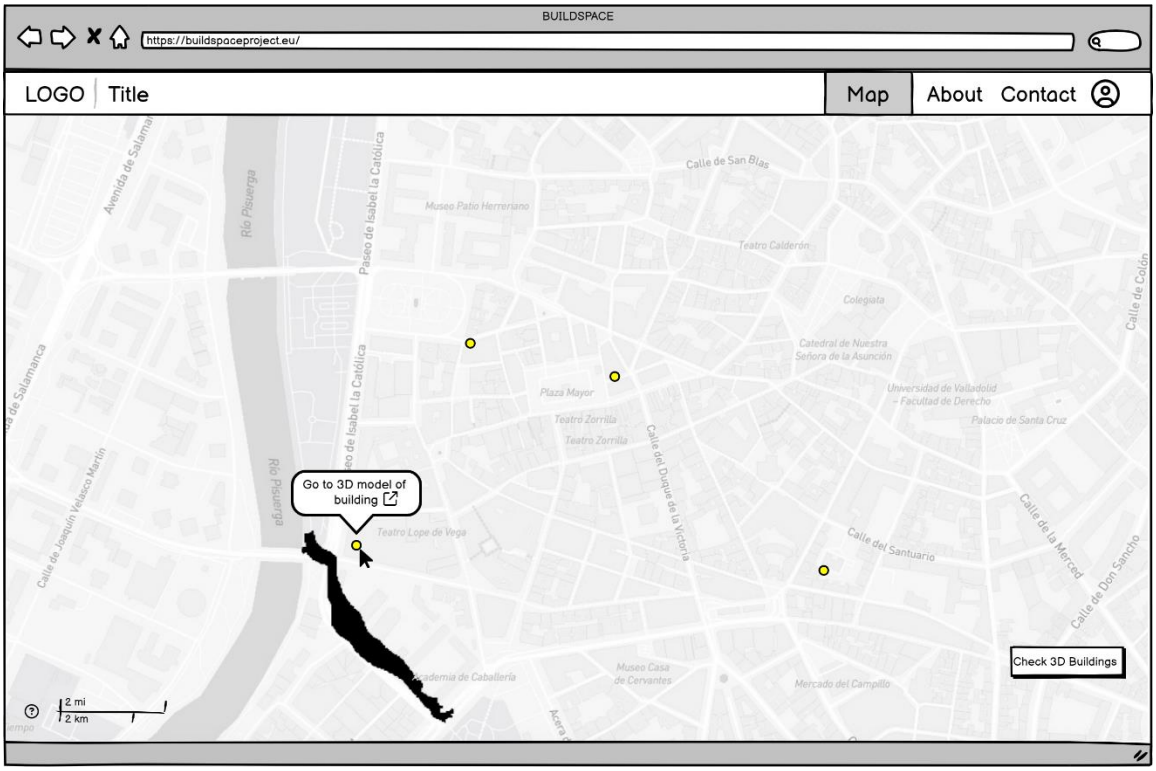

Figure 54: Wireframes: Link to 3D buildings version 1

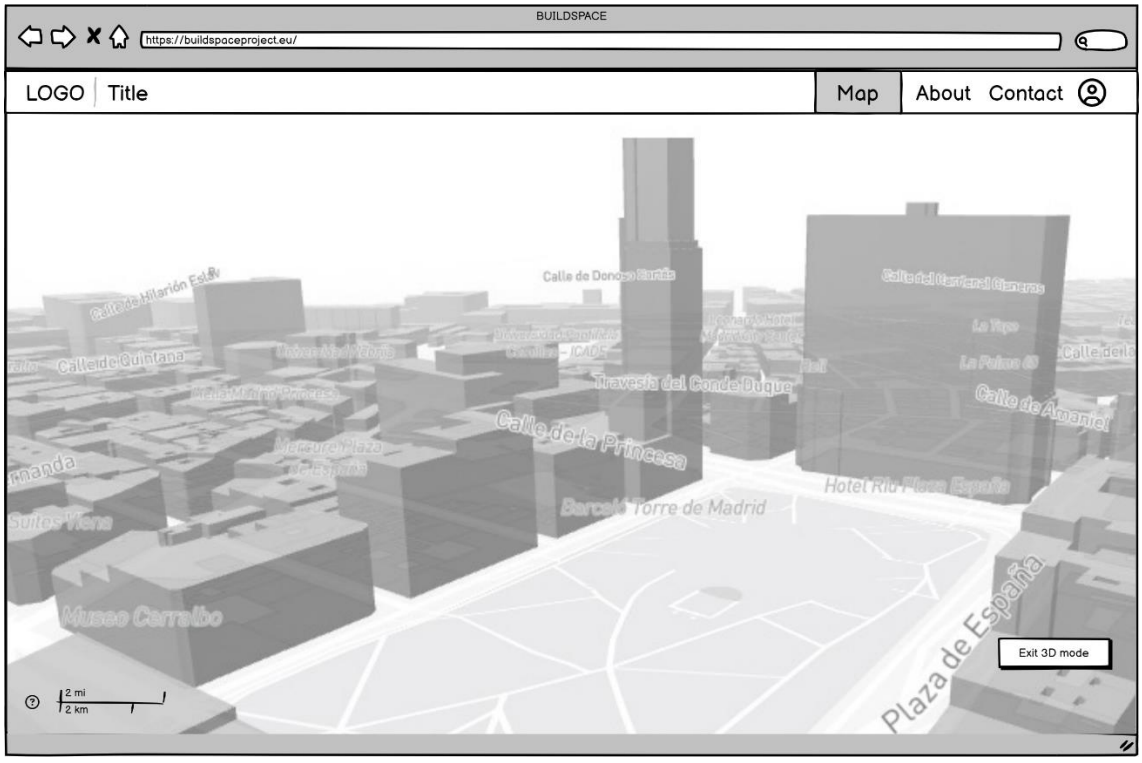

Figure 55. Wireframes: Link to 3D buildings version 2

6. Conclusion

This deliverable reports on the progress made in WP2 to get closer to the BUILDSPACE solution. This document shows that the theoretical work that has been performed for D2.1, has led to more concrete steps towards the development of the BUILDSPACE services. Firstly, the consortium has invested a lot in social engagement by involving external stakeholders in a co-creation process by organizing a co-creation session. In this session, the possible future end-users provided valuable feedback that has been processed and used to define detailed technical use cases for all services. Secondly, an extensive approach has been used to define and create detailed wireframes that are useful for all the partners and services. This has been achieved by using an iterative circle of creating wireframes and asking feedback from the partners. The result is an extensive wireframing guide that can be used as the main framework for the development of the services.

7. References

Gibbons, S. (2016, October 23). Opgehaald van Nielsen Norman Group: https://www.nngroup.com/articles/design-critiques/

Jake Knapp, J. Z. (2016). *SPRINT, How to slove big problems and test new ideas in just five days.* London, England, United Kingdom: Transworld Publischers.

8. Annexes

8.1. User flows

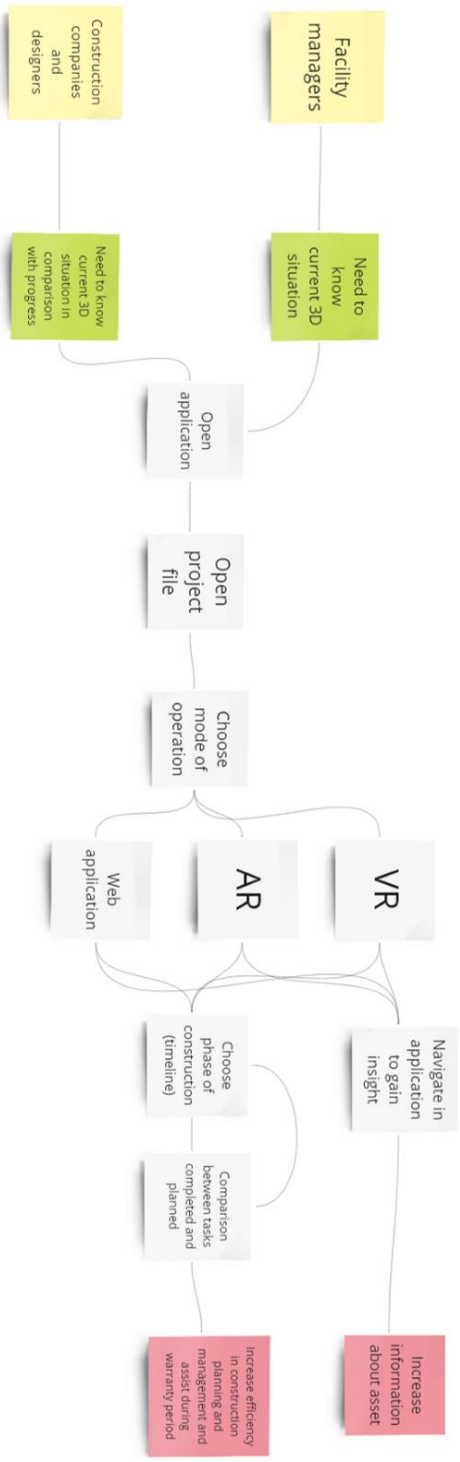

Figure 56. Enlarged user flow of service 1 & 2.

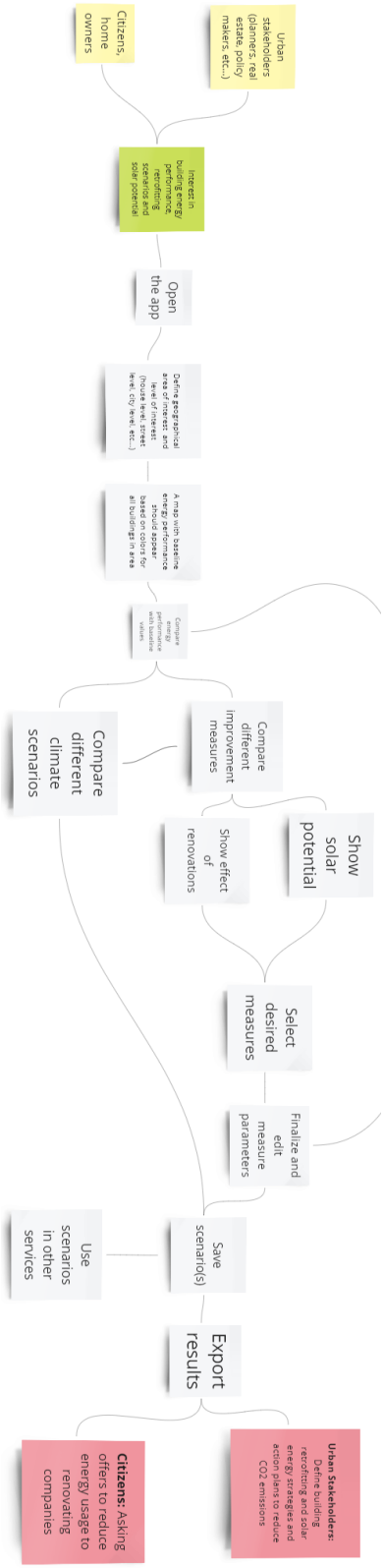

Figure 57. Enlarged user flow of service 3.

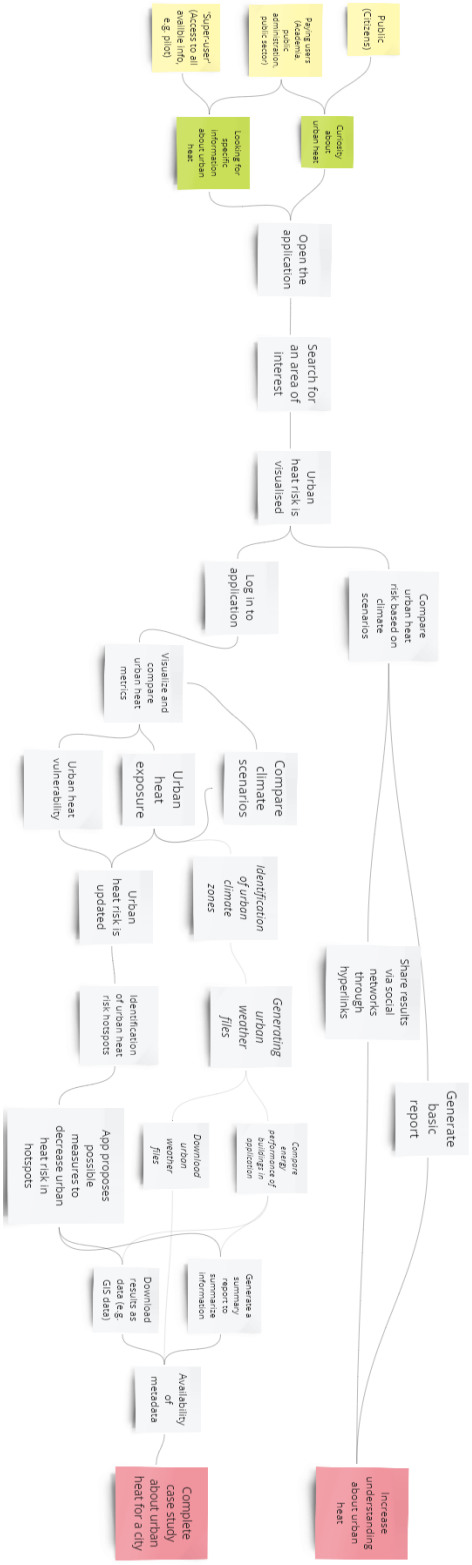

Figure 58. Enlarged user flow of service 4.

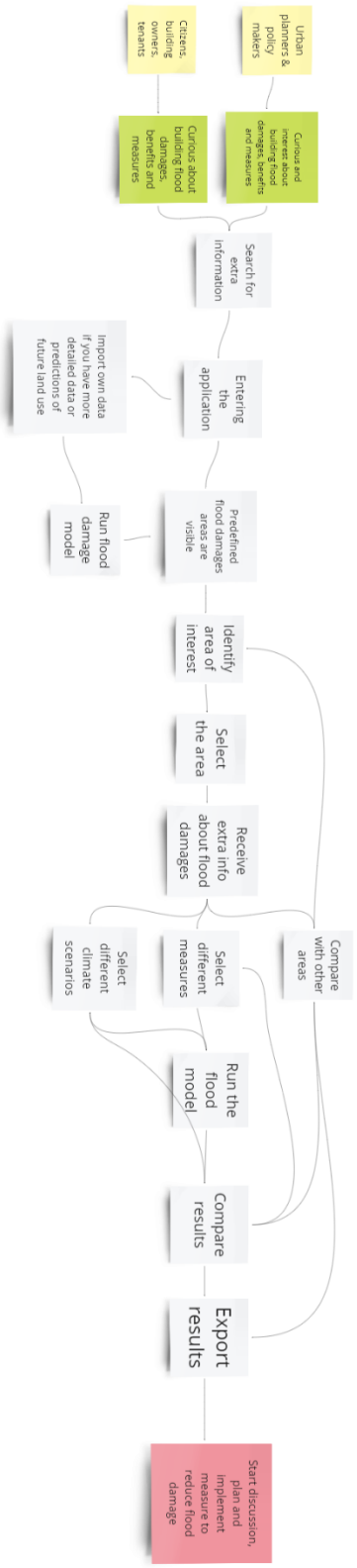

Figure 59. Enlarged user flow of service 5

8.2. First version of the wireframes

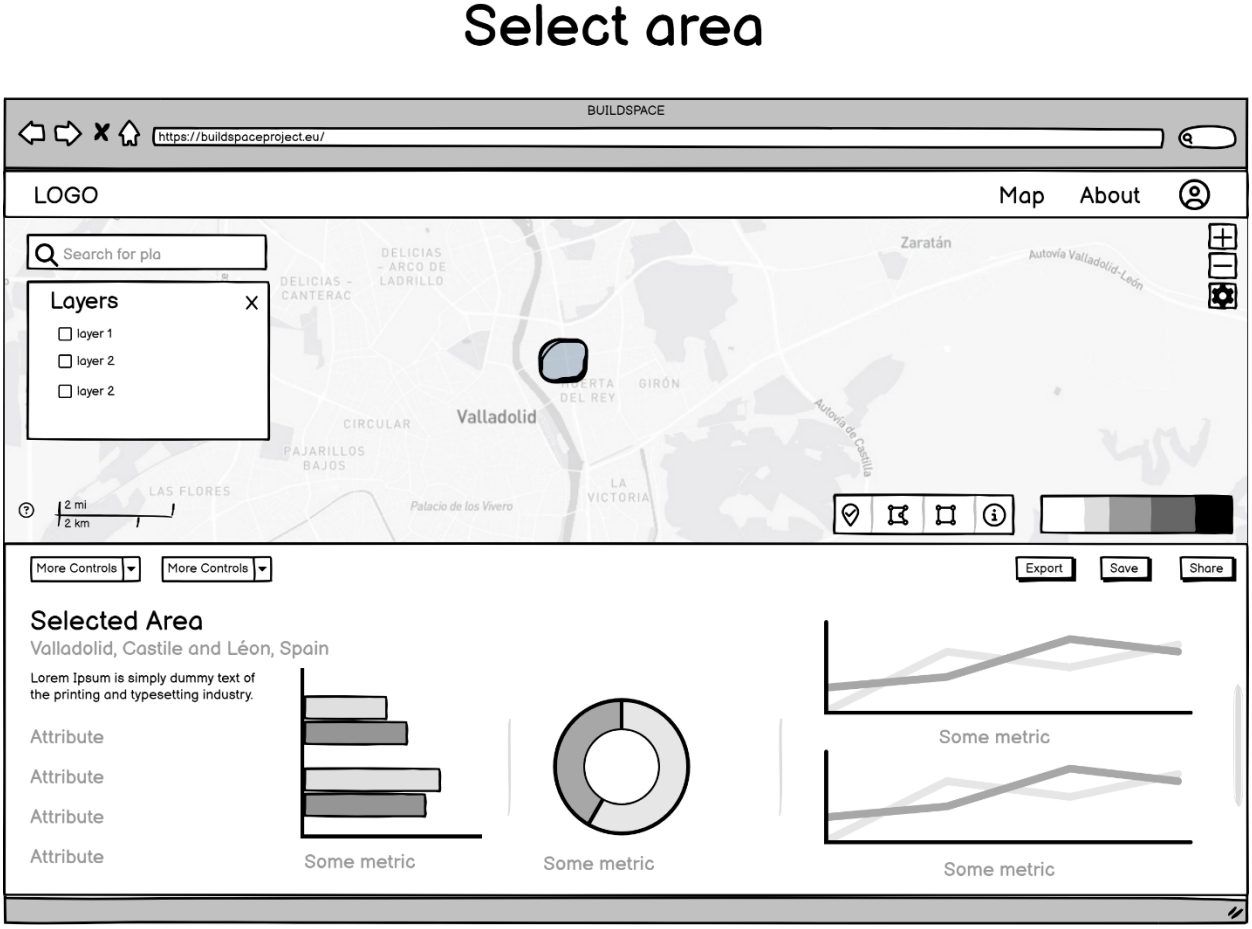

Figure 60. Wireframes v1: General station - Select area

Service launcher

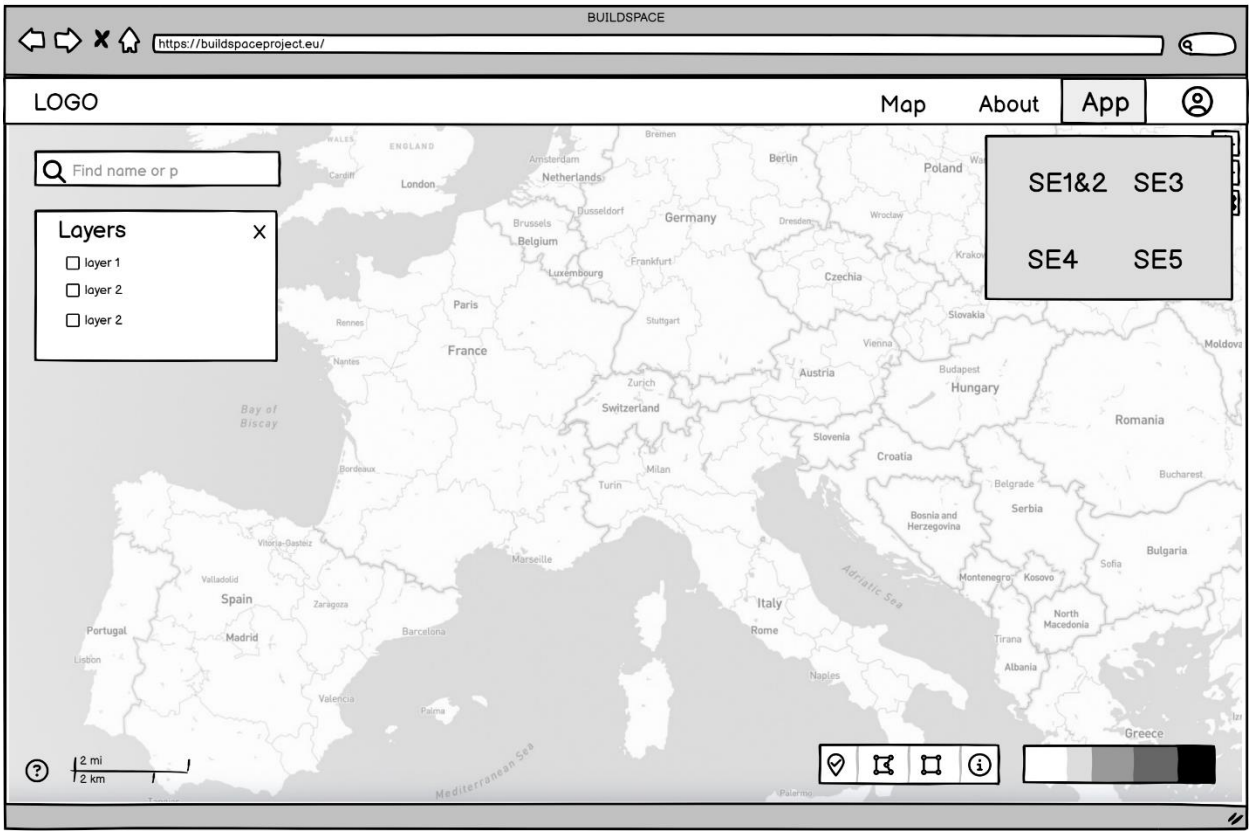

Figure 61. Wireframes v1: General station - Service launcher

Starting page

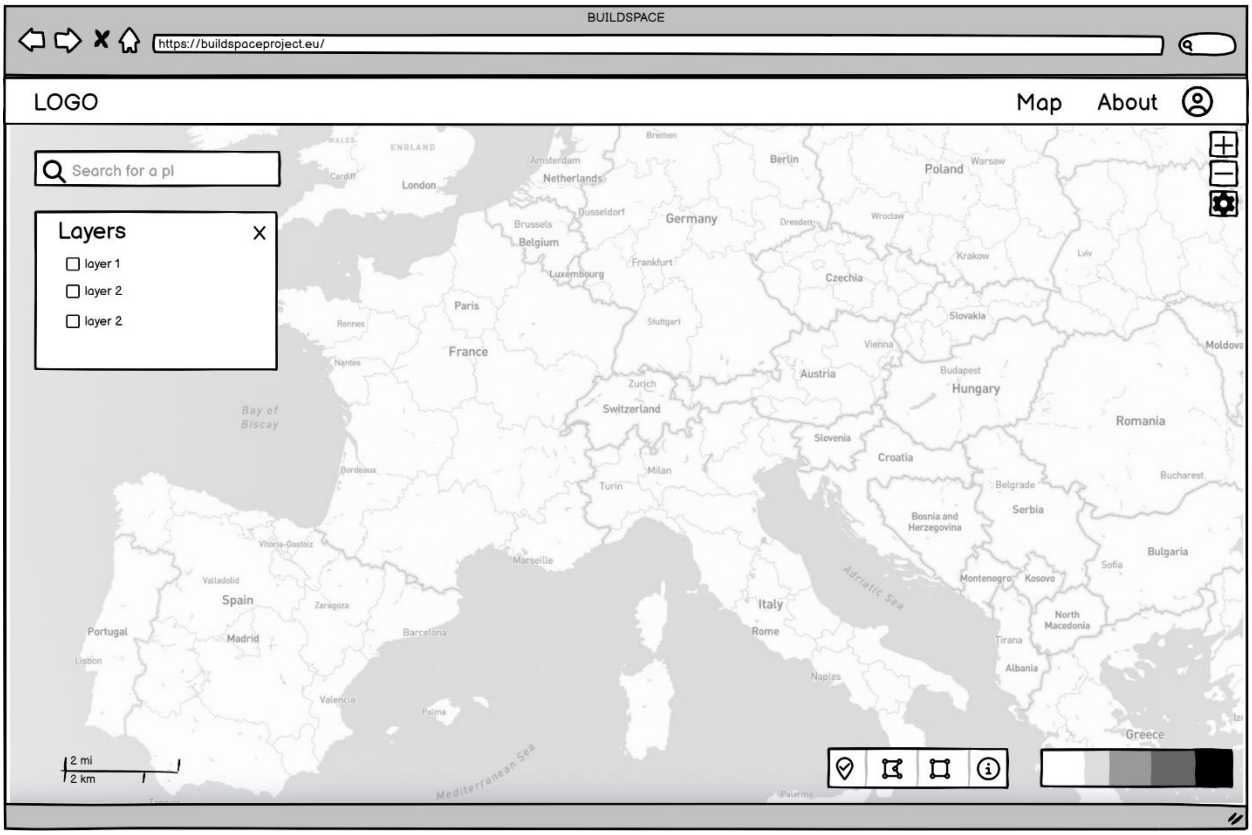

Figure 62. Wireframes v1: General station - Starting page

Compare measures

Figure 63. Wireframes v1: Compare station – Compare measures

Compare scenarios

Figure 64. Wireframes v1: Compare station – Compare scenarios

Switch scenarios

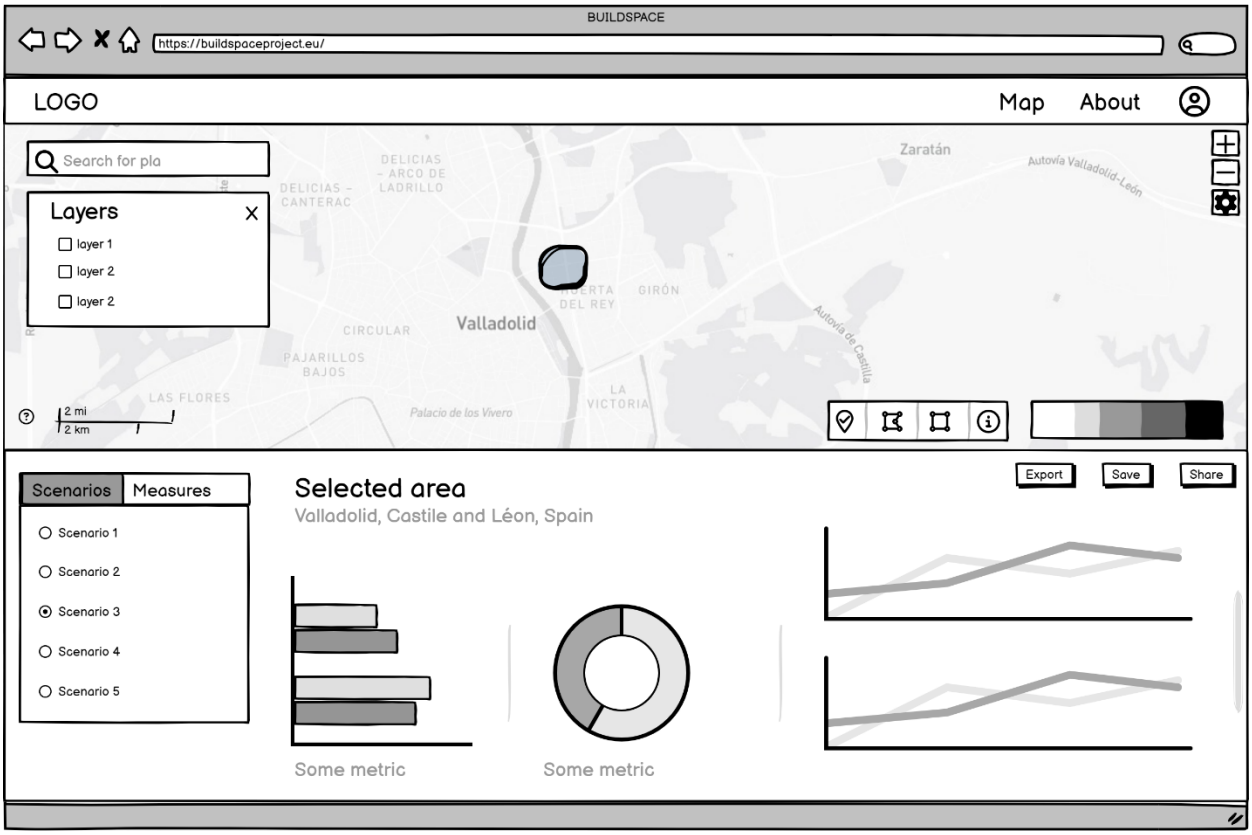

Figure 65. Wireframes v1: Compare station – Switch scenarios

Landing page

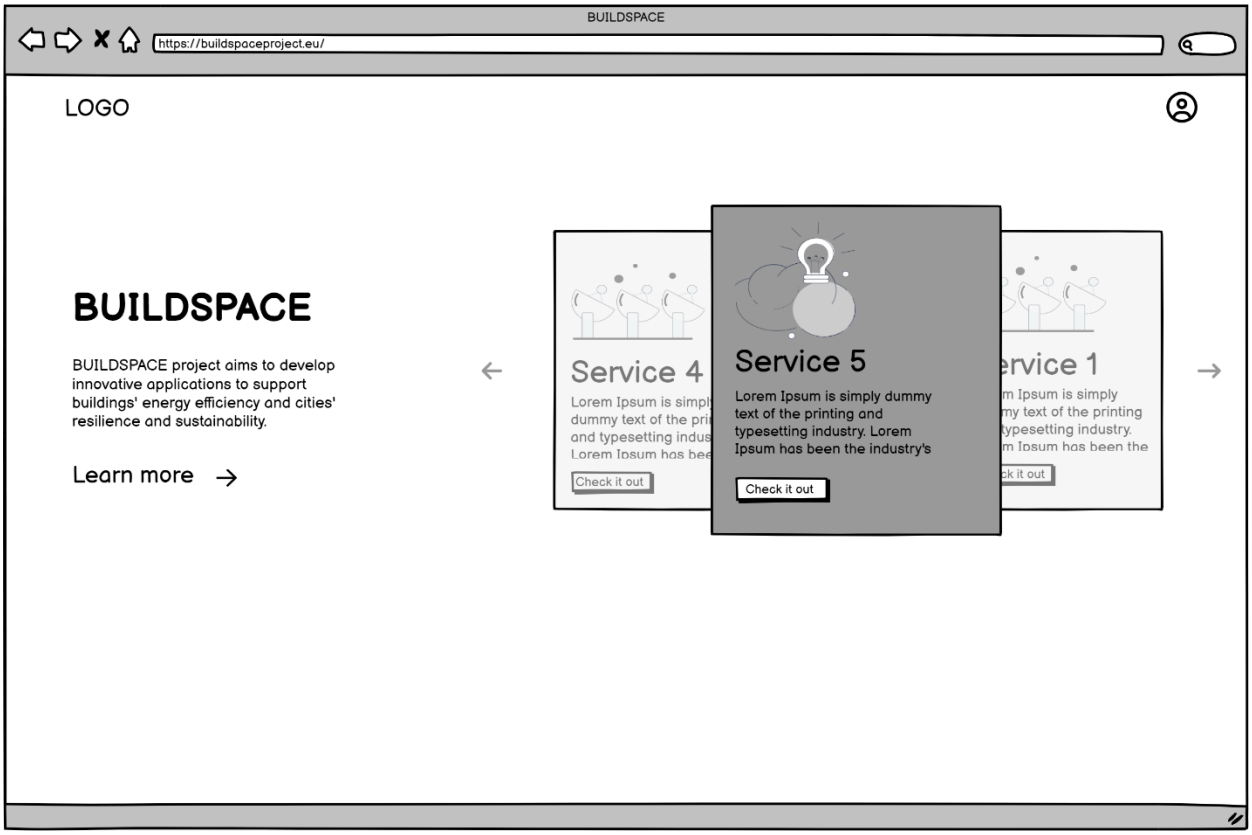

Figure 66. Wireframes v1: Starting station – Landing page

Login page

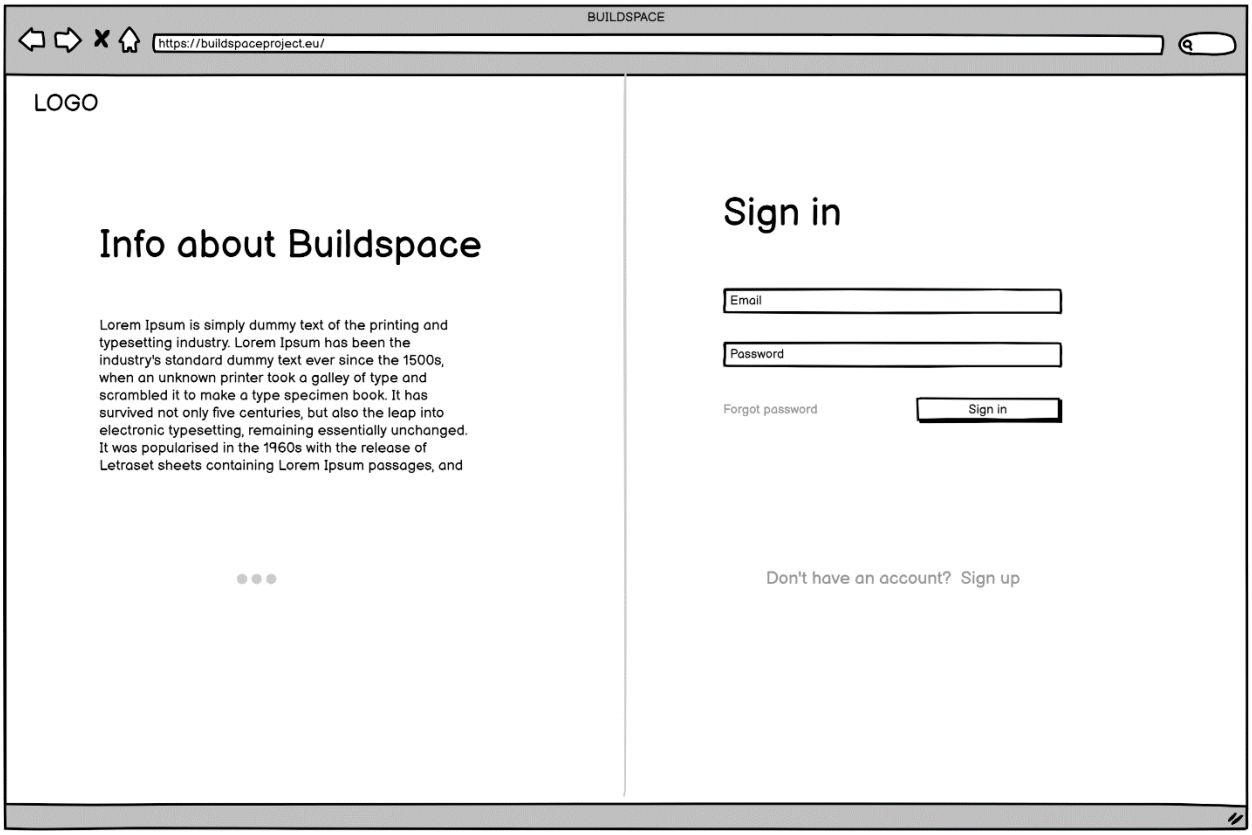

Figure 67. Wireframes v1: Starting station – Login page

User profile

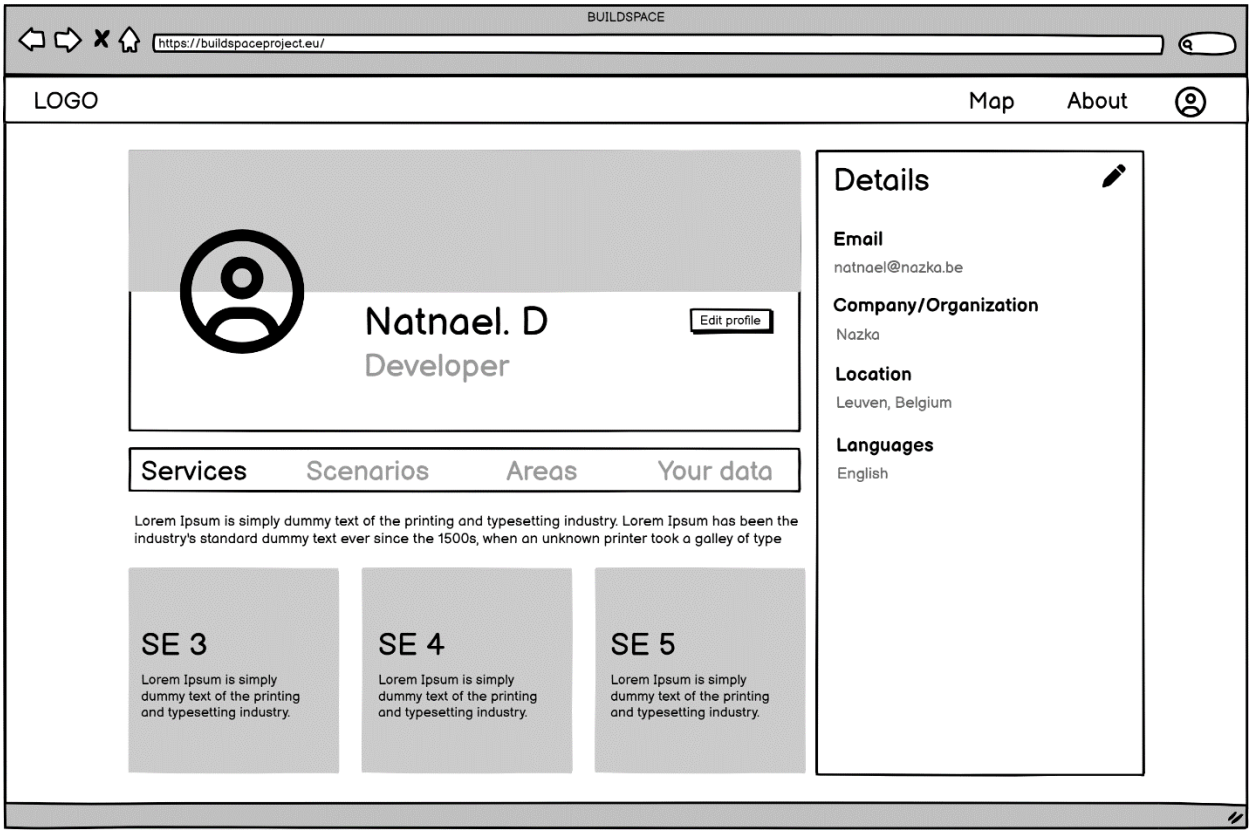

Figure 68. Wireframes v1: Starting station – User profile

Compare areas

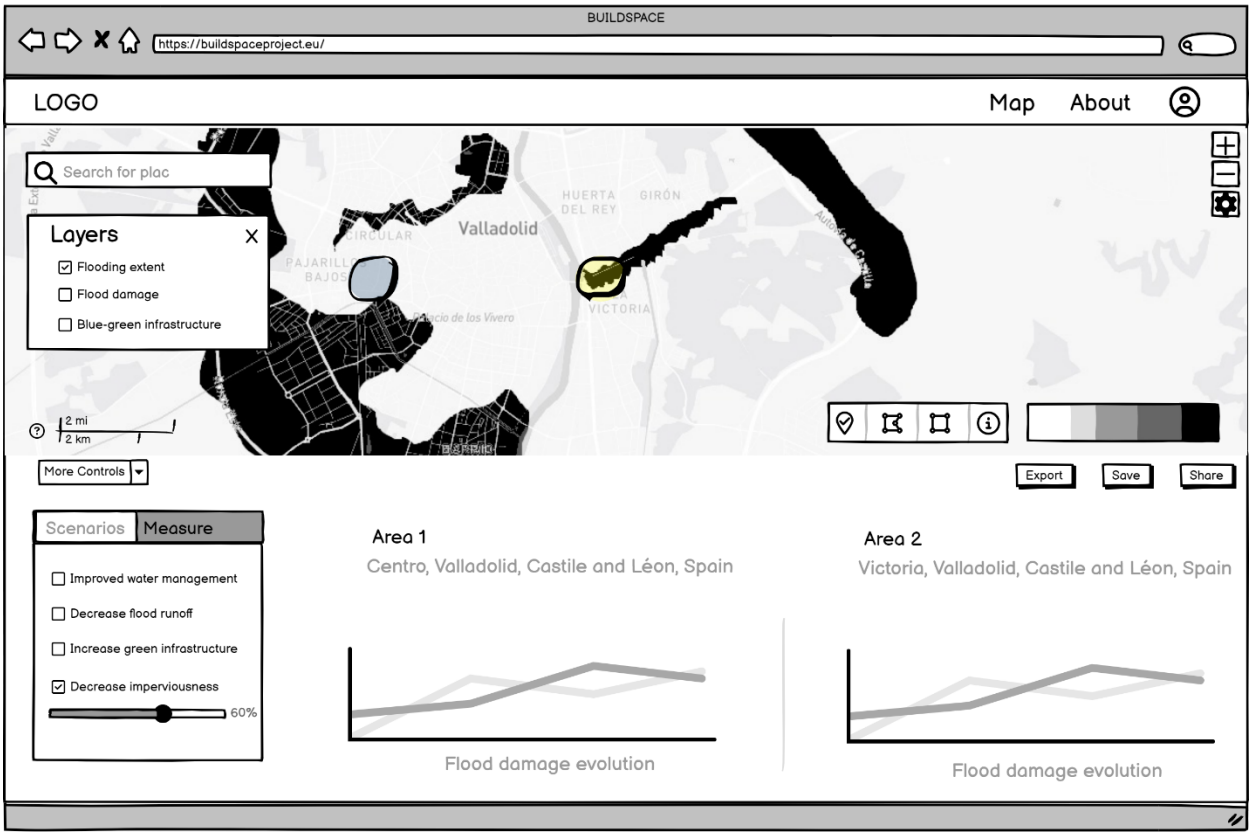

Figure 69. Wireframes v1: Example station – Compare areas

Link to SE1&2

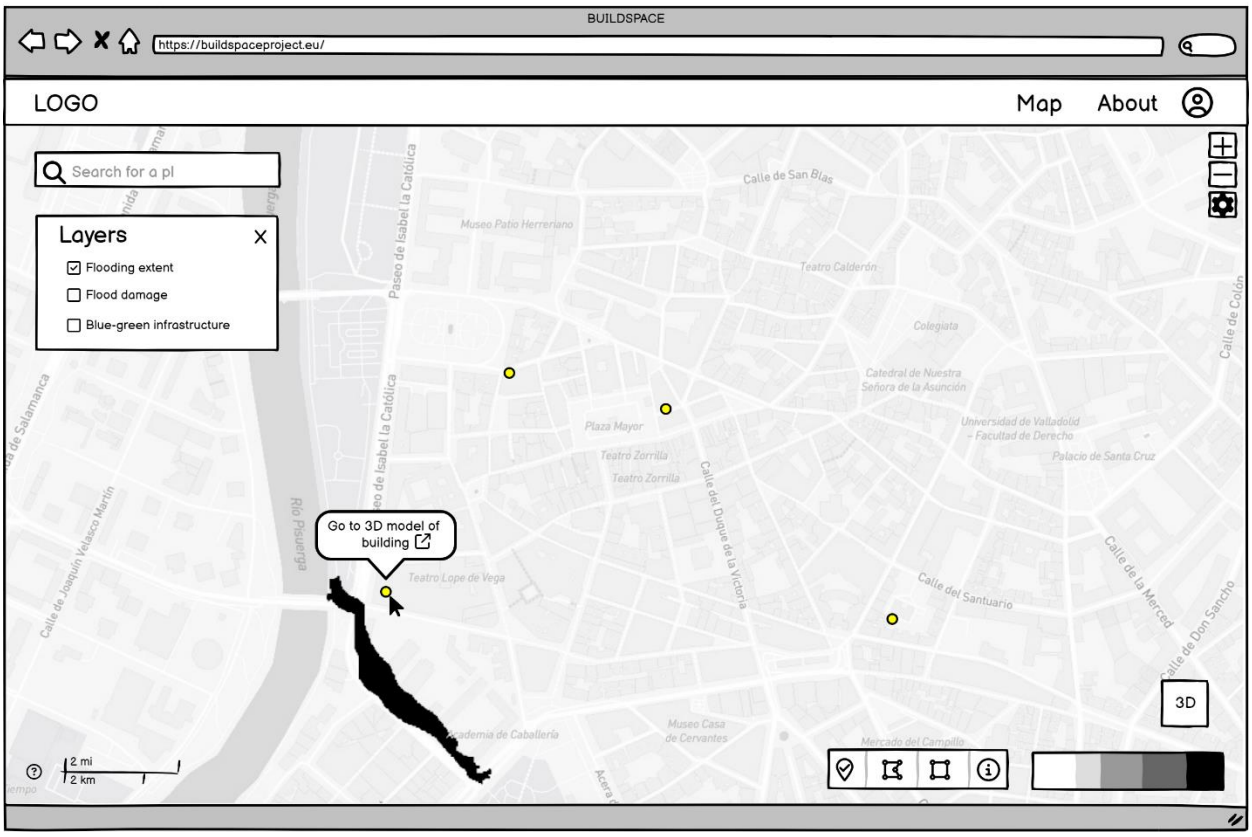

Figure 70. Wireframes v1: Example station – Link to SE1&2

Service 5 map

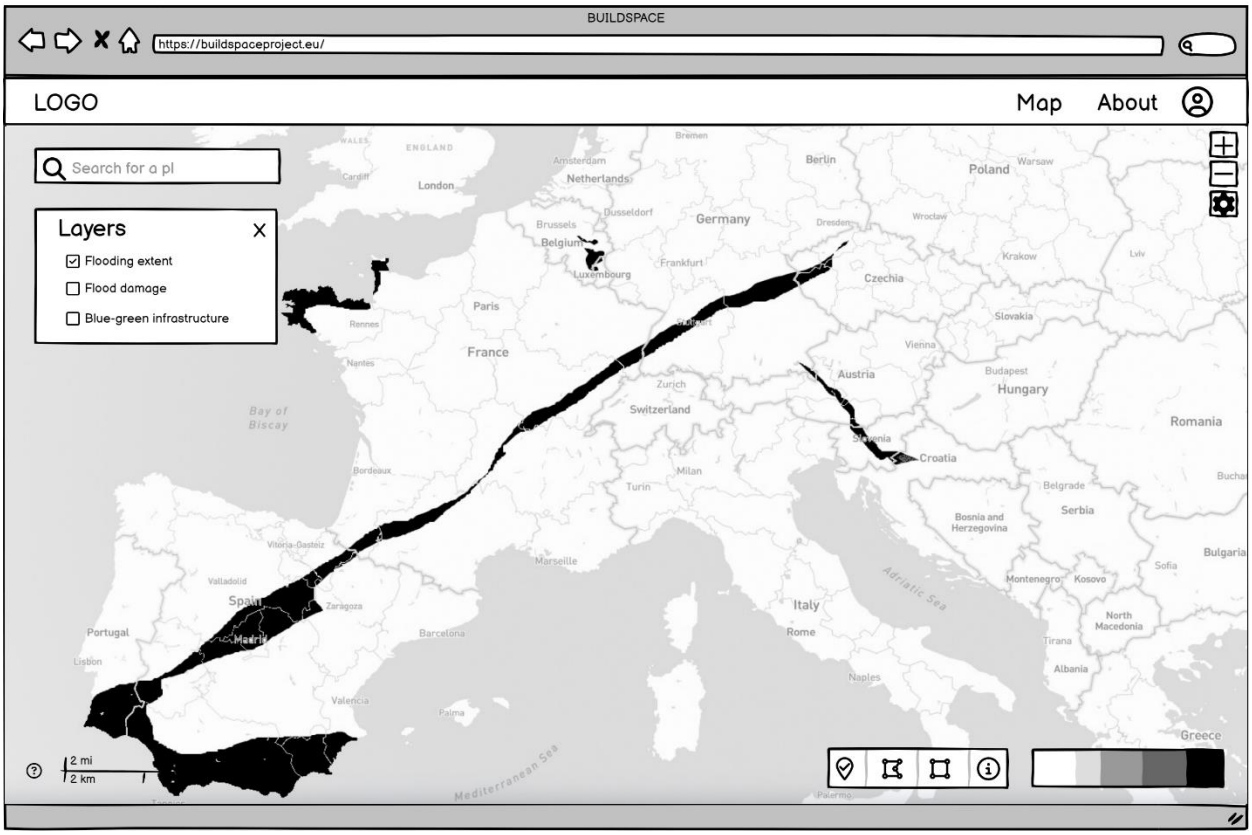

Figure 71. Wireframes v1: Example station – Service 5 map

8.3. Feedback Valladolid session

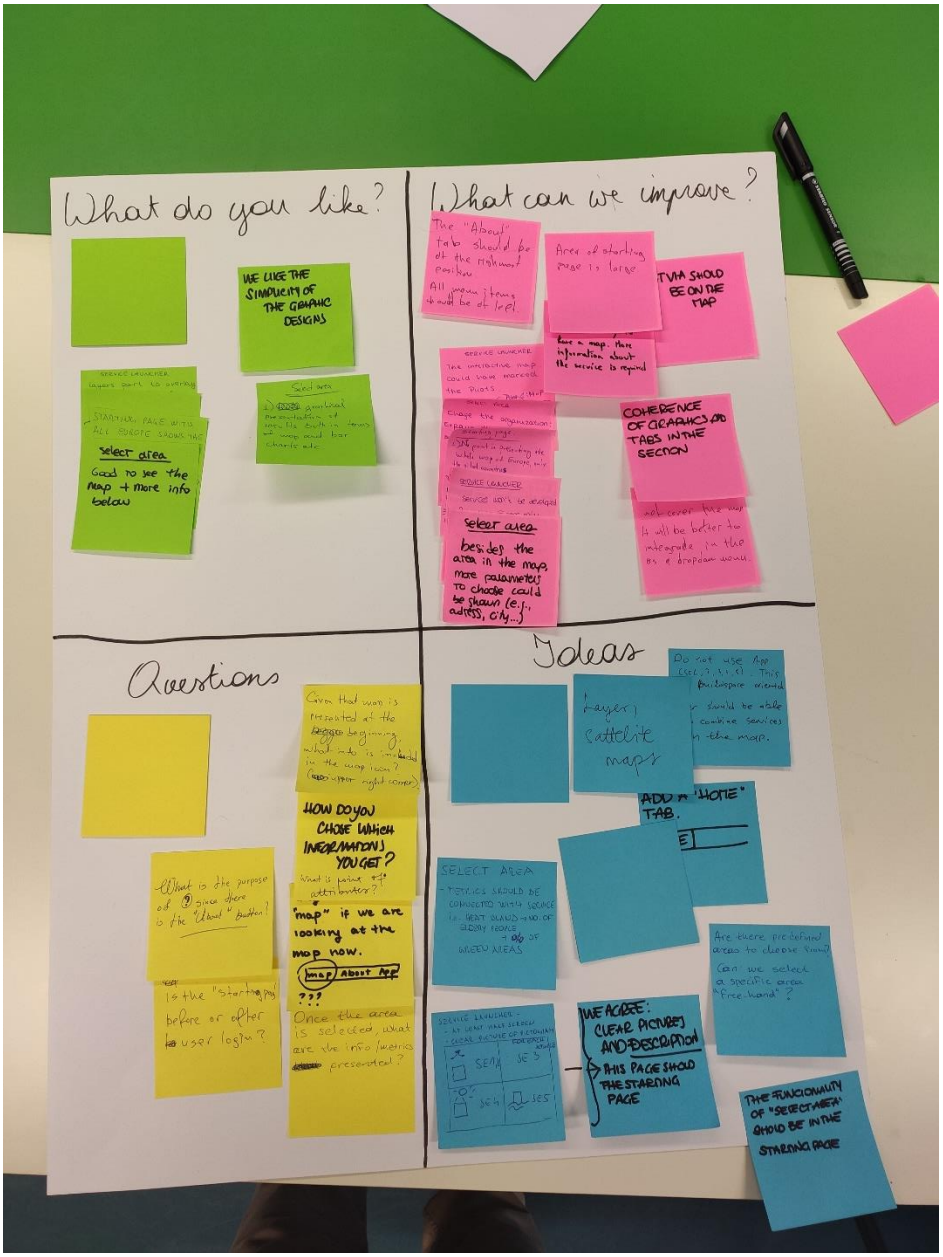

Figure 72. Feedback results for the general station

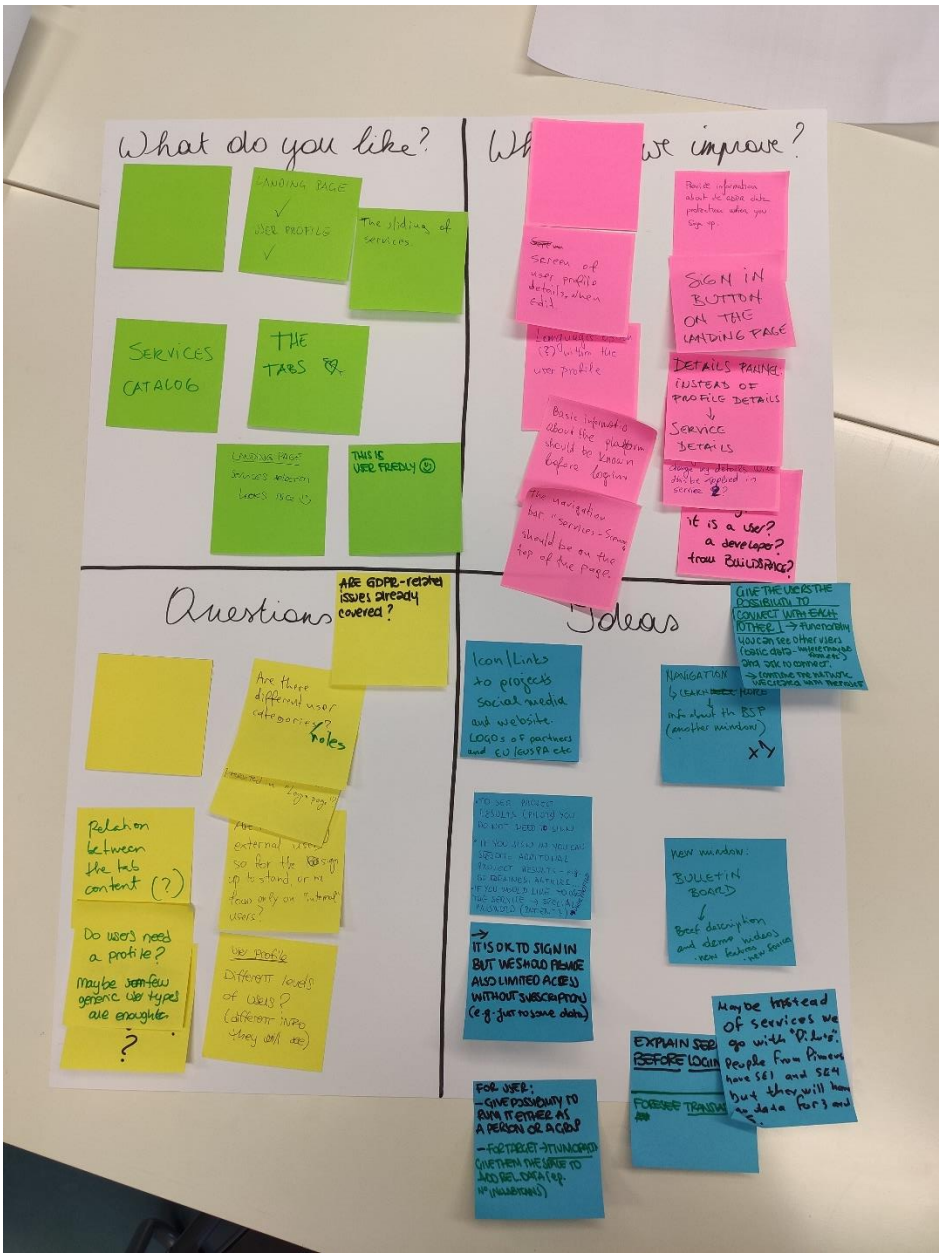

Figure 73. Feedback results for the onboarding station

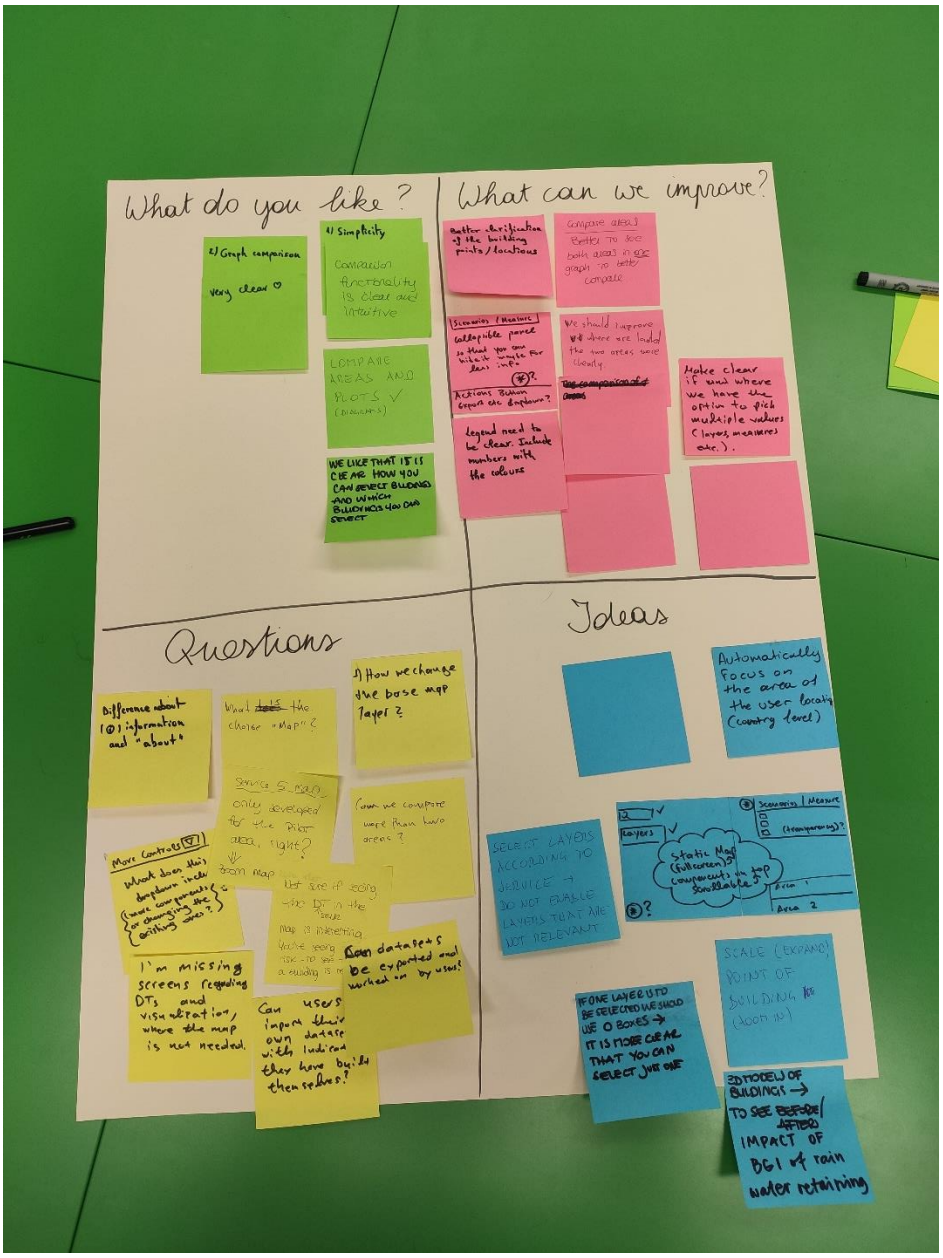

Figure 74. Feedback results for the example station

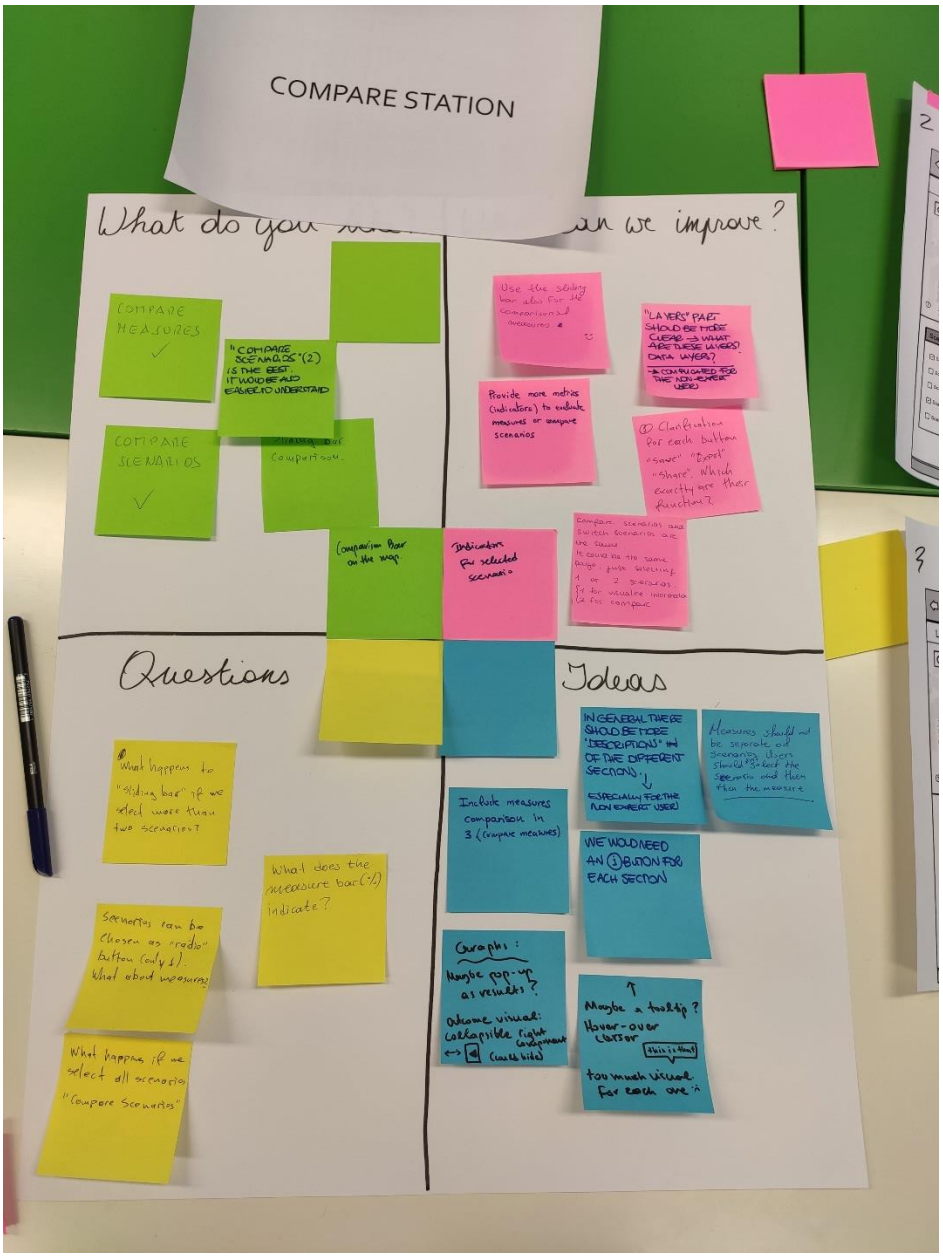

Figure 75. Feedback results for the compare station

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