BUILDSPACE

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

D2.1 BUILDSPACE User Requirements

May 2023

Document history

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Terminology

Term	Brief Description
Pilots	Pilots are real-world implementations of the BUILDSPACE services that are conducted in order to test the BUILDSPACE functionality and gather feedback from potential users. For the purpose of BUILDSPACE, the following pilots have been considered: 1. Municipality of Piraeus (MoP) – Greece 2. Mostostal – Poland 3. Institut za Modro-Zeleno Infrastructuro (IMZI) – Slovenia 4. Riga Planning Region (RPR) – Latvia
Users	Users are individuals and/or organisations who access and utilise the BUILDSPACE services and features to achieve their goals and objectives.
Stakeholders	Stakeholders (e.g., associations, cooperatives, Non-Governmental Organisations (NGOs), investors, Small- and Medium- Sized Enterprises (SMEs), companies, entities, constructors, facility managers, etc.) will bring the necessary expertise into the process and thus will be mainly engaged in the development of the user stories (and of the use cases later on) on behalf of the pilots, through co-creation sessions of various formats (e.g., workshops, online or physical presence, in person events/sessions, etc.). Stakeholders may be also included in the target groups, if they intend to use the final services and benefit from them.

Target groups	Target groups constitute the direct beneficiaries of a user story implementation (e.g., citizens, etc.). They may also act as the main users of the services within the pilots, although such a perspective is optional.
Personas	Personas are fictional characters created to understand more comprehensively a target group's behaviour, thoughts, feelings, needs and wants, to ensure that their perspective is considered when developing a user story, and eventually when the resulting final service is provided. For each target group, several personas may exist.
User story	A user story is a simple statement that enables to capture a platform feature from the user's perspective on a high level. User stories are written in a natural language and focus on the following three main elements: (1) Who is it for? (2) What is it expected from the implementation of a user story, in terms of output services? (3) Why is this important? – on the basis of what benefit is it to be obtained. User stories are structured under the following format: As a <user/persona>, I want to <goal> so that <benefit>. User stories constitute the first step that will guide the final development and implementation of use cases, and make sure that the user perspective is always kept in mind.
User requirements	User requirements express what is expected from the pilots and personas (i.e., user story tellers) in terms of the service(s) that will be eventually provided after the implementation of a user story. User requirements carry information that will serve as the basis for further specification, design, and verification of the overall architecture of BUILDSPACE. They are elicited from the user stories.
Technical requirements	Translation of the high-level user requirements to technical specifications.
Use case	Use cases represent the last step prior to the platform design and their aim is to capture the interrelationships between data, users, modules and repositories involved in the platform operation. They are written in technical language and represent a functionality which should fulfil a requirement or a set of requirements. Use cases define a series of steps that need to be followed to cover a specific functionality in the platform. In this line, not only the interactions with the end-users are contemplated, but also with other components within the platform, such as the repositories, external services, etc.
Wireframes	A wireframe is a visual blueprint representing the basic layout of the platform to be developed, without any final comment. Wireframes are typically created to help stakeholders understand and make decisions about the overall functionalities of the platform.

Mockups	Mockups refer to a visual representation of the platform, showing users and stakeholders how it may look and be used, and is developed to evaluate its design.

List of acronyms

Acronym	Description
AR	Augmented Reality
BIM	Building Information Modelling
BSO	Building Stock Observatory
CAMS	Copernicus Atmosphere Monitoring Service
CLMS	Copernicus Land Monitoring Service
CMIP	Coupled Model Intercomparison Project Phase
CWS	Climate Watch System
C3S	Copernicus Climate Change Service
DEM	Digital Elevation Model
DHW	Domestic Hot Water
DT	Digital Twin
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EGNSS	European Global Navigation Satellite System
ESA	European Space Agency
ESCO	Energy Service Company
FDAM	Flood Damage Assessment Methodology
GIS	Geographic Information System
GHSL	Global Human Settlement Layer

GUI	Graphical User Interface
H	Historical
HAS	High Accuracy Service
ICT	Information and Communication Technologies
IMZI	INSTITUT ZA MODRO-ZELENO INFRASTRUCTURO
LIDAR	Light Detection and Ranging
LUCAS	Land Use/Cover Area Frame Statistical Survey
LUZ	Larger Urban Zone
MoP	Municipality of Piraeus
MOS	MOSTOSTAL WARSZAWA SA
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organisation
NUTS	Nomenclature of Territorial Units for Statistics
OSM	OpenStreetMap
RES	Renewable Energy Sources
RGB	Red-Green-Blue
RCP	Representative Concentration Pathway
RPR	Riga Planning Region
RT	Real Time
RQ	User Requirement
SCD	Sub-city District
SE	Service
SLAM	Simultaneous Localisation and Mapping

SME	Small and Medium-Sized Enterprise
SSP	Shared Socioeconomic Pathway
TR	Technical Requirement
UAV	Unmanned Aerial Vehicle
US	User Story
VR	Virtual Reality
WMS	Web Map Service
WUDAPT	World Urban Database and Access Portal Tools
ZUI	Zooming User Interface

Executive summary

This document has the ambition to identify user requirements, thus constituting a very important step towards shaping the BUILDSPACE solution and methodological approach. The activity was carried out in tight collaboration with all partners and produced a high-level description of user stories and the related requirements, as a basis for service development and integration. To ensure the alignment with Copernicus and European Global Navigation Satellite System (EGNSS), the most appropriate data sources and services are reported in order to meet the needs of the potential use cases. In addition, a detailed list of the monitoring parameters, temporal scales, spatial and temporal resolution of data that will be used in the four pilots and the five BUILDSPACE services is provided. The engagement and co-creation strategy is detailed, initiating with the definition of the principles and procedure steps for the co-creation sessions, and secondly, through the application of those methods in the planning of different sessions, considering the project activities, methods, feedback needs and loops, formats, expected outcomes and interaction type. Finally, an introduction to the technical use cases that will guide the development of the BUILDSPACE services and the platform is presented.

1 Introduction

1.1 Purpose of the Document

D2.1 – BUILDSPACE User Requirements is produced within the WP2 – BUILDSPACE Requirements, Co-creation, Specifications and Alignment with Satellite Services and it gathers the activities carried out in T2.1 – User Requirements Elicitation, T2.2 – Specifications of BUILDSPACE – Copernicus/EGNSS alignment and synchronization, and T2.3 – Social Engagement for Co-Creating the BUILDSPACE Use-cases and Applications. The purpose of this document is fourfold: (a). extraction of user stories and user requirements, (b). first translation of the user requirements into technical specifications, (c). examination of the specifications defined by Copernicus and EGNSS, and (d). identification and engagement of stakeholders for the co-creation of technical use cases combining both the technical specifications elicited from the user requirements and key specifications by Copernicus and EGNSS.

The present document serves as the key starting point for the activities of BUILDSPACE project. By performing an exhaustive analysis, user stories and user requirements are initially identified, and respective technical requirements are extracted to drive the next BUILDSPACE development processes. The involved tasks play a central role in order to shape the BUILDSPACE solution and methodological approach on the basis of the conceptual scenarios, user expectations and needs, and possible constraints and boundaries.

1.2 Relation to Other Documents

The present document plays a crucial role within the BUILDSPACE project, paving the way for the forthcoming project tasks. First, there is a strong dependence with Task 2.4 where the extracted technical requirements will be further elaborated and adjusted, following the social engagement and co-creation processes conducted in Task 2.3, and Task 2.5, where the conceptual architecture will be developed by bringing under the same conceptual umbrella the final technical specifications (resulting from Tasks 2.1 – 2.3) and other existing frameworks, architectures and services by Copernicus and EGNSS. Secondly, D2.1 is related to WP3 - BUILDSPACE location-based and remote sensing applications development, where the BUILDSPACE services and platform will be developed by leveraging on the technical specifications that were drawn from the elicited user requirements and presented in D2.1. Finally, D2.1 is interlinked to WP4 – Demonstration of BUILDSPACE towards sustainable and resilient building and cities, where the detailed test scenarios that will be defined, must reflect the requirements set forth in Tasks 2.1 – 2.3.

1.3 Document Structure

This document is organised as follows: **Section 2** presents the methodology adopted throughout the whole WP2, broken down per task, to ease understanding and facilitate better tracking of the activities included within each step. **Section 3** presents the elicited user stories, the mapping of each of them to specific target groups and personas, the user requirements that have been drawn from these user stories, and eventually the technical specifications extracted from the user requirements. **Section 4**, delves into the five services that will be developed for the purpose of BUILDSPACE based on the technical specifications, and presents in detail the framework and background in terms of objectives, challenges, data requirement, service input/output, etc. for each of them. **Section 5** provides a detailed analysis of the available datasets and services provided by Copernicus and EGNSS, attempting to identify the monitoring parameters, temporal scales, and spatial resolution of the data that will be utilised in the BUILDSPACE project. **Section 6** emphasises the social engagement for co-creating the BUILDSPACE use cases and applications, highlighting the main principles of the co-creation strategy to be followed and presenting potential stakeholders to be engaged on behalf of each pilot within the whole process of developing these use cases. **Section 7** includes a preliminary description of the technical use cases that will be developed in BUILDSPACE, although without providing in-depth details, since such an activity will be part of the deliverables to follow. Finally, **Section 8** summarises the key points of the analysis, concluding the deliverable.

2 Methodology

The methodology used throughout the whole WP2, broken down per task, is presented in detail in **Figure 1**. Each of the included steps, prescribes the following:

1. **Pilot Test Cards (T2.1):** Pilot test cards are created to serve as horizontal templates (i.e., templates that follow the same structure across all pilot partners that are shared with) and are circulated among all pilot partners of the BUILDSPACE project. These templates attempt to elicit all the necessary information from the pilots, including their user stories and a brief description of each one of them, their objectives, challenges that are expected to be encountered during the actual implementation phase that will follow, key stakeholders that will be engaged as well as target groups that will be benefited from the user stories and relevant personas.
2. **Personas (T2.1):** Drawing from the “Terminology” section presented at the beginning of this deliverable, Persona is a fictional character created to represent the needs, desires and behaviours of a Target Group, to ensure that the perspective of its members is always considered along the process. To specify, Personas will serve as future user of the services that will be developed for the purpose of the BUILDSPACE project, acting on behalf a specific target group. Despite the fact that according to the GA, such an activity is part of the Task T2.4, to enhance inclusiveness of the Pilot Test Card that was circulated among all pilots, to make clear the strong

link between the Target Groups and Personas, and to ease understanding, a first set of Personas is identified in Task T2.1.

3. **Pilot user stories (T2.1):** User stories are high-level descriptions that seek to elicit information from the pilot partners regarding the following three main elements: (1) Who is it for? (2) What is it expected from the implementation of a user story, in terms of output services? (3) Why is this important?. In this respect, pilot user stories are structured under the following format: As a <pilot>, I want to <goal> so that <benefit>.
4. **User requirements (T2.1):** The description of each pilot user story is deeply analysed and structured in the form of a preliminary version of user requirements. In other words, each pilot user story, hitherto, is represented by a set of user requirements that capture the needs and context of what the respective pilot partner considers important for implementation.
5. **Personas user stories (T2.4):** Based on the first version of the user requirements that was gathered from the pilot user stories, personas user stories will be developed. Personas user stories are also well-aligned to the description of the pilot user stories, since they follow the same structure. As of this, personas user stories are structured under the following format: As a <persona>, I want to <goal> so that <benefit>. Personas user stories are more technically-oriented and focus on the practical use of the BUILSPACE platform, given that Personas stand for different user profiles.
6. **User requirements (discussion, refinement) (T2.4):** Once the Personas user stories are provided, the first list of user requirements that was originally developed based on the pilot user stories will be updated to incorporate the personas user stories and the potential new user requirements that will be elicited from them. This new list will be further elaborated and discussed so as to be refined, and the final list of user requirements will be defined.
7. **Wireframes (mock-ups for visualisation) (T2.4):** Wireframes will be made to discuss user requirements and the overall layout and navigation of the application. In a final stage, the wireframes result in mock-ups that visually perfectly represent how the map application will look after development.
8. **Copernicus and EGNSS analysis (T2.2):** The specifications and products defined by Copernicus and EGNSS for exploiting available data/services will be analysed, with particular focus on Climate Change, Land Monitoring and Atmosphere Monitoring Services. On that reflection, key technical requirements will be derived, including monitoring parameters, temporal scales, spatial and temporal resolution of data, which in turn will “feed” the extraction of technical requirements as prescribed in Task T2.3.
9. **Link to services data specifications (T2.2):** The extraction of technical requirements from the analysis of the Copernicus and EGNSS frameworks will be linked to the final services to be developed for the purpose of the BUILDSPACE project, on the basis of assessing their feasibility and their relevance to the scope of the developed components of the BUILDSPACE services.

10. **Technical requirements (T2.3):** A preliminary version of the BUILDSPACE technical requirements is presented, as a result of the translation of the user requirements, including a detailed description of the BUILDSPACE technical requirements along with the related user requirements from which each technical requirement has been elicited. This list of technical requirements is the result of an initial desk research that has been performed by the authors of this deliverable, combined with a first discussion round with the dedicated technical partners of the BUILDSPACE project.
11. **Social and stakeholder engagement (T2.3):** The extracted technical requirements presented in the previous step will be further elaborated, following several rounds of social and stakeholder engagement so as the final list of technical requirements to be defined.
12. **Technical use cases (T2.3):** The development of the technical use cases will exploit the final list of technical requirements focusing on capturing the interrelationships between data, users, modules and repositories involved in the platform operation. They are written in technical language and represent a functionality which should fulfil a requirement or a set of requirements.
13. **Services (T2.3):** A mapping of the final technical requirements, as described through the developed technical use cases, to the prescribed services will be carried out, towards paving the way for the actual implementation of the BUILSPACE services.
14. **Conceptual architecture (T2.5):** The resulting open conceptual architecture will leverage on the extracted technical requirements and will provide a seamless aligned framework which will enable the development of the services for the purpose of BUILDSPACE. The proposed conceptual architecture will receive as input the results of Tasks 2.1-2.4, towards identifying the technical constraints and specifications, as well as the desired functionalities and usage of the platform to be designed.

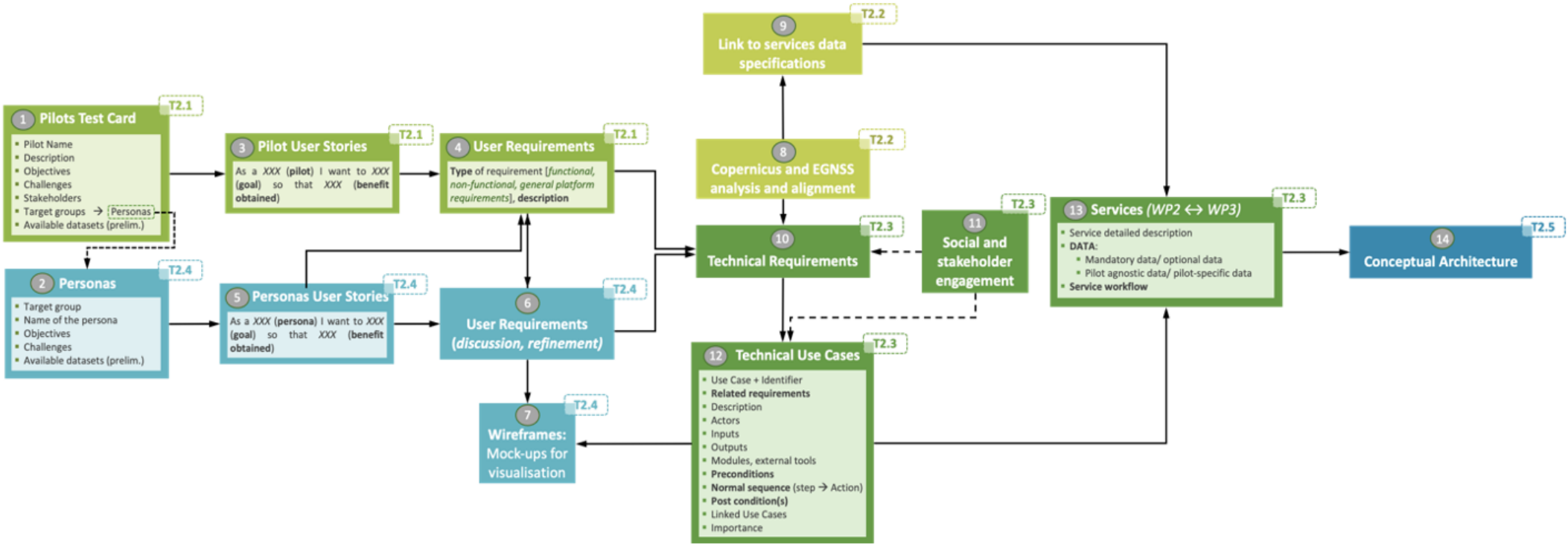

Figure 1. Methodology used throughout the WP2, broken down per task, to elicit the user requirements, extract the technical requirements, develop the technical use cases, configure the services, and eventually present the detailed conceptual architecture.

3 Identification of user stories and requirements

This section gives an overview of the methodological approach followed within BUILDSPACE, in order to specify the requirements needed for achieving the project objectives. This methodology helped all project partners to describe, formalise, and track the user requirements in an explicit and unambiguous way.

There are several approaches to introduce the advantages of user-centered design into the whole requirements engineering process (Paech and Kohler, 2003; Davey et al., 2015; Schneidewind et al., 2012). For instance, Ferré describes the integration of typical usability techniques in the software engineering process focused on requirements engineering activities in analysis phase (Ferré 2003; Castro et al., 2008).

Partners provided their contributions structured in user stories, accompanied with a description of the objectives and a list of requirements for each of them, as well as the respective data availability to support their implementation. For the purpose of BUILDSPACE, user stories have been developed by pilots and personas (if any provided by the pilots) and provide a high-level description of a pilot's/persona's specific needs to be covered. In this direction, a dedicated template has been developed in collaboration by of WP2, commonly agreed with all the participants, and circulated among the pilot partners involved in the task to identify the first set of user stories. This activity was managed and led through several video calls between the task leader and the partners. Contributions were provided in two rounds, supported by a review and a follow-up activity.

3.1 Elicitation of user stories

During the elicitation process, twelve user stories in total were extracted and are briefly described, as presented in Table 1. It should be mentioned here that the elicited user stories describe what the pilots would ideally want to be implemented within BUILDSPACE. However, these user stories need to be further reviewed by the final service developers, to assess them in terms of feasibility and relevance to the project. In other words, there is a possibility that we may end up covering only some of the below presented user stories at their full potential and some of them partially.

Table 1. Number of user stories extracted during the elicitation process per pilot partner and a brief description for each of them.

Pilot partner	User Story (US) ID	Brief Description
Riga Planning Region	**US1**	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.

	US2	As a municipality, I want to record heat energy consumption along the city and, in particular, to create a "Register of Chimneys" so that to implement activities to improve air quality at city level.
	US3	As a municipality, I want to offer 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.
Mostostal	**US4**	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.
	US5	As a construction company, I want to have clear insight on the groundwater level so that to support decision making regarding building foundation.
	US6	As a construction company, I want to deploy the capabilities of building's DT representation so that to report building's green energy production.
	US7	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.
	US8	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 neighboring ones that in close proximity to the construction site.
Municipality of Piraeus (MoP)	**US9**	As a municipality, I want to have a clear view of the energy and thermal performance of city's buildings so that improved energy efficiency and building management can be achieved through dedicated measures.
	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.
IMZI	**US11**	As urban planner, I want to use an online application, based on the Flood Damage Assessment Methodology, so that flooding hotspots can be visualized and the expected damage on buildings and other urban assets can be addressed.
	US12	As urban planner, I want to deploy a simplified tool, based on the calculation and per building visualization of NDVI, so that impervious urban areas and monitor blue-green infrastructure can be determined.

At this point, it should be highlighted that, although the elicited user stories have been drawn from the BUILDSPACE pilot partners following tentative bilateral meetings and several discussion rounds, their context is not constrained to the specific pilot cases, however they are extended to cover a broader

spectrum of target groups (e.g., municipalities, construction companies, etc.). As of this, the pilot-specific user stories are further clustered according to the original related target group, as presented in **Table 2**.

Table 2. Scale-up of the pilot-specific user stories to cover a broader range of target groups.

Target groups	Related user stories
Municipalities	Use building information and couple it with heat consumption data so that to compare the thermal performance between apartment buildings (US1).
	Record heat energy consumption along the city and, in particular, to create a "Register of Chimneys" so that to implement activities to improve air quality at city level (US2).
	Provide an online tool where users 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 (US3).
	Clear view of the energy and thermal performance of city's buildings so that improve energy efficiency and other aspects of building management through applying dedicated measures (US9).
	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 (US10).
Construction companies	Clear overview of the schedule of completed, ongoing, and delayed tasks for a building construction project (US4).
	Clear insight on the groundwater level so that to support decision making regarding building foundation (US5).
	Deploy the capabilities of building's DT representation so that to report building's green energy production (US6).
	Deploy the capabilities of building's DT representation so that to have clear overview on building's thermal bridges (US7).
	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 neighboring ones that in close proximity to the construction site (US8).
Urban Planners	Use an online application, based on the Flood Damage Assessment Methodology, so that to visualise flooding hotspots and address the expected damage on buildings and other urban assets (US11).
	Deploy a simplified tool, based on the calculation and per building visualisation of NDVI, so that to determine impervious urban areas and monitor blue-green infrastructure (US12).

3.2 Delving into the user stories

In this section, related user stories, as captured by the BUILDSPACE pilots, are thoroughly presented, along with their context in terms of objectives, challenges, and available data. The user stories reflect the main needs of users and stakeholders, with the aim to define further the platform services and related potential business opportunities. The same kind of aggregation that has been carried out to the user stories (**Table 2**) based on the spectrum of target groups (i.e., municipalities, construction companies, and research institutions) that they cover, will be applied to the following in-depth presentation of the user stories as well.

3.2.1 Municipalities

Thermal performance comparison based on the coupling of building information with heat consumption data

User Story ID	US1				
Pilot	RPR				
Description	Municipality of Riga wants to use available building information and couple it with heat consumption data in order to compare the thermal performance between apartment buildings.				
Rationale *(Justification of the user story)*	Energy efficiency improvement for every building which is connected to the district heating network.				
Challenges	District heating company data systems are not fully linked to building data register and thus need some preparation to be usable with machine learning algorithms.				
Data Availability					
Dataset name	**Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**
Heat energy meter	Energy consumption	Database, api, .csv	Available in few months	H (Previous day)	Need to be clarified

Streets & addresses	Information on actual Riga city addresses and streets; LKS-92 TM coordinate system.	.shp, gpkg	Available without restrictions	H (updated from time to time according to changes)	Authorised download via cloud solution
LIDAR point cloud	Automatically classified point cloud – ground level, low vegetation, high vegetation, buildings; LKS-92 TM coordinate system	.las	Available with restrictions	H (2021)	Authorised download via cloud solution
LOD1, LOD2	3D models of buildings (level of details 1 and 2); LKS-92 TM coordinate system	.gpkg	Available without restrictions	H (point cloud from year 2021)	Authorised download via cloud solution
Cadastral data	The cadastral map of the cadastral objects. Spatial data: borders of a land unit and part of a land unit; Boundary points of the land unit and part of the land unit; External contours and placement of the building in the land unit; Boundary and identifier of the easement territory	.shp	Available without restrictions	H (updated from time to time according to changes)	Download in Latvian open data webpage https://data.gov.lv/dati/lv/dataset/kadastra-informacijas-sistemas-atverti-telpiskie-dati

Decentralised heat generation and air pollution: creation of "Register of chimneys"

User Story ID	US2
Pilot	RPR
Description	Municipality of Riga has to create and implement activities to improve the quality of air. Modelling of heat energy consumption shows a large impact of decentralised heat supply solutions on air quality in the city. Municipality of Riga has to create the "Register of Chimneys" which provides information on air pollution, which comes from decentralised

	heat generation in given areas of the city. All local heating boilers have to be identified and sources of heat need to be added.
Rationale ***(Justification of the user story)***	Implementation of activities towards air quality improvement.
Challenges	Lack of data sources to identify the heat source of a building.

Data Availability

Dataset name	**Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**
LIDAR point cloud	Automatically classified point cloud – groud level, low vegetation, high vegetation, buildings; LKS-92 TM coordinate system	.las	Available with restrictions	H (2021)	Authorised download via cloud solution
Population data	Number of permanent residents by registered place of residence in 100×100 m grid cells; LKS-92 TM coordinate system	.shp	Available without restrictions	H (2020-2022)	Authorised download via cloud solution
Streets and addresses	Information on actual Riga city addresses and streets; LKS-92 TM coordinate system	.shp, .gpkg	Available without restrictions	H (updated from time to time according to changes)	Authorised download via cloud solution
Cadastral data	The cadastral map of the cadastral objects. Spatial data: borders of a land unit and part of a land unit; Boundary points of the land unit and part of the land unit; External contours and placement of the building in the land unit; Boundary and identifier of the easement territory.	.shp	Available without restrictions	H (updated from time to time according to changes)	Download in Latvian open data webpage https://data.gov.lv/dati/lv/dataset/kadastra-informacijas-sistemas-

					atverti-telpiskie-dati
Pollution data (solid particles (PM10) and NO2)	Territorial zoning of air pollution according to the annual average concentration of air pollutants - nitrogen dioxide (NO2) and particles PM10 in the air.	.shp	Available without restrictions	H (2018)	Authorised download via cloud solution
Gas heating infrastructure data	Highly detailed topographical information on gas infrastructure	WMS	Available with restrictions	H (updated from time to time according to changes)	Authorised login solution

Energy production prediction for solar panels on buildings' roofs

User Story ID	**US3**				
Pilot	RPR				
Description	Municipality of Riga wants to promote the use and installation of solar panels on roofs of private and public buildings. Municipality of Riga wants to create an online tool where buildings' owners can find out the solar potential of the building under consideration.				
Rationale ***(Justification of the user story)***	Increase the penetration of RES in buildings				
Challenges	Complexity of calculations due to the use of real weather and climate data, forecasting algorithms, spatial data, etc.				
Data Availability					
Data set name	**Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**

LOD1, LOD2	3D models of buildings (level of details 1 and 2); LKS-92 TM coordinate system	.gpkg	Available without restrictions	H (until 2021)	Authorised download via cloud solution
LIDAR point cloud	Automatically classified point cloud – ground level, low vegetation, high vegetation, buildings; LKS-92 TM coordinate system	.las	Available with restrictions	H (2021)	Authorised download via cloud solution
Streets and addresses	Information on actual Riga city addresses and streets LKS-92 TM coordinate system	.shp, .gpkg	Available without restrictions	H (updated from time to time according to changes)	Authorised download via cloud solution
DSM	Digital surface model; three different models - with 0.25m, 0.5m and 1m step; LKS-92 TM coordinate system	.tif (georeferenced)	Available with restrictions	H (from 2021 aerolasers scanning data)	Authorised download via cloud solution
Cadastral data	The cadastral map of the cadastral objects; spatial data: borders of a land unit and part of a land unit; Boundary points of the land unit and part of the land unit; External contours and placement of the building in the land unit; Boundary and identifier of the easement territory	.shp	Available without restrictions	H (updated from time to time according to changes)	Download in Latvian open data webpage https://data.gov.lv/dati/lv/dataset/kadastra-informacijas-sistemas-atverti-telpiskie-dati

Buildings energy and thermal performance monitoring

User Story ID	US9
Pilot	MoP

Description	As a public authority, MoP wants to have a clear view of the energy and thermal performance of its buildings in order to to have the necessary information to improve their energy efficiency and corresponding aspects of building management.
Rationale ***(Justification of the user story)***	• Identify and label different parts of the building(s) to be used for energy efficiency analysis. • MoP aims to perform analysis on energy and resource efficiency of buildings and make informed decisions for interventions. • Overview of buildings' energy and thermal performance.
Challenges	• Most municipal buildings are old and the information needed for the creation and enrichment of the DT is subject to availability. For this, exact prerequisites must be provided. This will also facilitate the selection of the building(s) for the pilot. • The proposed decisions / interventions need to follow the architectural specifications of the particular building(s) (e.g., buildings classified as preserved due to architectural elements and / or historical value, etc.).

Data Availability

Data set name	Description	Format	Availability	Real Time (RT)/ Historical (H)	Access
Sensors	Energy consumption, temperature sensors	database, api	Available in a few months	RT and H from 6/2023	Authorised Login
Plans	Building plans	cad, photos	Available for few buildings	H	Upon request (local storage)

Urban heat analysis

User Story ID	US10
Pilot	MoP
Description	As a Municipal Authority, MoP wants to enable urban heat analysis and calculate social vulnerability to urban heat in order to support the resilience of buildings in the city against climate change (urban heat), as well as the public healthcare.

Rationale *(Justification of the user story)*	• Identification of environmental hotspots that increase pressure to local city ecosystems. • Get insights on the social vulnerability to heat. • Make informed decisions for interventions for the mitigation of urban heat. • Perform repeated heated analysis to any building or area
Challenges	• Most municipal buildings are old and there is no information on materials used, only assumptions based on date of construction. • Obtaining up to date socioeconomic data.

	Data Availability				
Dataset name	**Data Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**
Demographic data	Age, gender, residence location, marital status, nationality, etc.	pdf	Application to Hellenic Statistical Authority	H (2001, 2011, 2021 Census)	Some publicly available, some through application to Hellenic Statistical Authority
Socioeconomic data	Type of housing, energy, economic status, employment status, profession etc.	pdf	Application to Hellenic Statistical Authority	H (2001, 2011, 2021 Census)	Some publicly available, some through application to Hellenic Statistical Authority
Meteorological and air pollution data from sensors	DeltaOHM HD33MT and HD35 meteorological station and PM measurements (PM1, PM2.5, PM10, CO_2, Solar radiation etc.)	database, api	Available	RT and H from 6/2023	Authorised login and download

3.2.2 Construction companies

Monitoring of the construction process

User Story ID	US4				
Pilot	MOS				
Description	As a construction company, MOS wants to have a clear overview of the schedule of completed, ongoing, and delayed tasks.				
Rationale *(Justification of the user story)*	Schedule overview				
Challenges	• Create DT models of the current state of progress of construction works. • Connect DT models with BIM models and construction work schedule. • Data connect with AR device (communication aspect). • Correct identification of elements on the construction site, which is a changing environment.				
Data Availability					
Dataset name	**Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**
BIM model	Construction model	IFC	Warsaw demo	BIM data	Dalux platform
Work schedule	Descriptions, timelines, etc.	xls or mpp	Yes	RT and H	Local host

Groundwater level insight

User Story ID	US5

Pilot	MOS
Description	As a construction company, MOS wants to have clear insight on the groundwater level.
Rationale *(Justification of the user story)*	• Decision making support related to building foundation level and indication of possible risks • Information on the groundwater level
Challenges	• Access to current environmental data on the groundwater level. • Link geometrical BIM data of the building with the GIS model. • Employment of Copernicus data regarding urban flood.

Data Availability

Dataset name	Description	Format	Availability	Real Time (RT)/ Historical (H)	Access
BIM model	Construction model	IFC	Warsaw demo	BIM data	Dalux platform
GIS database	Hydrogeological Map of Poland (MHP) in the scale of 1:50,000	GIS	Yes	H	*https://www.pgi.gov.pl/psh/dane-hydrogeologiczne-psh.html*

Monitoring of buildings' green energy production

User Story ID	US6
Pilot	MOS
Description	As a construction company, MOS wants to create a digital twin representing dynamic data on building's green energy production.
Rationale *(Justification of the user story)*	Visual representation of building's green energy production

Challenges	• Creation of building's digital twin • Connecting sensors related to the measurement of energy production • Forecast of energy production taking into account weather conditions

Data Availability

Dataset name	Description	Format	Availability	Real Time (RT)/ Historical (H)	Access
BIM model	Construction model	IFC	Szczecin demo	BIM data	Dalux platform
Weather data	Meteorological data	.csv	Szczecin demo	H and RT	Online weather station

Thermal Bridges Inspection

User Story ID	US7
Pilot	MOS
Description	As a construction company, MOS wants to have a clear overview of the thermal bridges in the building.
Rationale *(Justification of the user story)*	Quality control
Challenges	• Building DT creation • DT connection with BIM models and thermal scanning

Data Availability

Dataset name	Description	Format	Availability	Real Time (RT)/ Historical (H)	Access
BIM model	Construction model	IFC	Warsaw, Szczecin, Gdańsk	BIM data	Dalux platform

Point cloud	Thermal scanning	Infrared thermal images	Szczecin, Gdańsk	RT and H	Local host

Buildings Quality Control

User Story ID	US8				
Pilot	MOS				
Description	As a construction company, MOS wants to perform quality control (cracks) of new or renovated buildings, as well as neighboring buildings that are in close proximity to the construction site.				
Rationale *(Justification of the user story)*	Quality control				
Challenges	• DT creation of the built building and surrounding buildings • Detection of cracks of the buildings control of the structure of the building under construction • Control of cracks in the facades of surrounding buildings • Detection of building movements based on historical data				
Data Availability					
Dataset name	**Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**
BIM models	Construction model	IFC	Warsaw	BIM data	Dalux platform

3.2.3 Urban Planners

Flood damage assessment

User Story ID	US11

Pilot	IMZI
Description	As IMZI, we want to develop a user-friendly online application based on the already developed Flood Damage Assessment Methodology (FDAM). FDAM will be upgraded to address the expected damage on buildings and other urban assets in urban flooding caused by short-term extreme rainfall events. By adding new features of calculating the terrestrial altitude and making individual geolocated inputs for flood damage events, we will provide a visualization of flooding hotspots, creating evidence of historical events and, simultaneously, enabling the validation of the proposed FDAM.
Rationale ***(Justification of the user story)***	Develop a user-friendly online application for visualising flooding hotspots and addressing the expected damage on buildings and other urban assets by adopting an existing assessment methodology.
Challenges	• A GIS-based application with "intersection of layers" functionalities. • Large amount of data that are non-standardised and/or specific for Slovenia; difficulty to make an app. more simple and universal for several European countries • How to make the app. more user-friendly for end-users without GIS and ICT skills • How to attract, include, engage stakeholders into the engagement process; to prepare appropriate simple interactive surveys, how to activate users to provide inputs into BUILDSPACE platform • How to give appropriate feed-back to the engaged users within the BUILDSPACE project. • Data quality and EU data availability assessment

Data Availability

Dataset name	**Description**	**Format**	**Availability**	**Real Time (RT)/ Historical (H)**	**Access**	**Related tools/modules**
Sentinel-1 SAR imagery	Flooded urban areas	Shapefile /Geotiff	Public available data	Near RT	apiGFM	Swagger
LIDAR	DEM	Geotiff	Public available data	H	eVode	INSPIRE; open source softwares: QGIS, LAStools, FUSION, SAGA
Water Cadastre -	Planar spatial objects represent	Shapefile	Public available data	H	eprostor	INSPIRE

Integral Map of Flooding Depths	areas of depths; 3 layers for 3 different flooding depths: GM, GS, GV					
Registry of spatial units	14 layers for 14 different types of spatial units	Shapefile	Public available data	H	ipi	JGP application
Consolidated Cadastre of Public Infrastructure	16 layers for 16 different types of infrastructure	Shapefile /XML	Public available data	H	gu/eprostor	INSPIRE WFS, ATOM, WFC feed
Cadastrial Parcels	4 shapefiles /Zipped GML, split into 212 files	Shapefile /GML	Public available data	H	gu/ eprostor	EGP application
The Land Use database	Zipped GML	GML	Public available data	H	e-prostor	INSPIRE ATOM feed
Building	shapefiles/Zipped GML, split into 212 files	Shapefile /GML	Public available data	H	gu/eprostor	EGP application/ service INSPIRE WFS, ATOM, WFC feed
Registry of assets	CSV, D96, 26.05.2022	CSV	Public available data	H	gu	EGP application
Protection Regimes of Cultural Heritage	shapefiles/Zipped GML	Shapefile /GML	Public available data	H	kult/opsi	service INSPIRE WFS, ATOM, WMS

Determination of impervious urban areas by calculating the average Normalised Difference Vegetation Index

User Story ID	US12
Pilot	IMZI
Description	As IMZI, we want to develop a simplified global tool for the determination of impervious urban areas by calculating an average Normalized Difference Vegetation Index (NDVI) to

	enable visualisations of average NDVI per building or building's plot. Its comparison on a neighborhood or city level will help to stimulate all responsible for taking action for higher urban climate resilience. By enabling inputs to be entered manually in the system as the records from the ground by end users, we will allow creating evidence of blue-green infrastructure measures and, simultaneously, enabling the validation of the proposed calculating tool. Incorporating this information into the enriched building Digital Twin will allow the combining and automatisation of modeling, simulation and monitoring of blue-green infrastructure impact.
Rationale *(Justification of the user story)*	• Develop a tool for visualising the Normalised Difference Vegetation Index (NDVI); an index that results what is impervious and what is pervious. • Comparing NDVI on a neighborhood or city level will help the prioritisation of blue-green infrastructure measures. • Identification of critical urban flooding risk points. • Provide input for reporting requirements, such as for the local, national and EU urban planning and water management politics.
Challenges	• Make automatisation of data updating • A GIS-based application with "intersection of layers" functionalities • Use LIDAR as a large amount of data and not to slow down the app • Choose the most appropriate way to provide a set of visualisations for several historical and/or current satellite images • How to attract, include, engage stakeholders into the engagement process; to prepare appropriate simple interactive surveys, templates for questionnaires/personal interviews, etc.; how to activate users to provide inputs into BUILDSPACE platform • How to give appropriate feed-back to the engaged stakeholders within the BUILDSPACE project • Data quality and EU data availability assessment • Integrate information about NDVI in enriched Digital Twin to support evaluating blue-green infrastructure impact

Data Availability

Dataset name	Description	Format	Availability	Real Time (RT)/ Historical (H)	Access	Related tools/ modules
NDVI	4 layers	XML, corresponding XSLT for XML viewing and a coloured	BUILDSPACE service	H: within 3 days after synth. period	Copernicus	Copernicus Global Land Service app.

		quicklook in GeoTiff format are made available separately				
LIDAR	DEM	Geotiff	Publicly available	H	eVode; for tasting and data preparation phase	open source softwares: QGIS, LAStools, FUSION, SAGA
Building	shapefiles/ Zipped GML, split into 212 files	Shapefile/GML	Publicly available	H	gu/ eprostor	EGP application/ INSPIRE WFS, ATOM, WFC
Registry of assets	CSV, D96, 26.05.2022	CSV	Publicly available	H	gu	EGP application
Cadastrial Parcels	4 shapefiles/Zipped GML, split into 212 files	Shapefile/GML	Publicly available	H	gu/ eprostor	EGP application
Water land	1 shapefile/ Zipped GML	Shapefile/GML	Publicly available	H	evode/ eprostor	download/ download service INSPIRE WMS, ATOM
Water Body under the Water Framework Directive	GML	GML+XML	Publicly available	H	INSPIRE Geoportal	INSPIRE Geoportal application
Actual land use	1 shapefile/ Zipped GML	Shapefile/GML	Publicly available	H	eprostor	download/ download service

						INSPIRE WMS, ATOM
Urban planning data – future land use	1 layer	Shapefile/GML	Public available data; Spatial planning is country specific and we cannot expect standardised/ EU availability	H	eprostor	download/ download service INSPIRE WMS, ATOM
Soil Water Index	3 layers	A multi-band netCDF4 files with metadata according to the Climate and Forecast (CF) conventions (v1.6). An INSPIRE compliant metadata file, XSLT for XML viewing and a sub-sampled, coloured quick look image in GeoTIFF format are provided separately	Publicly available	H (daily)	Copernicus	Copernicus Global Land Service app.
Surface Soil Moisture	2 layers	A multi-band netCDF4 files with metadata according to the Climate and Forecast	Publicly available	H (within 2 days after observation)	Copernicus	Copernicus Global Land Service app.

		(CF) conventions (v1.6). An INSPIRE compliant metadata file, XSLT for XML viewing and a sub-sampled, coloured quicklook image in GeoTIFF format are provided separately				

3.3 Mapping of the user stories to target groups and personas

To facilitate next steps and link the elicitation of user stories with task T2.4, pilot partners were also asked to identify related stakeholders to be engaged in the whole user story development process, as well as target groups to be directly benefited from the services prescribed within each user story (i.e., target groups will be the main users of the services that will be developed) and potential personas.

According to the "Terminology" developed and adopted for the purpose of BUILDSPACE (presented at the beginning of this deliverable), by *Target Group* we mean a group of potential users of the services, that will be benefited from the outcomes of the actual implementation of each user story within each pilot. Based on the pilots' input, we have classified the identified target groups as presented in **Table 3**.

Table 3. Identified target groups during the user story elicitation process and a brief description for each of them.

Target Group	Brief Description
Citizens, tenants, and owners	Citizens and individual owners
Facility managers	Managers that oversee the management of a facility's physical assets

SMEs, companies, and entities	Small and Medium enterprises that deal with sustainability issues of buildings and cities
Policy makers	Public authorities and policy makers (e.g., municipalities)
Utilities	Public and private utilities
Constructors and contractors	Construction companies and engineering consultancy firms
Investors	Real estate investors

Target groups are closely interrelated to Personas. *Persona* is a fictional character created to represent the needs, desires and behaviours of a Target Group, to ensure that the perspective of its members is always considered along the process (see "Terminology" at the beginning of this deliverable). Each Persona captures a different point of view within a Target Group, and as of this, several Personas may exist for each Target Group. In the same context, there may be Target Groups where no specific Personas have been identified, since there are some cases where the identified Target Groups are considered sufficient enough to express the different needs and behaviours. Personas (if present) will develop their own user stories as well (on top of the pilots' user stories), respective service functionalities will be designed, tailored also to the needs of Personas. **Table 4** presents the identified Personas per Target Group for each user story according to the pilots' input during the elicitation process.

Table 4. Identified Personas per Target Group for each user story.

User Story	Target Group	Persona
US1	Citizens, tenants, and owners	Active apartment building owners who support building renovation and need some supporting information
		Building owners and inhabitants
	Facility managers	Building renovation managers
	SMEs, companies, and entities	Energy auditors
		Building maintenance companies

US2	Policy makers	Energy Agency at municipal level
		Development Department at municipal level
		Responsible employees and decision makers of the municipality
	Citizens, tenants, and owners	-
	Utilities	-
US3	Facility managers	Public building renovation managers
		Apartment building renovation managers
	SMEs, companies, and entities	Energy consultants
		Energy auditors
		ESCOs
	Citizens, tenants, and owners	Active apartment building owners
		Business property owners
		Building owners and inhabitants
US4	Constructors and contractors	Construction workers
US5	Constructors and contractors	Construction managers
		Designers

US6	Citizens, tenants, and owners	Building owners
	Facility managers	Building managers
	Investors	-
US7	Constructors and contractors	Construction workers
	Citizens, tenants, and owners	Building owners
US8	Citizens, tenants, and owners	Building owners
	Facility managers	Building managers
	Constructors and contractors	Construction workers
US9	Citizens, tenants, and owners	Building owners
		Building occupants (people working or using the building for other purposes)
	Policy makers	-
	Facility managers	Building managers
US10	Citizens, tenants, and owners	Citizens of Piraeus
		Residents vulnerable to heat
		Owners of buildings/apartments
	Policy makers	MoP Social Services

		MoP Urban Planning Dept
US11	Policy makers	Civil protection
		Public authorities
		Urban planners
	Utilities	Infrastructure providers
	Investors	Potential investors
	SMEs, companies, and entities	Insurances
	Citizens, tenants, and owners	Landowners
		Building owners
	Constructors and contractors	Land developers
US12	Policy makers	Public authorities
		Urban planners
	Utilities	Infrastructure providers
	Investors	Potential investors
	SMEs, companies, and entities	Institutions (e.g., research and development, academic, etc.)
		Energy consultants

	Citizens, tenants, and owners	Land-owners
		Building owners
	Constructors and contractors	Land developers

3.4 Elicitation of user requirements

To capture the user requirements (functional/non-functional) from the user stories, an elicitation process in collaboration with the pilot partners was followed. The user requirement elicitation process results in two categories of requirements which are defined below:

- **Functional requirements** describe the expected behaviour or output of a system and/or its components in case of a certain input, facilitating the development team to decide which technical problem is addressed (Broy 2010). The elicited functional requirements have been classified in the following categories:

    - Analytics
    - Compatibility
    - Visualisation
    - Collection
    - Reporting
    - Integration
    - Interaction

- **Non-functional requirements** define system attributes such as security, reliability, performance, maintainability, scalability, and usability, ensuring effectiveness of the entire system. Non-functional requirements must be always considered on the basis of designing and implementing an integrated system (Chung and do Prado Leite, 2009). The elicited non-functional requirements have been classified in the following categories:

    - Efficiency
    - Interoperability
    - Reliability
    - Security
    - Usability

The elicitation of user requirements (functional and non-functional) along with the category that each requirements belongs to, the type of requirement, the related user story and the related services prescribed within BUILDSPACE (for the case of functional user requirements only), are presented in **Table 5** and **Table 6,** respectively. It should be mentioned here that the extracted technical specifications will be further reviewed by the final service developers as the project continues. This implies (as was the case for the user requirements) a possibility that some of them will be covered at their full potential and some of them partially.

To ease readability of **Table 5,** below the services that will be developed for the purpose of BUILDSPACE are presented:

- **Service 1 (SE1)** – Digital Twin Generation: This service will integrate methods for generating the geometry of Digital Twins of Buildings and will build the associated interfaces for human-information interaction between users and Digital Twins (Pilots: RPR, MOSTOSTAL, MoP, IMZI).
- **Service 2 (SE2)** – Digital Twins enrichment by combining UAV, thermography and SLAM approaches: This service will enable the integration of SLAM-based approaches, UAV platforms and thermal analysis for Digital Twins enrichment for an advanced and accurate building energy performance assessment (Pilots: MOSTOSTAL, MoP).
- **Service 3 (SE3)** – Building Environment Climate Scenarios: This service will rely on forecast of energy demand and will support urban stakeholders in understanding how the building stock energy demand will be affected in the future by climate change (Pilots: RPR).
- **Service 4 (SE4)** – Urban Heat Analysis and Resilience: This service will analyse urban heat at high resolution and will combine demographic data to calculate the urban heat risk and assess social vulnerability to heat (Pilots: MoP).
- **Service 5 (SE5)** – Urban Flood Resilience: This service will combine Copernicus data and available public or city data and systematic measurements to increase building resilience to flood damages in urban environments (Pilots: IMZI).

Table 5. Elicitation of functional user requirements along with the category that each requirement belongs to, the related user story and the related services prescribed within BUILDSPACE.

ID	Requirement Description	Category of requirement	Related User Story	Related Service
RQ01	Connect district heating consumption data in apartment buildings with available building information (e.g., area, volume, etc.)	Analytics, Compatibility	US1	SE1, SE3

RQ02	Calculate energy efficiency rating of buildings that are connected to the district heating network	Analytics	US1	SE1, SE3
RQ03	Visualise building's energy efficiency rating	Visualisation	US1	SE1, SE3
RQ04	Link "bad" energy efficiency rating buildings with recommended solutions	Analytics	US1	SE1, SE3
RQ05	Identify all chimneys by using satellite thermography images	Collection	US2	SE1, SE3
RQ06	Connect every "hot" chimney to building and heated area data	Collection	US2	SE1, SE3
RQ07	Connect every "hot" or used chimney to heat source used in the building	Collection	US2	SE1, SE3
RQ08	Create a list of heated buildings and used heat source	Reporting	US2	SE1, SE3
RQ09	Calculate building's heat consumption	Analytics	US2	SE1, SE3
RQ10	Calculate air pollution for each heat source	Analytics	US2	SE1, SE3
RQ11	Measure the roof area that is available for solar energy generation	Analytics	US3	SE1, SE3
RQ12	Measure the shaded roof area	Analytics	US3	SE1, SE3
RQ13	Calculate the yearly output of solar panels	Analytics, Reporting	US3	SE1, SE3

RQ14	Calculate the available amount of solar energy (solar energy potential of the building)	Analytics, Reporting	US3	SE1, SE3
RQ15	Visual representation of the progress of construction works on daily/weekly basis	Visualisation	US4	SE1, SE2
RQ16	Identify quickly and accurately hazards that are associated with groundwater levels, taking also into account the weather changes	Analytics, Compatibility, Visualisation	US5	SE1, SE2
RQ17	Visual representation of green energy production and related savings	Visualisation	US6	SE1, SE2
RQ18	Visual identification of thermal bridges of the buildings	Visualisation	US7	SE1, SE2
RQ19	Detect cracks in the building structure or displacement of the building or surrounding buildings	Analytics, Visualisation	US8	SE1, SE2
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	Analytics	US9	SE1, SE2, SE4
RQ21	Provide a baseline indicator value for the thermal performance, as well as a procedure to replicate on more municipal or other buildings	Analytics	US9	SE1, SE2, SE4
RQ22	Measure the impact of interventions at building scale	Analytics	US9	SE1, SE2, SE4
RQ23	Measure the impact of interventions at city scale	Analytics	US9	SE1, SE2, SE4

RQ24	Provide a baseline indicator value for the social vulnerability to urban heat	Analytics	US10	SE1, SE2, SE4
RQ25	Measure relevant heat indicator values at any time	Analytics	US10	SE1, SE2, SE4
RQ26	Acquire necessary expertise and equipment to perform building and city level heat analysis at any time, at any building	Reporting	US10	SE1, SE2, SE4
RQ27	Identify specific areas where urban heat is significantly higher than the rest of the city	Analytics	US10	SE1, SE2, SE4
RQ28	Measure the impact of interventions at the city level regarding urban heat and social vulnerability	Analytics	US10	SE1, SE2, SE4
RQ29	Develop an online version of the already existing Flood Damage Assessment Methodology (FDAM) tool	Integration	US11	SE5
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	Analytics, Interaction	US11	SE5
RQ31	Make the upgraded FDAM more user-friendly in terms of eliminating the needs for GIS and requiring programming skills by the end-users	Interaction	US11	SE5
RQ32	Visualise flooding hotspots by combining available off-line flooding altitude data, satellite urban floods images and	Visualisation, Compatibility	US11	SE5

	satellite terrestrial altitude data			
RQ33	Calculate the flood damage per m^2 of urban area	Analytics	US11	SE5
RQ34	Calculate the flood damage per m of urban infrastructure	Analytics	US11	SE5
RQ35	Calculate the flood damage per building	Analytics	US11	SE1, SE5
RQ36	Build evidence of urban planning events by enabling to make individual georeferenced inputs by the end users	Interaction	US11	SE5
RQ37	Calculate the terrestrial altitude from satellite LIDAR DEM model with open source softwares: QGIS, LAStools, FUSION, SAGA and make a kind of intersection of them	Compatibility	US11	SE5
RQ38	Calculate the average Normalized Difference Vegetation Index (NDVI) per buildings or buildings‘ plots	Analytics	US12	SE1, SE5
RQ39	Assess how blue-green is a building or a building's plot	Analytics	US12	SE1, SE5
RQ40	Identify where are the critical points in view of high urban flooding risk	Analytics, Reporting	US12	SE5
RQ41	Create NDVI trends over seasons and years	Analytics	US12	SE5
RQ42	Monitor existing blue-green infrastructure measures by attaching photos and writing	Analytics, Compatibility, Interaction	US12	SE5

	some connected text/descriptions			
RQ43	Calculate the terrestrial altitude from satellite LIDAR DEM model with open source softwares: QGIS, LAStools, FUSION, SAGA	Analytics, Compatibility	US12	SE5
RQ44	Combine available terrestrial with satellite data in order to identify potential flooding hotspots	Analytics, Compatibility	US12	SE5
RQ45	Analyse the effects of blue-green infrastructure measures on flooding resilience of buildings	Analytics	US12	SE1, SE5

Table 6. Elicitation of non-functional user requirements, horizontally applied to all user stories.

ID	Requirement Description	Category of requirement
RQ46	Guarantee the security of stored information	Reliability
RQ47	Support real time data collection	Interoperability
RQ48	Provide time-efficient analytics methods	Efficiency
RQ49	Support different authorisation access level for different users	Security
RQ50	Support error protection methods for user input fields	Usability
RQ51	Enable easy user navigation through the platform	Usability

RQ52	Prevent users from inserting invalid input	Usability
RQ53	Allow extensibility and easy implementation of new functionalities	Usability

3.5 Extracting Technical Requirements from the elicited User Requirements

In this section, a first iteration of BUILDSPACE technical requirements is presented, as a result of the translation of the user requirements. To this end, Table 7 includes the description of BUILDSPACE technical requirements along with the related user requirements from which each technical requirement has been elicited. However, it should become clear that the following list of technical requirements is the result of an initial desk research that has been performed by the authors of this deliverable, combined with a first discussion round with the dedicated technical partners of the BUILDSPACE project. Given that the process for capturing the final context of each technical requirement is an ongoing and ever developing process, the technical requirements presented below will be further elaborated and enhanced in the near future, following several co-creation activities and rounds of social and stakeholder engagement that will be carried out as part of the Task T2.3 of the BUILDSPACE project. The alignment and merging with the respective work that is currently being done for the purpose of Task T2.2, which is focused on the synchronisation of the final technical requirements with existing frameworks and available components of Copernicus and EGNSS, will be also taken into consideration.

Table 7. Technical requirements elicited as a result of the translation of the user requirements and a brief description for each of them.

Technical Requirement ID	Description	Details	Related User Requirement
TR01	Energy efficiency visualisation	It is required to fligh a DRONE equipped with an RGB camera and a thermal camera to capture a set of images from which it will be possible to generate the final 3D model. Additionally, this flight needs to be supported by GPS points in order to scale and georeference the data.	RQ03
TR02	Visualisation of building's energy efficiency rating	The output of the SE 1 (Digital Twin) in .ifc format could provide the required visualization of the building. For this, the data for Digital Twin generation must contain X. Y, Z, R, G, B and t data to generate the final 3D model.	

TR03	Must provide data visualisation tools and functionalities	Web GIS tool to visualise Copernicus Urban Atlas land use data (.shp/.gpkg) along with building energy performance ratings.	
TR04	Support importing datasets in different formats	Copernicus Urban Atlas data (.shp/.gpkg) must be supported to link "hot chimneys", address with land use.	RQ06
TR05	Construction works monitoring	A survey is required with a Mobile Mapping Solution that is able to provide a 3D point cloud of the real state of the construction. This 3D point cloud could be captured at different stages of the building and then compared.	RQ15
TR06	Visualisation of progress monitoring	The output of the SE 1 (Digital Twin) could provide the required visualisation for progress monitoring. The final output – Digital Twin can be updated in near real-time with the as-is data to provide a real picture of the different construction phases of the building and can be compared with the as-design information. AR/VR technology can be used as a means for visualisation for the comparison between the planned and as-is analysis.	
TR07	Social vulnerability indicator to urban heat	• Statistics data are required at infra-municipal/census section scale in .csv format: ▪ Age ▪ Gender ▪ Income ▪ Education ▪ Home composition • Shapefile (.shp) containing the georeferenced of census sections.	RQ24
TR08	Support importing datasets in different formats	Sentinel 2 and Sentinel 3 data (JPEG2000) should be supported in order to define environmental indicators and hotspots.	
TR09	Heat indicator at any time	• Requires meteorological data with points distributed in different sectors of the city which will contain at least the following parameters recorded at real-time: ▪ Air temperature ▪ Relative Humidity • The above parameters may be complemented with: ▪ Air pollutants ▪ Live traffic data	RQ25

		• Use of GIS to geo-reference the data obtained. A platform will be needed to host the heat indicator and display a real-time heat indicator value.	
TR10	Support importing datasets in different formats	Climate Service data (netcdf, tiff) should be supported to provide temperature forecasts and ERA5 reanalysis data to calculate heat indicators.	
TR11	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise the spatial variability of hotspots, heat indicators and environmental indicators.	
TR12	Expertise and equipment for performing heat analysis, both at building and city level	• Design a learning programme • Training materials • Equipment: thermal drones, thermographic cameras.	RQ26
TR13	Identification of specific areas where urban heat is significantly higher than the rest of the city	• Requires meteorological data with points distributed in different sectors of the city which will contain at least the following parameters: ▪ Air temperature ▪ Relative Humidity • The above parameters may be completed with: ▪ Air pollutants ▪ Live traffic data • Additional data: ▪ Satellite images	RQ27
TR14	Support importing datasets in different formats	Sentinel 2 and Sentinel 3 data (JPEG2000) should be supported in order to identify urban heat hotspots.	
TR15	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise the spatial variability of the areas where urban heat is significantly higher than the rest of the city.	
TR16	Interventions impact at the city level regarding urban heat and social vulnerability	• A baseline should be established against which to compare the impact of interventions. This will require data on the current state of temperature and humidity. • The above can be complemented with measurements of energy consumption and temperature and humidity inside	RQ28

		vulnerable households to obtain results and verify whether the actions are having an impact on these households.	
TR17	Support importing datasets in different formats	Climate Service data (netcdf, tiff) should be supported to provide temperature forecasts and ERA5 reanalysis data to calculate heat indicators.	
TR18	Support importing datasets in different formats	Sentinel 2 and Sentinel 3 data (JPEG2000) should be supported in order to identify urban heat hotspots.	
TR19	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise the spatial variability of hotspots, heat indicators and environmental indicators.	
TR20	District heating consumption data linkage with building information	The output of the SE 1 (Digital Twin) in .ifc format could provide the required building information (e.g., area, volume, etc) to connect district heating consumption data in apartment buildings.	RQ01
TR21	Support importing datasets in different formats	Copernicus Urban Atlas data (.shp/.gpkg) must be supported to link energy consumption, address and cadastral data with land use.	
TR22	Chimneys' identification	The output of the SE 1 (Digital Twin) in .ifc format could provide the required identification and visualisation of the building. For this, the data for Digital Twin generation must contain X. Y, Z, R, G, B and t data to generate the final 3D model.	RQ05
TR23	Measure the roof area that is available for solar energy generation	The output of the SE 1 (Digital Twin) in .ifc format could provide the required area calculations for solar energy generation.	RQ11
TR24	Support importing datasets in different formats	EU data from GHSL - Global Human Settlement Layer (.tiff) should be supported to provide detailed data for buildings.	
TR25	Visual identification of thermal bridges of the buildings	The output of the SE 1 (Digital Twin) in .ifc format could provide the required identification and visualisation of the building. For this, the data for Digital Twin generation must contain X. Y, Z, R, G, B and t data to generate the final 3D model.	RQ18

TR26	Detect cracks in the building structure or displacement of the building or surrounding buildings	The output of the SE 1 (Digital Twin) in .ifc format can be used to identify and locate the cracks in the building structure or displacement of the building or surrounding buildings.	RQ19
TR27	Support importing datasets in different formats	Copernicus Urban Atlas data (.shp/.gpkg) must be supported to link energy consumption, address and cadastral data with land use. Also processed Sentinel 2 data (JPEG2000 format) should be supported to evaluate the state of vegetation with the use of vegetation indices.	RQ02
TR28	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise Copernicus Urban Atlas land use data (.shp/.gpkg) along with heated buildings and heat source.	RQ08
TR29	Support importing datasets in different formats	CAMS European air quality forecasts data (GRIB/netcdf) should be supported in order to validate air pollution calculations.	RQ10
TR30	Support importing datasets in different formats	EU data from GHSL - Global Human Settlement Layer (.tiff) should be supported to provide detailed data for buildings.	RQ12
TR31	Support importing datasets in different formats	CAMS solar radiation time series (GRIB/netcdf) should be supported to calculate yearly output.	RQ13
TR32	Support importing datasets in different formats	CAMS solar radiation time series (GRIB/netcdf) should be supported to calculate yearly output.	RQ14
TR33	Support importing datasets in different formats	Climate Service data (netcdf, tiff) should be supported to provide temperature forecasts and past data for energy consumption analysis.	RQ20
TR34	Support importing datasets in different formats	Climate Service data (netcdf, tiff) should be supported to provide temperature forecasts and past data for energy consumption analysis.	RQ21
TR35	Support importing datasets in different formats	Climate Service data (netcdf, tiff) should be supported to provide extreme precipitation and flood risk indicators.	RQ30

TR36	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise the spatial variability of flood risk and extreme precipitation projections.	
TR37	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) should be supported in order to identify flooded areas.	RQ32
TR38	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise the spatial extent of flooded areas from satellite images.	
TR39	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) should be supported in order to calculate the flood damage area.	RQ33
TR40	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) and CLMS Imperviousness data (.tiff) should be supported in order to calculate the flood damage area of urban areas.	RQ34
TR41	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) and EU data from GHSL - Global Human Settlement Layer (.tiff) should be supported in order to calculate the flood damage area of urban areas.	RQ35
TR42	Support importing datasets in different formats	CLMS DEM products should be supported (.tiff).	RQ37
TR43	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) should be supported to calculate NDVI.	RQ38
TR44	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) should be supported in order to calculate related indices.	RQ39
TR45	Support importing datasets in different formats	CLMS DEM products should be supported (.tiff).	RQ40
TR46	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) should be supported to calculate NDVI.	RQ41

TR47	Support importing datasets in different formats	CLMS DEM products should be supported (.tiff).	RQ43
TR48	Support importing datasets in different formats	Sentinel 2 data (JPEG2000) should be supported in order to identify flooded areas.	RQ44
TR49	Must provide data visualisation tools and functionalities	Web GIS capabilities to visualise the spatial extend of flooded areas from satellite images.	
TR50	Support importing datasets in different formats	• Soil Water Index (Sentinel-1 C-SAR and Metop ASCAT) • Surface Soil Moisture (Sentinel-1 C-SAR)	
TR51	Support importing datasets in different formats	Copernicus Urban Atlas data (.shp/.gpkg) must be supported to link flood risk with land use.	RQ45

3.6 Feasibility of User Requirements

For the purpose of BUILDSPACE, the feasibility of user requirements has been assessed in conjunction with the presence of a technical requirement. To specify, if a technical requirement has been extracted based on a specific user requirement (from the technical partners of BUILDSPACE), then this user requirement is considered feasible. In the same context, if a user requirement cannot be translated into a technical requirement, then it is classified as unfeasible. This is when mitigation measures are required, in that this user requirement needs to be mitigated in terms of what is requested for its implementation, so as to become feasible. In this respect, **Table 8**, presents the feasible user requirements along with those where mitigation measures need to be applied. This table will be used as a starting point for the creation of the use cases that will rely on a feedback loop between the technical and pilot partners. A more detailed presentation of the information included in **Table 8** is presented in **Table 21** (Annex).

Table 8. Feasibility assessment for the elicited user requirements.

Related User Story	User Requirement ID	Feasibility of User Requirement	Related Technical Requirement	Mitigation measures required
US1	RQ01	✓	TR20, TR21	×
	RQ02	✓	TR27	×

	RQ03	✓	TR01, TR02, TR03	×
	RQ04	×	-	✓
US2	RQ05	✓	TR22	×
	RQ06	✓	TR04	×
	RQ07	×	-	✓
	RQ08	✓	TR28	×
	RQ09	×	-	✓
	RQ10	✓	TR29	×
US3	RQ11	✓	TR23, TR24	×
	RQ12	✓	TR30	×
	RQ13	✓	TR31	×
	RQ14	✓	TR32	×
US4	RQ15	✓	TR05, TR06	×
US5	RQ16	×	-	✓
US6	RQ17	×	-	✓
US7	RQ18	✓	TR25	×
US8	RQ19	✓	TR26	×
US9	RQ20	✓	TR33	×
	RQ21	✓	TR34	×
	RQ22	×	-	✓
	RQ23	×	-	✓
US10	RQ24	✓	TR07, TR08	×
	RQ25	✓	TR09, TR10, TR11	×

	RQ26	✓	TR12	×
	RQ27	✓	TR13, TR14, TR15	×
	RQ28	✓	TR16, TR17, TR18, TR19	×
US11	RQ29	×	-	✓
	RQ30	✓	TR35, TR36	×
	RQ31	×	-	✓
	RQ32	✓	TR37, TR38	×
	RQ33	✓	TR39	×
	RQ34	✓	TR40	×
	RQ35	✓	TR41	×
	RQ36	×	-	✓
	RQ37	✓	TR42	×
US12	RQ38	✓	TR43	×
	RQ39	✓	TR44	×
	RQ40	✓	TR45	×
	RQ41	✓	TR46	×
	RQ42	×	-	✓
	RQ43	✓	TR47	×
	RQ44	✓	TR48, TR49, TR50	×
	RQ45	✓	TR51	×

4 Description of services

In addition to the User Stories and Requirements, a high-level Service description, including relevant data and scenarios, was completed by all partners that lead the services' development, following a template with instructions prepared to that end.

The services' description are useful documents to include data and scenarios, and will allow the definition of services implementation, while matching the functionalities that the service is intended to have as a first approach with the actual needs from the users (expressed through the User Stories and User Requirements).

The template to describe the services was defined, including the scope and objective(s) of the service, a short description, input requirements, service operation, service output and service workflow. It also includes data requirements, divided into data non-dependent from Pilot (excluding Copernicus and EGNSS data services for the moment, since they are being addressed through another parallel process, as can be seen in **Section 5** and Pilot-dependent data.

The template defined is presented in the following **Table 9**. It is divided into main sections of service ID, scope and objectives of the service, narrative of the service, and data requirements.

Table 9. Services description template, with instructions, provided to provide a high-level description of the services.

Service ID			
Service name	***SE 1/2/3/4/5: Name of the service***		
Lead partner	*Partner acronym*	**Other partners involved**	*Partners acronym*
Scope and objectives of Service			
Scope	*Briefly describe what the service does and what is its scope*		
Objective(s)	*Briefly describe what is the final benefit that can be achieved with the service*		
Narrative of the service			
Short description			
Provide a short description of what the service does			
Complete description			
Input requirements	*Indicate what are the inputs needed for the service to work (for example, temperature readings with a certain reporting rate, historical data about energy consumption for at least XX years, data about the year of construction of the buildings, etc…)*		

Service operation	*Describe in a simple way relevant details about the service operation (for example, how the service uses the inputs previously indicated in order to run, if it runs periodically -every XX minutes- or if it is triggered by some events or by user request, etc.).*
Service output	*Indicate what data and/or results will be produced as output by the service and how these will be made available (for example, results only visualised in some GUI, results are in form of PDF report, other…)*

Service Workflow

Provide a preliminary description of the functionalities of the service, to then see if service match with the Pilots' needs (assessed through requirements, user stories and so on). This should be done as a series of functional envisaged steps:

1. *XXX (e.g., access to the service)*
2. *XXX (e.g., selection of pilot area to which the service has been developed)*
3. *XXX (e.g., an interactive map appears showing the building stock with coloured information of …)*
4. *XXX (e.g., there are several options to see more or less information, also by zooming an area…)*
5. *XXX (e.g., if you click on one building, it provides…)*
6. *XXX*
7. *XXX*

Data requirements

Data non-dependent from Pilot (**Copernicus and EGNSS data services** will be included in a later stage, as part of Task 2.2)

Dataset 01	**Monitoring parameter**	
	Description	
	Data format	
	Availability	
	Real time/ historical	
	Way to access/ connect	
	Spatial Resolution / Accuracy	
	Temporal Resolution	
Dataset 02	**Monitoring parameter**	
	Description	
	…	
	…	
…	**Monitoring parameter**	

	…	
Pilot-dependent Data		
Pilot – Dataset 01	**Name, Monitoring parameter**	
	Description	
	Data format	
	Availability	
	Real time/ historical	
	Way to access/ connect	
	Spatial Resolution / Accuracy	
	Temporal Resolution	
	Mandatory or Optional data	*This can be further explained if needed, some words can be added to know in case of "optional data" what functionalities we may lose*
Pilot – Dataset 02	**Name, Monitoring parameter**	
	Description	
	…	
	…	
…	**Name, Monitoring parameter**	
	…	

In the following sections, the services' descriptions included in the previous template are presented, starting from Service 1 (SE 1 - Digital Twin Generation) to Service 5 (SE 5 - Urban Flood Analysis and Resilience).

4.1 SE 1 - Digital Twin Generation

Table 10. Service 1 (SE1) - Digital Twin Generation description.

Service ID			
Service name	**SE1 Digital Twin Generation**		
Lead partner	UOC	**Other partners involved**	-

<table>
<tr><th colspan="2">Scope and objectives of Service</th></tr>
<tr><td>Scope</td><td>This service will generate the Geometric Digital Twins of the buildings from registered point cloud data containing geometry (X, Y, Z), visual (RGB) and thermal (t) information.</td></tr>
<tr><td>Objective(s)</td><td>To integrate methods for generating the geometry of Digital Twins of Buildings from locally sourced geometry data and to build the associated interfaces for human-information interaction between users and Digital Twins in mixed reality environments.</td></tr>
<tr><th colspan="2">Narrative of the service</th></tr>
<tr><td colspan="2">Short description</td></tr>
<tr><td colspan="2">This will develop a service that automatically generates geometric Digital Twins (DTs) of buildings, link the resulting DTs with EGNSS data for integration into city-scale models, and enable users to visualise the resulting DTs in mixed-reality environments. It will also enable interactive screen use, VR and AR interfaces for visualising DTs at the construction site and 3D DT visualisation for existing buildings.</td></tr>
<tr><td colspan="2">Complete description</td></tr>
<tr><td>Input requirements</td><td>The main input is a static dataset of registered points, which should be dense as possible, and the points should have 7 variables registered as one data set. The seven variables are XYZ coordinates of each point - the geometry; colour information RGB - the visuals, and the thermal information t. The density cannot be defined at this stage properly, however, would like to propose some suggestions regarding the nature of the data and some specifications.

<u>Geometry XYZ</u>
As a general guideline, point spacing should be considered at the following intervals.
<table><tr><td>Mass model, Rights to Light or LOD 1 / 2 models:</td><td>Point spacing 20mm</td></tr><tr><td>Typical building or LOD 3 models:</td><td>Point spacing 10mm</td></tr><tr><td>Heritage buildings or LOD 4 models:</td><td>Point spacing 5mm</td></tr></table>
<u>Visuals RGB</u>
High quality, high dynamic range, 360° panoramic photography to enhance the appearance and aid interpretation of the point cloud data. Specification of the panoramic imagery must include:
• Minimum 12-megapixel photography
• Parallax-free imagery, with the optical centre of the camera precisely located at the same point as the laser origin of the scanner
• Full 360° x 270° coverage
• High dynamic range imagery, colour balanced
The imagery (RGB) should be accurately aligned to the registered point cloud.

<u>Thermals (t)</u></td></tr>
</table>

	• 640 × 512 px Thermal • Should support point and area temperature measurement
Service operation	This service will take the aforesaid registered point cloud and will use computer vision and machine learning techniques to generate the geometric Digital Twins of the buildings. The final Digital Twin will be in the .ifc format which can be visualised and exploited by a range of commercial software. This Digital Twin will later be enriched with appropriate data depending on the challenge addressed in each of the pilots.
Service output	Output is a building object with tessellation-type as-is geometry and their spatial relationships comprising an object-oriented model in .ifc format.
Service Workflow	
1. Use data-driven approaches based on machine learning and AI techniques to automatically detect, segment and create labelled point clusters of the building objects' points with acceptable accuracy. 2. 3D reconstruction of the aforesaid labelled point clusters into .ifc objects. 3. Create native converters to output the result into the project's overall model structure using EGNSS data, as well as into popular data formats such as .ifc that can be exploited by a range of commercial software. 4. Test the resulting system on all use cases of this project and user-testing it in mixed reality environments to benchmark its performance.	
Data requirements	
Not completed for the moment	

4.2 SE 2 - Digital Twin Semantic Enrichment

Table 11. Service 2 (SE2) - Digital Twin Semantic Enrichment description.

Service ID			
Service name	**SE 2 Digital Twin Semantic Enrichment**		
Lead partner	UPM	**Other partners involved**	-
Scope and objectives of Service			
Scope	Integration of UAV data for the external envelop and SLAM-based point clouds for the inner envelop		
Objective(s)	The main objective is the integration of the data (RGB images and thermal images) coming from a drone (external envelop) and SLAM-based point clouds for the inner envelop.		
Narrative of the service			
Short description			

This service is focusing on providing additional information to the DT platform at building scale. This information will be provided in form of 3d point cloud which is the result of the combination of UAV, thermal imaging for the external envelop and SLAM-based point clouds for the inner space.

Complete description	
Input requirements	For the external envelop enrichment it is required a set of images (RGB and thermal images) as well as topographic points (in form of GPS coordinates or total station coordinates). These inputs will allow to obtain 3D point clouds of the external envelop by using photogrammetric approaches. Additionally, it is highly recommended to have some in-situ temperature readings in order to corroborate the data obtained by the thermal imaging with the real one. For the inner envelop it is recommended the use of SLAM-based approaches equipped with RGB cameras. Between the inner and the outdoor spaces, we will need to have an overlapped area. This is necessary in order to place, in the same coordinate system, both 3D point clouds.
Service operation	For the outdoors the service will take the images and topographic points and will generate a metric 3D point cloud of the building by using the Structure from Motion approach. This point cloud is a discrete representation (made by millions of points-measures with real and thermal colour). For the indoor the inputs previously require will be cleaned from noise (non-related objects) and integrated into a common coordinates system with respect to the previous one. As a result, the service will obtain a 3D digitalization of the building in form of point cloud that will be used to enrich the DT platform.
Service output	The output of this service is a 3D point cloud of the building, including geometrical information, RGB colour and thermal data (outdoors). This point cloud will be in a interoperable format .e57 or similar in order to be integrated with the DT platform.

Service Workflow

The service workflow is the following one:

1. Pre-processing of the imaging data captured by the UAV
2. Processing of the imaging data captured by the UAV and the topographic survey through the use of the Structure from Motion approach.
3. Post-processing of the 3D point cloud obtained by the photogrammetric approach
4. Post-processing of the 3D point cloud obtained by the SLAM-based sensor
5. Integration of both 3D point clouds
6. Generation of the final 3D point cloud in an interoperable format

This service match with the user story of MOS (analysis of the construction evolution) as well as the user story of RPR

Data requirements

Not completed for the moment

4.3 SE 3 - Building Environment Climate Scenarios

Table 12. Service 3 (SE3) - Building Environment Climate Scenarios description.

Service ID			
Service name	**SE 3 Building Environment Climate Scenarios**		
Lead partner	CARTIF	**Other partners involved**	NTUA
Scope and objectives of Service			
Scope	The service calculates the current **energy demand of the building stock and its evolution** according to different **climate change scenarios**. Relevant KPIs to **retrofitting strategy gains** will be also calculated, to see the effects of different future climate scenarios on the energy performance of the building stock with the application of different retrofitting strategies.		
Objective(s)	The service supports urban stakeholders in the understanding of how the **building stock energy demand** will be affected in the future by climate change. It also supports decision-making processes at urban scale by the modelling of relevant KPIs to retrofitting strategy gains.		
Narrative of the service			
Short description			
It is a user-friendly interactive tool that provides an understanding of how the building stock energy demand will be affected in the future by climate change. The service relies on forecast of energy demand according to the standard accepted CMIP6 scenarios (SSPs-RCPs) through the downscaling the climate data and their bias-correction with historical data from weather stations.			
Complete description			
Input requirements	- Buildings' data: ▪ Year of construction for all buildings ▪ Buildings' geometry (boundary and area) ▪ Buildings' height ▪ Buildings' use/ typology ▪ Building characteristics: ○ Thermal characteristics for the envelope ○ Window-to-wall ratio ○ Energy systems ○ Others: glass reflectivity - Historical weather data from weather stations (at least from 30 years) or historical data in grid format for 30 years.		

	- Future climate date: 3 models and 2 scenarios from 2023 to 2100. - Energy use profiles for Heating, Cooling and DHW - Retrofitting Measures Catalogue (*TBC – research needs to be made*)
Service operation	The service will be based in an interactive map with menus and queries to select the different scenarios to run at a certain scale (city level or district level, to see it in a more detailed way): current energy demand and consumption, or future hypothesis for energy demand calculation in a climate change scenario. In the visualization, the buildings are coloured according to their energy demand. The menus and queries will also allow the user to select the application of some retrofitting measures to certain buildings, allowing to run a simulation and be able to visualise the results and KPIs to compare different retrofitting scenarios.
Service output	The results will be the energy demand and consumption of the building stock, both in the current year and in a climate change scenario projected in different periods (short, mid and long-term). Another result will be the energy demand of the building stock with the application of some retrofitting measures and strategies. These results will be visualised in a user interface, in the form of an interactive map. The possibility of producing PDF reports with information about the results will be studied.

Service Workflow

1. Open the service in the Platform
2. A map appears showing the whole city (pilot area), the user can zoom into the area to see some parts in more detail
3. A coloured map with the building stock is shown, you can see in a right menu what the colours mean (related to energy demand and consumption) and to which period is referred (current year or future projection of energy demand) -such as a map legend
4. In the right menu, the user can change the period to see the projection or the current energy demand of the building
5. By moving the mouse through the map, a pop-up info message will appear, with further information on the selected building (e.g., construction year, typology, building characteristics, precise figures for energy demand and consumption)
6. The menu will offer also the possibility to select some retrofitting measures/strategies and apply them to buildings (single or few ones, at district level…)
7. The map then will show how the energy demand and consumption change with the application of those retrofitting measures/strategies.

Data requirements		
Data non-dependent from Pilot à Not completed for the moment		
Pilot-dependent Data		
Pilot – Dataset 01	**Name, Monitoring parameter**	**OpenStreetMap (building)**

	Description	OpenStreetMap (OSM) is a free, open geographic database updated and maintained by a community of volunteers via open collaboration. Contributors collect data from surveys, trace from aerial imagery and also import from other freely licensed geo-data sources. OSM represents physical features on the ground (e.g., roads or buildings) using tags attached to its basic data structures (nodes, ways, and relations)
	Data format	geojson
	Availability	Open data source
	Real time/ historical	Historical. Real time data is not needed
	Way to access/ connect	Directly: *https://www.openstreetmap.org/* Using API see: *https://wiki.openstreetmap.org/wiki/Overpass_API*
	Spatial Resolution / Accuracy	There are data quality mechanisms in the generation of the dataset, but not always are used
	Temporal Resolution	-
	Mandatory or Optional data	This dataset will be the basis of the geometry, so its use Is **mandatory**. It could be integrated with *GlobalMLBuildingFootprints* to define the boundaries for demand calculation.
Pilot – Dataset 02	**Name, Monitoring parameter**	**Building Stock Observatory**
	Description	The EU Building Stock Observatory monitors the energy performance of buildings across Europe. Its main objective is to provide a better understanding of the energy performance of the building sector through reliable, consistent and comparable data. The EU Building Stock Observatory tracks many different aspects including building typologies, construction periods, energy performance certificates, renovation rates, and more
	Data format	.xlsx
	Availability	*https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/eu-bso_en*
	Real time/ historical	Historical information
	Way to access/ connect	Data can be download form its website: *https://ec.europa.eu/energy/eu-buildings-datamapper_en*
	Spatial Resolution / Accuracy	Information is provided by country
	Temporal Resolution	Information is organised by year

	Mandatory or Optional data	**Optional**. If more specific building information for the location is found, this dataset can be eliminated from the service
Pilot – Dataset 03	**Name, Monitoring parameter**	**PLANHEAT**
	Description	Database with relevant data to characterise the energy performance of the building sector through thermal envelope values and energy scheduled for heating, cooling and DHW. Data cover different building typologies, years of construction and countries.
	Data format	.csv
	Availability	*https://github.com/Planheat/Planheat-Tool*
	Real time/ historical	Historical information
	Way to access/ connect	Data can be download form its website: *https://github.com/Planheat/Planheat-Tool*
	Spatial Resolution / Accuracy	Country level and building typology
	Temporal Resolution	Static. Historical values
	Mandatory or Optional data	This dataset can be combined with BSO to define the relevant data for energy demand and consumption calculation

4.4 SE 4 - Urban Heat Analysis and Resilience

Table 13. Service 4 (SE4) - Urban Heat Analysis and Resilience description.

Service ID			
Service name	**SE 4 Urban Heat Analysis and Resilience**		
Lead partner	UPM	**Other partners involved**	MOBICS
Scope and objectives of Service			
Scope	This service will provide an urban heat risk analysis at city scale using climate and socio-economic data.		
Objective(s)	To improve informed decision making for urban stakeholders in terms of adaptation and mitigation strategies to climate change at building and neighbourhood scales, by identifying the areas with the highest risk to heat within the city.		
Narrative of the service			
Short description			

This service aims to examine the urban heat intensity and distribution at a detailed resolution level and incorporate socio-economic vulnerability factors to determine the urban heat risk under the present and future climate scenarios.

Complete description	
Input requirements	Open source and standardised meteorological data (minimum 1 year); statistical, geo-referenced socio-economic data; statistical geo-referenced building stock information (year of construction, typology, energy certificate); satellite-derived data such as geospatial land use information, thermal bands, infra-red bands, NDVI, true colour data, high resolution RGB band.
Service operation	The service should be presented through a platform compatible with Geographic Information Systems. The information is hosted in different layers with indicators of exposure, vulnerability, and risk to urban heat for a determined climate scenario (current and future).
Service output	Through a zooming user interface (ZUI), the urban heat will be displayed through an interactive high-resolution cartographic representation. Information contained will incorporate suitable adaptation and mitigation strategies to climate change at building and neighbourhood scales. It will allow the user to identify through heat exposure and socioeconomic indicators, the social vulnerability to heat.

Service Workflow

1. Access to the service
2. A map of the pilot appears with a colour scale according to the Urban Heat Risk index.
3. In the upper area the user could select the different climate scenarios as well as the main layers to be represented (urban heat risk index, urban heat exposure index, urban heat vulnerability index). In addition, the service could have available the activation of a layer with the evolution of different variables through time as an increase/decrease percentage.
4. On the left, a graphical configuration section will allow the activation of the layer overlay as well as visual parameters (e.g., transparency percentage, colour palette).
5. When hovering over different areas of the map, information about the area could be displayed in a box on the right, depending on the information selected in the previous step.
6. Once the selection of a specific area has been made, a download option should be activated.

Data requirements		
Data non-dependent from Pilot		
Dataset 01	**Monitoring parameter**	**Meteorological variables from CWS**
	Description	Meteorological data provided by Citizens Weather Stations, including air temperature, relative humidity, and in some cases wind speed. Coordinates and IDs from each CWS are also provided.
	Data format	JSON / CSV

	Availability	Depends on the database, for commercial use might not be available
	Real time/ historical	Real time (time lag of 5-10 minutes) and historical
	Way to access/ connect	API / Web user registration / Direct manual download
	Spatial Resolution / Accuracy	The spatial resolution is variable and depends on the selected database. Stations tend to be concentrated in urban areas and high-income cities.
	Temporal Resolution	Hourly
Dataset 02	**Monitoring parameter**	**Socio-economic and demographic data from Urban Audit**
	Description	Statistical socio-economic and demographic data such as: age, gender, education, income. **Urban Audit** (EUROSTAT) population aged 65 and over (%), population aged 0-14 (%), households that are 1 person households (%), foreigners as a proportion of total population (%), unemployment rate (%), average annual net household income (€), percentage of commutes to work by public transport (%), proportion of journeys to work by car (%). NUTS level 1: 104 regions; level 2: 283; level 3: 1345/Spatial levels: administrative city (A), larger urban zone (LUZ) and sub-city district (SCD) for 5.000-40.000 inhabitants
	Data format	.CSV; shape file (.shp)
	Availability	Yes
	Real time/ historical	Historical
	Way to access/ connect	Manual download from online database. Eurostat seems to offer an API rest
	Spatial Resolution / Accuracy	Sub-city district (SCD, depends on the city availability)
	Temporal Resolution	Yearly / multi-yearly
Dataset 03	**Monitoring parameter**	**Building stock parameters from cadastre**
	Copernicus / EGNSS service	-
	Description	Building stock data such as: year of construction, typology, energy consumption
	Data format	GML / XML / Shape file
	Availability	Conditioned (each national database might have different requirements)
	Real time/ historical	Historical
	Way to access/ connect	Direct manual download / WMS

	Spatial Resolution / Accuracy	Neighbourhood
	Temporal Resolution	-
Dataset 04	**Monitoring parameter**	**Land use, land cover from Eurostat**
	Copernicus / EGNSS service	-
	Description	Land use/cover data from **LUCAS** (EUROSTAT database)
	Data format	Shape file (.shp)/Cloud Optimized GeoTIFF (.COG)
	Availability	Yes
	Real time/ historical	Historical
	Way to access/ connect	Website
	Spatial Resolution / Accuracy	City scale (LUCAS), NUTS level 2 (Hellenic Statistics Authority)
	Temporal Resolution	2009, 2012, 2015, 2018 (LUCAS, depends on the city),
Dataset 05	**Monitoring parameter**	**Local Climate Zones**
	Copernicus / EGNSS service	-
	Description	The Local Climate Zones is a classification scheme of urban morphology relevant to urban climate. Information derived from the World Urban Database and Access Portal Tools (WUDAPT)
	Data format	GEOTIFF
	Availabity	Yes
	Real time/ historical	Historical
	Way to access/ connect	Direct online download
	Spatial resolution/ Accuracy	100 m
	Temporal resolution	-
Pilot-dependent Data		
Pilot – Dataset 01	**Description**	**Building stock parameters from regional and local entities (e.g., Hellenic Statistical Authority)**
	Data format	.shp; .csv
	Availability	Online GIS viewer

	Real time/ historical	Historical
	Way to access/ connect	Website, direct download
	Spatial Resolution / Accuracy	Building level
	Temporal Resolution	2010; 2018-2019
	Mandatory or Optional data	Optional data – Resolution (level of detail) might be less accurate if not available. If there is not other information at European or National level, the service might be compromised.
Pilot – Dataset 02	**Name, Monitoring parameter**	**Socioeconomic data from regional and local entities (e.g., Hellenic Statistical Authority)**
	Description	
	Data format	PDF (unusual format. To be confirmed)
	Availability	
	Real time/ historical	Historical
	Way to access/ connect	
	Spatial Resolution / Accuracy	
	Temporal Resolution	
	Mandatory or Optional data	Optional data – Resolution (level of detail) might be less accurate if not available. If there is not other information at European or National level, the service might be compromised.
Pilot – Dataset 03	**Name, Monitoring parameter**	**Meteorological and air pollution data from regional and local entities (e.g., Hellenic Statistical Authority)**
	Description	Data from a municipality-wide monitoring network of 5 air quality and meteorological sensors; 5 noise sensors.
	Data format	.csv
	Availability	Online viewer
	Real time/ historical	Real Time/ historical from May 2023
	Way to access/ connect	Online cloud platform, direct download
	Spatial Resolution / Accuracy	Municipality scale
	Temporal Resolution	Hourly

	Mandatory or Optional data	Optional data – Resolution (level of detail) might be less accurate if not available.

4.5 SE 5 - Urban Flood Analysis and Resilience

Table 14. Service 5 (SE5) - Urban Flood Analysis and Resilience description.

Service ID			
Service name	**SE 5 Urban Flood Analysis and Resilience**		
Lead partner	IMZI	**Other partners involved**	NAZKA
Scope and objectives of Service			
Scope	- to determine expected annual flood damage for an urban asset, - to make calculations of average NDVI value per a basic unit, - to provide visualizations of potential flooding hotspots and blue-green infrastructure impact, - allows users to add some extra comments or observations,		
Objective(s)	SE 5 *will* improve the urban flood database and modelling options of blue-green infrastructure impact, enabling the analysis of future scenarios under blue-green infrastructure different conditions and providing decision support services to assist urban stakeholders in planning building stock maintenance and retrofitting against climate change risk by using simplified models for short- and long-term predictions.		
Narrative of the service			
Short description			
SE5, a user-friendly online interactive tool that calculates expected annual flood damage for one or more buildings by the intersection of relevant data layers, and user-uploaded temporal polygon, line, or point layer defining the area under consideration, based on updated flood damage assessment methodology. It forms impervious urban areas by calculating an average Normalised Difference Vegetation Index (NDVI) per building or building plot. By adding new features of calculating NDVI and the terrestrial altitude from LIDAR data and feeding with Urban planning data, Meteorological data of Air Temperature, Air Humidity and Precipitations, Flooded urban areas, Soil Water Index, and Surface Soil Moisture Data, besides the data already used within the interactive flood damage assessment tool, it provides a visualization of potential flooding hotspots and impact of blue-green infrastructure measures by using simplified models for short- and long-term predictions. It allows users to add some extra comments or observations about historical floods and existing blue-green infrastructure measures.			
Complete description			
Input requirements	- temporal polygon, line or point layer; user should be able to upload his own data (Shapefile) or to draw it directly in the application - georeferenced data about the Building		

	- georeferenced data about the Consolidated Cadastre of Public Infrastructure - georeferenced data about the Water Cadastre - Integral Map of Flooding Depths - georeferenced data about the Cadastrial Parcels - georeferenced data about the Registry of spatial units - georeferenced data about the The Land Use database - georeferenced data about the Urban planning data – future land use - terrestrial altitude data from satellite LIDAR DEM model - georeferenced inputs about historical flood damage events and existing blue-green infrastructure measures by users - readings of Air Temperature, Air Humidity and Precipitations with a reporting rate of 30 or 10 minutes - historical satellite data Sentilel-1 SAR imagery - Flooded Urban Areas about flooded urban areas for at least 10 years - historical satellite data about NDVI for at least 10 years - historical satellite data about Soil Water Index for at least 10 years - historical satellite data about Surface Soil Moisture for at least 10 years
Service operation	According to the intersection of temporal concerned polygon, line or point layer with Infrastructure data or Building data and Flood data it provides calculations to gain an expected flood damage per m2 of urban area, per m of urban infrastructure or per a building (point). From NDVI satellite data it calculates an average NDVI per building (Building data) or building plot (Cadastrial Parcels data or Urban planning data – future land use). The intersection by terrestrial altitude calculated from satellite LIDAR DEM model, Flood data, and Flooded Urban Areas and Soil moisture satellite data provides a spatial visualisation of flooding hotspots. It allows users to add some extra comments or observations by individual georeferenced inputs about historical flood damage events and existing blue-green infrastructure measures, e.g., uploading a photo, drawing a polygon directly to the application, writing a text. This built evidence, combined with average NDVI polygons, terrestrial altitude calculated from satellite LIDAR DEM model, Urban planning data, Meteorological data, and Flooded Urban Areas and Soil Moisture satellite data, give an appropriate urban flood database enabling the use of a simplified model for short- and long-term predictions that provides spatial visualisation of blue-green infrastructure implementation and an impact indicator. All service operations are triggered by user request.
Service output	Results are visualised in some graphical user interface (map and diagrams), in form of PDF report, in form of Shapefile and in a table.
Service Workflow	
1. access to the service 2. selection of pilot area to which the service has been developed by uploading own data (Shapefile) or to draw it directly in the application	

3. an interactive map appears showing the building stock with coloured information of flooding hotspots (in red colour) and blue-green infrastructure implementation and impact (in different green shades)
4. there are several options to see more or less information, also by zooming an area
5. if you click on one building or draw a polygon, it provides expected annual flood damage (in EUR) and an indicator of blue-green infrastructure implementation and impact

Data requirements		
Data non-dependent from Pilot à Not completed for the moment		
Pilot-dependent Data		
Pilot – Dataset 01	**Name, Monitoring parameter**	**Water Cadastre - Integral Map of Flooding Depths**
	Description	Planar spatial objects represent areas of depths; 3 layers for 3 different flooding depths: GM, GS, GV
	Data format	Shapefile
	Availability	Public available data
	Real time/ historical	historical
	Way to access/ connect	eprostor
	Spatial Resolution / Accuracy	
	Temporal Resolution	Date of last modification: 29.03.2022
	Mandatory or Optional data	Mandatory
Pilot – Dataset 02	**Name, Monitoring parameter**	**Consolidated Cadastre of Public Infrastructure**
	Description	16 layers for 16 different types of infrastructure
	Data format	Shapefile /XML
	Availability	Public available data
	Real time/ historical	historical
	Way to access/ connect	gu/eprostor
	Spatial Resolution / Accuracy	
	Temporal Resolution	Date of last modification: 14.11.2022
	Mandatory or Optional data	Optional

Pilot – Dataset 03	**Name, Monitoring parameter**	**Cadastrial Parcels**
	Description	4 shapefiles /Zipped GML, split into 212 files
	Data format	Shapefile/GML
	Availability	Public available data
	Real time/ historical	historical
	Way to access/ connect	gu/eprostor
	Spatial Resolution / Accuracy	
	Temporal Resolution	Date of last modification: 26.05.2022
	Mandatory or Optional data	Optional– it can be replaced by "Registry of spatial units"
Pilot – Dataset 04	**Name, Monitoring parameter**	**Building**
	Description	shapefiles/Zipped GML, split into 212 files
	Data format	Shapefile/GML
	Availability	Public available data
	Real time/ historical	historical
	Way to access/ connect	gu/eprostor
	Spatial Resolution / Accuracy	
	Temporal Resolution	Date of last modification: 26.05.2022
	Mandatory or Optional data	Mandatory
Pilot – Dataset 05	**Name, Monitoring parameter**	**Urban planning data – future land use**
	Description	1 layer
	Data format	Shapefile/GML
	Availability	Public available data; Spatial planning is country specific and we cannot expect standardised/EU availability
	Real time/ historical	legislation
	Way to access/ connect	eprostor

	Spatial Resolution / Accuracy	5000
	Temporal Resolution	Metadata Date: Dec 13 2021
	Mandatory or Optional data	Optional – it would be used for providing scenarios
Pilot – Dataset 06	**Name, Monitoring parameter**	**Registry of spatial units**
	Description	14 layers for 14 different types of spatial units
	Data format	Shapefile
	Availability	Public available data
	Real time/ historical	historical
	Way to access/ connect	ipi/eprostor
	Spatial Resolution / Accuracy	
	Temporal Resolution	Metadata Date: Aug 30 2022
	Mandatory or Optional data	Optional – it can be replaced by “Cadastrial Parcels”
Pilot – Dataset 07	**Name, Monitoring parameter**	**The Land Use database**
	Description	Zipped GML
	Data format	GML
	Availability	Public available data
	Real time/ historical	historical
	Way to access/ connect	eprostor
	Spatial Resolution / Accuracy	
	Temporal Resolution	Date of last modification: 2021-12-15
	Mandatory or Optional data	Optional - it can be replaced by satellite data
Pilot – Dataset 08	**Name, Monitoring parameter**	**Meteorological data**
	Description	Temperature data, Humidity data, rain data and wind speed, both historical and current data

	Data format	CSV & JSON
	Availability	Public available data
	Real time/ historical	Real-time
	Way to access/ connect	OPSI
	Spatial Resolution / Accuracy	
	Temporal Resolution	30 or 10 minutes
	Mandatory or Optional data	Mandatory

5 Specification of BUILDSPACE – Copernicus/EGNSS alignment and synchronisation

This section is dedicated to a detailed analysis of the available datasets and services provided by Copernicus[1] and EGNSS[2]. Our goal is to identify the monitoring parameters, temporal scales, and spatial resolution of the data that will be utilised in the BUILDSPACE project. This analysis builds upon the work completed in Task 2.1, where user stories from the four pilots were created and specific requirements were established, as well as the objectives of the five BUILDSPACE services. By conducting this analysis, we aim to ensure the alignment and synchronization of BUILDSPACE platform with Copernicus-EGNSS and to ensure that we are utilising the most appropriate data sources and services to meet the needs of our users and to identify possible extensions that BUILDSPACE can offer to Copernicus/EGNSS services.

Section 5.1describes the three Copernicus core services related to BUILDSPACE, namely Land Monitoring Service, Atmosphere Monitoring Service and Climate Change Service. **Section 5.2** provides a detailed list of the monitoring parameters, temporal scales, spatial and temporal resolution of data that will be used in the four pilots and the five BUILDSPACE services. **Section 5.3** refers to the alignment of the architecture design of the BUILDSPACE core platform and applications with EGNSS.

5.1 Products Analysis

The Copernicus Programme is a European Union initiative supported by the European Space Agency (ESA) for the space component and the European Environment Agency (EEA) for the in-situ component aimed at developing data and information services based on satellite Earth observation and in situ data, and

[1] http://www.urbanlearning.eu/toolbox/stakeholders/

[2] https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/european-global-navigation-satellite-system-egnss

providing accurate, up-to-date, and reliable Earth observation data to support environmental monitoring, climate research, and other applications. Its objective is to deliver accurate and timely information on a wide range of environmental variables, including air quality, land use, ocean dynamics, climate change, and emergency management. It uses a constellation of satellites, ground-based sensors, and data from other sources to gather and analyse data on the Earth's environment. The data are made available to public authorities, businesses, and citizens through a dedicated web portal, which provides access to a range of services and applications for environmental monitoring, risk management, and other purposes. The Copernicus Programme is part of the EU's wider strategy to promote sustainable development and address global environmental challenges, operating since 2014 and is expected to continue providing valuable data and services for many years to come. The information services provided by Copernicus are available to its users, mostly public authorities, on a full free-of-charge and open basis and with continuity. The Copernicus Programme is served by dedicated satellites (i.e., the Copernicus Sentinel families) and a set of additional Contributing Missions (i.e., satellites run by various commercial and national agencies). Since the launch of Sentinel-1A in 2014, the European Union set in motion a process to place a constellation of almost 20 more satellites in orbit before 2030. This satellite data is complemented by and validated with in situ data.

5.1.1 Copernicus Land Monitoring Service

The Copernicus Land Monitoring Service (CLMS) is one of six services within the Copernicus Programme responsible for monitoring and providing information on land-related variables, such as land cover, land use, vegetation, and soil moisture, as well as producing high-resolution maps of land features. The data used by the CLMS is obtained from a range of sources, including satellite sensors, airborne campaigns, and ground measurements.

The CLMS is divided into five thematic services, each with its own focus and set of products:

- The Land Cover service: This service provides information on the type and extent of different land cover classes, such as forests, grasslands, and urban areas. It also monitors changes in land cover over time, which can be used to identify land use patterns and track deforestation, urbanisation and other land-use changes.

- The Land Use service: This service provides information on how the land is used, such as for agriculture, forestry, or urban development. It also includes information on land management practices, such as crop rotation and irrigation.

- The High-Resolution Layers service: This service provides detailed information on specific land features, such as water bodies, impervious surfaces, and forest types. It also includes information

on land fragmentation, which is the breaking up of natural landscapes into smaller and more isolated areas.

- The Vegetation Monitoring service: This service provides information on vegetation dynamics, such as vegetation cover, biomass, and productivity. It is used to monitor the health of vegetation, track the effects of climate change on plant growth, and assess the potential impact of forest fires and other natural disasters.
- The Soil Moisture service: This service provides information on soil moisture content, which is essential for predicting crop yields and managing water resources. It is also used to monitor the severity of droughts and floods.

The CLMS can contribute to energy-efficient buildings by providing information to construction, facilities management, and real estate companies on the urban environment in order to identify areas where energy efficient buildings can be built or retrofit, and where renewable energy sources, such as solar or wind power, can be installed. Also, CLMS provides information on the urban heat island effect, which is the phenomenon where urban areas are significantly warmer than the surrounding rural areas. This effect is caused by the high density of buildings, roads, and other infrastructure that absorb and retain heat, as well as the lack of vegetation that provides shade and evapotranspiration. On this basis, the CLMS can provide information on the extent and severity of the urban heat island effect, which can be used to identify areas where cool roofs, green roofs, and other urban heat island mitigation strategies can be implemented to reduce the energy needed to cool buildings. The CLMS can also provide information on the location and size of renewable energy sources, such as solar panels and wind turbines, which can be integrated into buildings or the urban environment to provide renewable energy.

Moreover, CLMS can contribute to the generation of digital twins by providing high-quality and up-to-date geospatial data on the land surface, land cover, and land use. In the case of urban environments digital twins as replicas of physical buildings/assets are used to simulate, monitor, and optimize their performance. The provided geospatial data from CLMS on a range of variables, including topography, land cover, land use, vegetation, and water resources can be used to create detailed 3D models and to update and improve existing digital twins, ensuring that they remain accurate and up to date.

CLMS can contribute to climate-resilient cities by providing insights on the vulnerability of cities to climate change. This includes data on the location and extent of urban areas, as well as data for the exposure of cities to hazards such as floods, landslides, and heatwaves. This information can be used to identify areas that are at high risk and to prioritize adaptation and mitigation measures.

In addition, the CLMS can provide input on the potential for green infrastructure, such as urban forests, green roofs, and parks, to mitigate the impacts of climate change. Green infrastructure can provide multiple benefits, such as reducing the urban heat island effect, improving air quality, and reducing the

risk of flooding. The CLMS can provide data on the location, extent, and quality of green infrastructure, which can be used to identify areas where green infrastructure can be enhanced or expanded.

Finally, the CLMS can contribute to climate-resilient cities by providing information on the energy use and emissions of urban areas. This includes data on the location and size of energy-intensive industries, as well as information on the use of renewable energy sources. This knowledge can be used to identify opportunities for reducing greenhouse gas emissions and promoting energy efficiency.

In summary, the Copernicus Land Monitoring Service is a key component of the Copernicus Programme, providing accurate and up-to-date information on land-related variables and high-resolution maps of land features. Its data and products are related to BUILDSPACE SE1, and are widely used by a range of stakeholders and can be applied in a variety of fields, supporting decision-making and improving the understanding of the Earth's environment.

5.1.2 Copernicus Atmoshpere Monitoring Service

The Copernicus Atmosphere Monitoring Service (CAMS) is a service provided by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Union. CAMS is designed to provide reliable and up-to-date information on atmospheric composition and quality in Europe and worldwide, using state-of-the-art satellite and ground-based observations, models, and data assimilation techniques.

CAMS focuses on the monitoring and forecasting of key atmospheric constituents, including greenhouse gases, aerosols, ozone, and reactive gases such as nitrogen dioxide and sulfur dioxide. It also provides information on air quality, pollen and wildfires aiming to support various sectors, such as health, environment, climate change mitigation, and policy-making, among others.

CAMS offers a range of products and services, including:

- Daily and long-term air quality forecasts, available for various pollutants, such as nitrogen dioxide, sulfur dioxide, ozone, and particulate matter. These forecasts can be used to support public health, environmental management, and policy-making.

- Global atmospheric composition monitoring, which provides detailed information on key atmospheric constituents and their interactions. This information can be used to support climate research, atmospheric chemistry, and policy-making.

- Greenhouse gas monitoring, which tracks the emissions and concentrations of carbon dioxide, methane, and other greenhouse gases. This information can be used to support climate change mitigation efforts, such as the monitoring of emissions reduction targets.

- Monitoring of stratospheric ozone, which provides information on the depletion of the ozone layer and the effectiveness of international efforts to protect it.

- Monitoring of air pollution from wildfires, which provides information on the location, extent, and intensity of wildfires, as well as the resulting air pollution. This information can be used to support public health and environmental management.

Regarding energy efficient buildings, CAMS can help by providing data on air quality and greenhouse gas concentrations that can help identify sources of emissions and areas for improvement. CAMS can provide information on outdoor air quality, including the concentration of pollutants such as carbon dioxide, which is an indicator of poor ventilation. By monitoring outdoor air quality, urban planners can identify areas for improvement and take steps to improve ventilation and air quality, which can reduce energy consumption and improve citizens' health and comfort. For energy consumption modelling, CAMS can provide data on energy consumption patterns and emissions from nearby sources such as traffic or industrial facilities, which can be used to develop more accurate models of building energy use.

Moreover, CAMS provides air quality forecasts, which can help city officials plan for high-pollution events and take steps to reduce energy use during these periods. For example, if high levels of pollution are forecasted, the building automation systems can be adjusted to reduce ventilation rates, which can help save energy while maintaining indoor air quality. Information on the concentration and distribution of greenhouse gases such as carbon dioxide and methane are also provided to help the identification of areas where energy use can be reduced, such as through improved insulation or the use of renewable energy sources. The reduction of greenhouse gas emissions supports the mitigation of climate change while also reducing energy costs.

In line with the above, CAMS can contribute to climate-resilient cities in several ways, primarily by providing information on air quality, weather, and greenhouse gas concentrations that can help identify areas of vulnerability and inform strategies to adapt to climate change. Data on air quality, including the concentration of pollutants such as particulate matter and ozone, helps urban planners identify areas with poor air quality and take steps to improve it. By improving air quality, cities can reduce the health impacts of air pollution, which can be exacerbated by extreme weather events such as heatwaves. In addition, the weather forecasts, provided by CAMS, can help city planners prepare for extreme weather events such as heatwaves, floods, and storms. By being better prepared for extreme weather events, cities can reduce the risks to public safety and infrastructure. CAMS can also provide data on the dispersion of hazardous substances in the atmosphere. This knowledge can be used to develop disaster response plans and reduce the risks associated with industrial accidents or other hazardous events.

In summary, the Copernicus Atmosphere Monitoring Service (CAMS) is a comprehensive service that provides reliable and up-to-date data on atmospheric composition and quality worldwide. The service

aims to support various sectors, such as health, environment, climate change mitigation, and policy-making, among others, using state-of-the-art satellite and ground-based observations, models, and data assimilation techniques.

5.1.3 Copernicus Climate Change Service

The Copernicus Climate Change Service (C3S), operated by the European Centre for Medium-Range Weather Forecasts (ECMWF), provides authoritative information about the Earth's climate and its changes over time. The C3S combines information from a wide range of sources, including satellite and ground-based observations, computer models, and historical climate data. Its goal is to provide accurate and reliable information to help policymakers, businesses, and individuals make informed decisions about climate-related issues.

The service provides a range of climate information products and services, including:

- Climate bulletins: Monthly and seasonal climate bulletins, which provide an overview of the current state of the climate, as well as predictions for the coming months.
- Climate indicators: These are key climate variables, such as temperature, precipitation, and sea level, that can be used to track changes in the climate over time.
- Climate reanalysis: This is a process that combines historical climate observations with computer models to create a complete picture of the Earth's climate over the past few decades.
- Climate projections: These are computer-generated forecasts of future climate conditions, based on a range of different scenarios and assumptions.
- Climate data access: The C3S provides access to a wide range of climate data, including historical observations, model output, and other climate-related information.
- Sectoral information: The C3S also provides climate-related information specific to different sectors, such as agriculture, energy, and transport.

The C3S can contribute to energy efficient buildings given the access it provides to a wide range of climate data described previously, which can help construction companies understand the local climate conditions and design buildings that are optimised for energy efficiency. Moreover, climate projections can help building designers and engineers anticipate future climate conditions and design buildings that are more resilient to climate change. For example, if a building is located in an area that is projected to experience more frequent heat waves, designers can incorporate features such as shading devices and natural ventilation to help keep the building cool without relying on energy-intensive air conditioning. The C3S

also provides energy demand forecasts that can help building owners and operators anticipate energy demand and optimise energy use.

Regarding climate-resilient cities, C3S provides data that helps to understand the local climate conditions and develop strategies to improve climate resilience. Based on the future climate conditions, city planners and policymakers can develop strategies to mitigate the impacts of climate change. For example, if a city is located in an area that is projected to experience more frequent extreme precipitation events leading to urban flood, planners can develop strategies to provide early warning systems, increase green spaces to absorb and retain stormwater, and promote flood-resistant building design. Moreover, the C3S provides early warning systems for extreme weather events that can help cities prepare for and respond to these events. For example, the C3S provides information on the likelihood and severity of heat waves, storms, and floods, which can help cities prepare emergency response plans and inform the public about potential risks.

Overall, the Copernicus Climate Change Service is an important resource for anyone interested in understanding the Earth's climate and its changes over time. Its combination of scientific expertise, cutting-edge technology, and global reach make it a valuable tool for policymakers, businesses, and individuals alike.

5.2 Satellite technical specifications

Based on the user stories and technical requirements presented in Section 3 and on the objectives of BUILDSPACE services, a subsample of the datasets provided by Copernicus has been selected for BUILDSPACE. This selection is meant to act as a suggestion to answer users' needs. Thus, it is not intended to be exhaustive. Indeed, depending on the specific activity or data needed, other datasets included in the above-mentioned climate services could be considered. **Table 15** showcases the main fields considered in the dataset, along with the set of available options and meaning on the mentioned fields. The selected datasets are provided in

Table 16. Detailed presentation of the datasets required from Copernicus.

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Table 15. Example of current dataset list template as part of BUILDSPACE's deliverable D2.1.

Fields	Options	Meaning
No.	Numbers	Order number
Dataset name	Free text	Product name as identified by the data producer
Variable domain	Atmosphere Land Climate Change other	Copernicus component (s) the variable refers to
Data type	Gridded/Gridded and catchments/Point data, Others (free text)	Type of object
Main variables	Free text	Climate variable name
Product type	In-situ observations, Reanalysis, Seasonal Forecast, Scenario, Satellite-derived product, Projections-derived product, Model and observation-derived product, Others (free text)	Type of climate data
Horizontal coverage	Global, Europe, Others (free text)	Spatial domain
Horizontal resolution	Free text	Geospatial resolution
Vertical resolution	Single level (surface), Multiple levels (plus specifications), Others (free text)	Number of vertical levels
Temporal resolution	Daily, Sub-daily, Monthly, Others (free text)	Information about the discrete resolution of a measurement with respect to time
File format	NetCDF, NetCDF-4, GRIB2, Others (free text)	Standard way to encode information for storage in a file

Source	Link	Direct link to the climate/operational service webpage to download data
Licenses	Link	Terms of use agreement for model output
BUILDSPACE Service	SE1. Digital Twin Generation SE2. Digital twin Enrichment SE3.Building Environmental Climate Scenarios SE4. Urban Heat Analysis and Resilience SE5. Urban Flood Resilience	The related BUILDSPACE service (s)
BUILDSPACE pilot	Pilot 1. Facilitating Building Construction Pilot 2. Energy Demand Analysis Pilot 3. Urban heat analysis Pilot 4. Urban Flood Analysis	The related BUILDSPACE pilot (s)

Table 16. Detailed presentation of the datasets required from Copernicus.

Dataset name	Domain	Data type	Main variables	Product type	Horizontal coverage	Horizontal resolution	Vertical resolution	Temporal resolution	File format	BUILDSPACE Service	BUILDSPACE pilot
cams-europe-air-quality-forecasts	Atmosphere	Gridded	Nitrogen monoxide, nitrogen dioxide, sulphur dioxide, ozone,PM2.5, PM10 and dust	Model and odservation-derived	Europe	10 km x 10 km	Surface	Hourly	GRIB, NetCDF	SE4	Pilot 3
CAMS European air quality reanalyses	Atmosphere	Gridded	Nitrogen monoxide, nitrogen dioxide, sulphur dioxide, ozone,PM2.5, PM10 and dust	Model and odservation-derived	Europe	10 km x 10 km	Surface	Hourly	NetCDF	SE4	Pilot 3
cams-solar-radiation-timeseries	Atmosphere	point data	Clear sky BHI, Clear sky BNI, Clear sky DHI, Clear sky GHI	Model and odservation-derived	Global	3-5 km	-	Hourly	CSV, netCDF	SE3	Pilot 2
derived-near-surface-meteorological-variables	Climate Change	Gridded	Near-surface air temperature, Near-surface specific humidity, Near-surface wind speed,	Model and odservation-derived	Global	0.5° x 0.5°	Surface	Hourly	NetCDF 4	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4
derived-utci-historical	Climate Change	Gridded	Mean radiant temperature, Universal thermal climate index	Model and odservation-derived	Global	0.25° x 0.25°	Surface	Hourly	NetCDF	SE4	Pilot 3

Dataset name	Domain	Data type	Main variables	Product type	Horizontal coverage	Horizontal resolution	Vertical resolution	Temporal resolution	File format	BUILDSPACE Service	BUILDSPACE pilot
projections-cmip5-daily-single-levels	Climate Change	Gridded	2m temperature, Mean precipitation flux,Daily near surface relative humidity	Model	Global	0.125° x 0.125° to 5° x 5°	Various	Daily	NetCDF	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4
projections-cmip5-monthly-single-levels	Climate Change	Gridded	2m temperature, Mean precipitation flux,Daily near surface relative humidity	Model	Global	0.125° x 0.125° to 5° x 5°	Various	Monthly	NetCDF	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4
projections-cmip6	Climate Change	Gridded	Air temperature, Precipitation, Relative humidity, Surface downwelling shortwave radiation,	Model	Global	Varies between models	Various	Monthly, daily	NetCDF4	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4
projections-cordex-single-levels	Climate Change	Gridded	2m temperature, Mean precipitation flux, Daily near surface relative humidity, Surface solar radiation downwards	Model	From 27°N to 72°N and from 22°W to 45°E	0.11°x 0.11°	single	3h, 6h, daily, monthly and seasonal	NetCDF4	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4

Dataset name	Domain	Data type	Main variables	Product type	Horizontal coverage	Horizontal resolution	Vertical resolution	Temporal resolution	File format	BUILDSPACE Service	BUILDSPACE pilot
reanalysis-era5-land	Climate Change	Gridded	2m temperature, Runoff, Total precipitation, Surface solar radiation downwards	Model and odservation-derived	Global	0.1° x 0.1°	Various	Hourly	GRIB	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4
satellite-cloud-properties	Climate Change	Gridded	Cloud fraction	Satellite derived	Global	0.25° x 0.25°	single	Monthly, daily	NetCDF4	SE3	Pilot 2
satellite-land-cover	Climate Change	Gridded	Land cover class	Satellite derived	Global	300 m	Surface	Yearly	NetCDF4	SE1, SE2, SE3, SE4, SE5	Pilot 1, Pilot 2, Pilot 3, Pilot 4
E-OBS daily gridded meteorological data	Climate Change	Gridded	Maximum temperature, Mean temperature, Minimum temperature, Precipitation amount, Relative humidity	In-situ onservations	Europe	0.1° x 0.1° and 0.25° x 0.25°	Near surface	Daily	NetCDF4	SE3	Pilot 2
CORINE Land Cover	Land	Gridded	Land cover class	Satellite derived	Europe	better than 100 m	Surface	Every 6 years	ESRI File Geodatabase, SQLite Database, Geotiff	SE1, SE2, SE3, SE4, SE5	Pilot 1, Pilot 2, Pilot 3, Pilot 4
Imperviousness	Land	Gridded	Percentage and change of soil sealing	Satellite derived	Europe	10m, 20m and 100m	Surface	Every 3 years	GeoTIFF	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4

Dataset name	Domain	Data type	Main variables	Product type	Horizontal coverage	Horizontal resolution	Vertical resolution	Temporal resolution	File format	BUILDSPACE Service	BUILDSPACE pilot
European Settlement Map	Land	Gridded	Human settlements in Europe	Satellite derived	Europe	2.5m, 10m and 100m	Surface	Every 3 years	GeoTIFF	SE3, SE4, SE5	Pilot 2, Pilot 3, Pilot 4
Urban Atlas	Land	Gridded	Land Cover Land Use	Satellite derived	Europe	25-100m	Surface	Every 6 years	ESRI File Geodatabase	SE1, SE2, SE3, SE4, SE5	Pilot 1, Pilot 2, Pilot 3, Pilot 4
Sentinel 1	Satellite	Gridded	Landscape topography, Multi-purpose imagery (land), Vegetation	Satellite derived	Europe	5-20 m	Surface	Daily	SAFE	SE3	Pilot 2
Sentinel 2	Satellite	Gridded	Multispectral images	Satellite derived	Global	10-20-60 m	Surface	2-3 days	JPEG2000	SE1, SE2, SE3, SE4, SE5	Pilot 1, Pilot 2, Pilot 3, Pilot 4
Sentinel 3	Satellite	Gridded	Multispectral images	Satellite derived	Global	300-1200m	Surface	Daily	JPEG2000	SE1, SE2, SE3, SE4, SE5	Pilot 1, Pilot 2, Pilot 3, Pilot 4
CAMS European air quality forecasts	Atmosphere	Gridded	Air quality	Model and odservation-derived	Europe	0.1°x0.1°	Surface	Hourly	GRIB, NetCDF	SE4	Pilot 3

5.3 EGNSS services specification analysis

The European Global Navigation Satellite System (EGNSS) is a global navigation system that consists of a network of satellites and ground control stations providing accurate positioning and timing information to users worldwide. EGNSS consists of two main segments: the space segment and the ground segment. The space segment includes a constellation of 30 satellites in medium Earth orbit that transmit navigation signals to users on the ground. The ground segment includes a network of ground control stations that monitor and control the satellites, as well as provide the data necessary to calculate precise positioning information.

EGNSS has several differentiators that set it apart from other GNSS systems, including increased accuracy and reliability, global coverage, multi-constellation support, open and commercial services, and safety-of-life services. These features make EGNSS a valuable tool for a wide range of applications.

EGNSS uses four different types of signals: open service, commercial service, safety of life service, and public regulated service. The open service provides free access to the EGNSS signal for civil users worldwide. The commercial service offers higher accuracy and availability for commercial applications, such as precision agriculture and surveying. The safety of life service is designed for safety-critical applications, such as aviation, maritime, and emergency services. Finally, the public regulated service is reserved for authorised users, such as government agencies and military.

EGNSS uses advanced technology to provide high-precision positioning and timing information to users. It utilises multiple frequencies and signal modulations, including binary offset carrier and composite binary offset carrier, to improve signal robustness and reduce interference. EGNSS also employs the use of atomic clocks onboard satellites, providing accurate timing information that can be used for a variety of applications, such as synchronization of telecommunication networks and financial transactions.

EGNSS can help in the creation and management of building's digital twins. Digital twins are virtual models of physical buildings or infrastructure that replicate their physical and operational characteristics. EGNSS can provide high-precision positioning and timing information that can help create and maintain accurate digital twins of buildings and construction sites and the resulting digital twins can be linked with EGNSS data for integration into city-scale models enabling users to visualize them in mixed reality environments. The resulting digital twin can be positioned through EGNSS at city context enabling their "consumption" by city level apps to allow dynamic building monitoring at city scale.

Moreover, EGNSS can assist in the construction of buildings by providing real-time monitoring of construction equipment and materials. By using EGNSS, the location and status of construction equipment and materials can be accurately tracked, providing valuable data for project management and scheduling. This data can also be used to create 3D models of the construction site and the building in real-time, which

can be used to optimise construction processes and avoid errors. EGNSS differentiators can be used to enable high precision mapping of the digital twin against the physical twin and allow high precision augmented reality based on-site visualisations of the design-intent version of the digital twin on the construction-phase physical twin. Furthermore, EGNSS can be used to monitor the movement and deformation of buildings and infrastructure over time. By tracking the position and movement of buildings and infrastructure, EGNSS can provide early warning of potential structural issues, allowing for timely maintenance and repair.

From January 2023, Galileo has launched High Accuracy Service (HAS), which increases the accuracy of Galileo to sub-meter levels, becoming the first constellation worldwide able to provide a high-accuracy service globally. Such high accuracy is of great importance for BUILDSPACE services than involve satellite positioning.

In summary, the European Global Navigation Satellite System is a sophisticated and advanced system that provides accurate positioning and timing information to users worldwide. Its use of advanced technology, multiple frequencies, and signal modulations, along with atomic clocks, allows for high-precision positioning and timing information, making it a valuable tool for a wide range of applications.

EGNSS/ Copernicus data alignment

In the context of BUILDSPACE, services SE1 (Digital Twin Generation) and SE2 (Digital Twins enrichment by combining UAV, thermography and SLAM approaches) utilise EGNSS (Galileo) data and Copernicus land data. It is of high importance for SE1 and SE2 to provide an accurate Digital Twin of Buildings. To this extent, BUILDSPACE will use Galileo High Accuracy Service (HAS) which offers sub-meter level accuracy in the terms of end user and UAV positioning, Augmented Reality, visualisation of DT on its physical location. On the other hand, Copernicus land service and especially Sentinel 2 and 3 data will be linked in the DT providing the details of climate changes (around the buildings) that will support informed decision-making regarding the energy efficiency within the building. Copernicus data incorporate positioning information (lat, long coordinates) and this will be the key feature on which the EGNSS data (latitude, longtitude coordinates) will be combined and aligned allowing dynamic building monitoring at the city scale.

6 Social engagement for co-creating the BUILDSPACE use-cases and applications

Stakeholder engagement is the systematic identification, analysis, planning and implementation of actions designed to involve stakeholders. The term reflects a broad, inclusive, and continuous process between a project and those potentially impacted by its results. The BUILDSPACE Co-Creation and Stakeholder Engagement Strategy will be based on various existing and established trust relations. Considering this

premise, all project partners will be involved in the stakeholder engagement, given the variety of existing connections and areas of interest, and considering the multidisciplinary approach.

Stakeholder engagement and co-creation consist of a process divided into different steps, that highlight essential actions for planning and managing engagement. On the other hand, it is important to note that stakeholder engagement is not a quick fix but it is a process that takes time and resources to build a connection and engage individuals rather than manage them.

The engagement of stakeholders follows an inclusive approach regarding communication with stakeholders. Inclusive communication is important for individuals and communities because it ensures that stakeholders are effectively included and can enjoy a positive, fair and equal experience for more effective interaction.

In the following sections, the engagement and co-creation strategy is detailed, in the first place with the definition of the principles and procedure steps for the co-creation sessions, and secondly, through the application of those methods in the planning of different sessions, considering the project activities, methods, feedback needs and loops, formats, expected outcomes and interaction type.

Although a living task all along the project, stakeholders as well as running and starting projects have already been identified, to start building links and relationships.

6.1 Co-creation strategy

6.1.1 Principles of the co-creation strategy

The co-creation strategy of the project is designed, and will be implemented following four key principles:

- **Transdisciplinarity** – BUILDSPACE will pilot a collaborative process of knowledge production, which draws from scientific and societal bodies of knowledge alike, to contribute to a multi-dimensional understanding of the role of data (including data and information from satellite services) in monitoring of building stock from different perspectives.
- **Flexibility** – In order to manage the co-creation activities, partners will have a flexible role in the project, considering the specificity and different background of each stakeholder, and specific goals for each co-creation session.
- **Balance** – In order to carry on a successful engagement and to determine the level of engagement of each stakeholder group, a balanced approach will be followed, considering the stakeholders' willingness to contribute to the core objectives of the project.
- **Recognition** – Considering that the participation to the co-creation process is carried out on a voluntary basis, and without compensation, the work for the stakeholders needs to be recognised.

6.1.2 Definition of the procedure steps for the co-creation sessions

In the co-creation activities two levels of engagement are foreseen and can be divided into two main categories**: low-level involvement**, that regards mainly communication and dissemination activities, and **high-level involvement**, which foresees the active participation of the stakeholders in the co-creation sessions and in the activities of the project.

Low level engagement is foreseen for all the stakeholders involved and identified by this document and it includes actions such as: subscribing to the project newsletter, following the project social media channels and contributing to disseminating news about it, raising visibility to the project activities and results whenever relevant, promoting events to their networks to both disseminate the project results and build confidence in the project's approach and tools.

High-level involvement is foreseen for the stakeholders identified and contacted for the co-creation activities and it includes the active participation in the co-creation activities organised by the project. Besides the co-creation activities, the stakeholder community formed in WP2 can continue being involved in other project initiatives such as the training, services testing (Task 4.2, Task 4.3 and Task 4.4), technical podcast and Hackathon foreseen in Task 6.4.

Low-level involvements can be perceived as lacking a dimension of real involvement since that is interactive, but often they are the first step for a potential more structured relationship between stakeholders and can lead to higher levels of involvement. While engaging stakeholders at a higher level allows for a more in-depth knowledge exchange and effective co-creation process, offering them information and keeping them updated are necessary first steps to make the stakeholders familiar with the project objectives and topics. Effective engagement, in fact, usually consists of a combination of different-level approaches. When foreseeing different levels of engagement, it is relevant to keep in mind that any type of engagement must always be at the same time purposeful for the technical partners (i.e., instrumental to the collection of useful insights) and valuable for the stakeholders.

The project strategy for the **development of the co-creation sessions** follows **three phases**:

Phase 1 Identification

The first step aims to identify the **project stakeholders** and the strategic priorities for Stakeholder Engagement and co-creation activities, having a clear vision of the project's main issues and desired impact. While identifying potential stakeholders, it is important to reflect on their relevance, i.e., the consortium needs to collectively determine the people and organizations that can both be impacted by the project and have the power to influence its outputs.

The identification of stakeholders is particularly relevant for the implementation of the co-creation activities, but it is an ongoing activity during the whole duration of the project.

Phase 2 Engagement and Co-creation

The second step is aimed at **first defining and then implementing, a co-creation strategy and planning** that can meet both the project and the stakeholders' expectations and goals. Once the stakeholders have been mapped and their needs identified, it is crucial to identify the correct approach from a wide range of possibilities.

To keep this kind of stakeholders engaged, it is fundamental to establish and maintain a structure that works for everyone.

Phase 3 Long term engagement

In this last step, it is also relevant to build a long-term relationship and have insights and objectives that can go beyond the life of the project and carry on its outputs after it ends.

6.2 Identified stakeholders and running/starting projects

Table 17 presents the stakeholder groups that have been identified as potential interested parties to be engaged throughout the whole process of developing the final BUILDSPACE services. For each of these stakeholder groups, a role has been assigned based on their focal area of engagement in the process (i.e., end-users, technological providers), along with the benefit(s) accrued for themselves once their involvement is assured. At this point, it should be highlighted that, drawing from the “Terminology” that has been created for the purpose of BUILDPSACE (presented at the beginning of this deliverable) towards facilitating common understanding among all partners, the identified “Target groups” will act as the end users of the developed services (please refer to **Section 3.3** for more details). Nevertheless, this does not preclude any other implicated body to also play the role of end user, and as of this, several potential identified stakeholder groups (**Table 17**) could fall under this category. It is also worth mentioning, that the list of potential stakeholder groups has been elicited following a literature review that has been conducted for this purpose, however not all of these groups have been deemed to suit the needs and priorities of the BUILDSPACE’s pilot partners, thus limiting the list of the final stakeholder groups to be potentially engaged.

Table 17 List of potential identified stakeholder groups, their role within the process of developing the final services, the benefits accrued for themselves, as well as the stakeholder groups that were selected as the most appropriate from the pilot partners.

Stakeholder group: Citizens	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★				✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the current building envelope condition in the neighbourhood					
SE3	Better knowledge on the energy demand of building stock (and its house)					
SE4	Better knowledge about the locations of the city with the highest urban heat risk					
SE5	Better knowledge and preparedness on flood events risk					

Stakeholder group: Neighbourhood associations	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★				✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the current state of the building envelope, more informed decisions on energy renovation of buildings, as well as on retrofitting in general (e.g., allows to check if there is any danger on the facades or elements of the buildings					
SE3	Better knowledge on the energy demand of building stock					
SE4	Better knowledge about the neighbourhood in comparison to other areas of the city terms of urban heat risk					
SE5	-					

Stakeholder group: Tenants	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★				✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge on current building envelopes condition for more informed home energy and general improvements (e.g., allows to check if there is any danger on the façades or elements of the building)					
SE3	Better knowledge on the energy demand of building stock, more informed decisions about building energy renovation					
SE4	Decision support in choosing the least urban heat risky neighbourhoods to live in					

SE5	Better knowledge about the neighbourhood in comparison to other areas of the city terms of flood events risk

Stakeholder group: Private homeowners	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★				✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the current condition of the building envelope, more informed decisions on energy and general renovation of buildings. (e.g., allows to check if there is any danger on the façades or elements of the building)					
SE3	Better knowledge on the energy demand of building stock, more informed decisions about building energy renovation					
SE4	More informed decisions about building renovations and resilience					
SE5	Better knowledge and preparedness on flood events risk, more informed decisions about building renovations and resilience, Cost Savings					

Stakeholder group: Companies (e.g., building envelope services, building renovation services, etc.)	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★	★	✓	✓	✓	✓
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge for the choice of company location or new business opportunities with regard to the condition of the buildings (e.g., better adjustment of budgets based on the actual conditions of the buildings)					
SE3	More information on building stock energy demand and on opportunities for energy renovation					
SE4	-					
SE5	New know-how and business opportunities					

Stakeholder group: Consultants	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓			
Benefits for the stakeholder group						
SE1	Better picture about the As-Is condition of the facility					
SE2	Better picture about the As-Is condition of the facility					
SE3	Information on building stock energy demand and opportunities for energy renovation					

SE4	-
SE5	-

Stakeholder group: Utilities	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
		★	✓		✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the condition of the building envelope and energy and general renovation possibilities. (e.g., detecting damaged solar panel cells or detecting serious cracks in buildings, or elements that are broken)					
SE3	More information on building stock energy demand and on opportunities for energy renovation					
SE4	-					
SE5	Better knowledge and preparedness on flood events risk, Better knowledge about the locations of the city with the highest urban flood events risk					

Stakeholder group: National governments	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓	✓	✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the quality of the thermal envelope of buildings, and better decision making to support energy and general renovation strategies for buildings					
SE3	More information on current building stock energy demand, supported informed decision-making on building energy renovation strategies					
SE4	Support for guidelines preparation/upgrade, Support for prioritisation of areas for the implementation of mitigation and resilience actions					
SE5	Support for guidelines preparation/upgrade					

Stakeholder group: Regional governments	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓	✓	✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the quality of the thermal envelope of buildings, and better decision making to support energy and general renovation strategies for buildings.					

SE3	More information on current building stock energy demand, supported informed decision-making on building energy renovation strategies
SE4	Support for prioritisation of areas for the implementation of mitigation and resilience actions
SE5	-

Stakeholder group: Public authorities	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓			
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the situation of the thermal envelope of buildings, and better decision making to support energy and general renovation strategies for buildings					
SE3	More information on current building stock energy demand, supported informed decision-making on building energy renovation strategies					
SE4	Support for prioritisation of areas for the implementation of mitigation and resilience actions					
SE5	Support for prioritisation of areas for the implementation of mitigation and resilience actions					

Stakeholder group: Municipalities	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓	✓	✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the condition of the envelope of buildings, and better decision making to support energy and general renovation strategies for buildings					
SE3	More information on current building stock energy demand, supported informed decision-making on building energy renovation strategies					
SE4	Support for decision making on building stock as well as target groups based on social vulnerability to urban heat					
SE5	Better preparedness for flood events, risk management, Support for prioritisation of areas for the implementation of mitigation and resilience actions					

Stakeholder group: Infrastructure	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
		★			✓	✓
Benefits for the stakeholder group						
SE1	-					
SE2	-					

SE3	Opportunities for energy renovation
SE4	-
SE5	Better knowledge and preparedness on flood events risk, Better knowledge about the locations of the city with the highest urban flood events risk

Stakeholder group: Urban developers	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
		★	✓			
Benefits for the stakeholder group						
SE1	Better picture about the As-Is condition of the facility					
SE2	Better knowledge of the condition of the envelope of buildings, and better decision making to support energy and general renovation strategies for buildings.					
SE3	More information on current building stock energy demand, supported informed decision-making on building energy renovation strategies					
SE4	Support for identifying priority areas for action and implementation of strategies					
SE5	-					

Stakeholder group: Green specialists	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓			✓
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the quality of the envelope of buildings, and better decision making to support building energy and general renovation strategies					
SE3	More information on building stock energy demand to support informed decision on building energy renovation					
SE4	Identification of areas in need of green infrastructure and services related to urban heat risk					
SE5						

Stakeholder group: NGOs	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓		✓	✓
Benefits for the stakeholder group						
SE1	-					
SE2	-					
SE3	Information on building stock energy demand and opportunities for energy renovation					
SE4	Identification of areas in need of green infrastructure and services related to urban heat risk					

SE5	Better knowledge and preparedness on flood events risk, Better knowledge about the locations of the city with the highest urban flood events risk

Stakeholder group: Housing corporations	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓	✓	✓	
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the condition of the envelope of buildings					
SE3	Better knowledge on the energy demand of building stock					
SE4	Support for decision making on building stock as well as target groups based on social vulnerability to urban heat					
SE5	-					

Stakeholder group: Educational and research institutions	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★	★	✓	✓	✓	✓
Benefits for the stakeholder group						
SE1	Better understanding about the state of practice and its limitations for more developed solutions in the future					
SE2	Better knowledge of the condition of the envelope of buildings					
SE3	Better knowledge on the energy demand of building stock					
SE4	Availability of data for research projects. Support for urban, climate change, and future climate scenarios research					
SE5	Better knowledge about the state of practice and its limitations for more developed solutions in the future					

Stakeholder group: Communities	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★			✓		
Benefits for the stakeholder group						
SE1	-					
SE2	-					
SE3	Better knowledge on the energy demand of building stock					
SE4	-					
SE5	-					

	Role		Pilots			

Stakeholder group: Agencies	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓		✓	

Benefits for the stakeholder group	
SE1	-
SE2	-
SE3	Information on building stock energy demand and opportunities for energy renovation
SE4	-
SE5	Better knowledge and preparedness on flood events risk, Better knowledge about the locations of the city with the highest urban flood events risk

Stakeholder group: Real estate developers	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★	★	✓			

Benefits for the stakeholder group	
SE1	Informed decision making
SE2	Better knowledge of the condition of the envelope of buildings
SE3	Better knowledge on the energy demand of building stock
SE4	Support for identifying priority areas for action and implementation of strategies
SE5	-

Stakeholder group: Planners	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★				✓	

Benefits for the stakeholder group	
SE1	Understanding about the built facility and informed decision making
SE2	Better knowledge of the state of the envelope of the building stock and informed decision-making on strategies for the energy and general renovation of buildings
SE3	Better knowledge on the energy demand of building stock, supported informed decision-making on building energy renovation strategies and planning
SE4	Decision support for establishing priority areas for climate change resilience/adaptation action related to urban heat risk
SE5	Decision support for Blue-Green infrastructure planning for climate resilient city

Stakeholder group: Non-profit organisations	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓	✓	✓	✓

Benefits for the stakeholder group	
SE1	-
SE2	-
SE3	Information on building stock energy demand and opportunities for energy renovation
SE4	Identification of the most vulnerable urban areas related to urban heat risk
SE5	-

Stakeholder group: Political institutions	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓	✓	✓	

Benefits for the stakeholder group	
SE1	-
SE2	Better knowledge of the state of the envelope of the building stock and informed decision-making on strategies for the energy and general renovation of buildings
SE3	More information on current building stock energy demand, supported informed decision-making on building energy renovation strategies
SE4	Support for the implementation of urban heat resilience strategies
SE5	-

Stakeholder group: Designers	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★	★	✓		✓	

Benefits for the stakeholder group	
SE1	Provides the near real time picture of the facility to enable design optimisation
SE2	Better knowledge of the state of the envelope of the building stock and informed decision-making on strategies for the energy and general renovation of buildings.
SE3	Better knowledge on the energy demand of building stock, supported informed decision-making on building energy renovation strategies and planning
SE4	-
SE5	Decision support for Blue-Green infrastructure design and implement

Stakeholder group: Entities	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓			

Benefits for the stakeholder group	
SE1	-

SE2	Better knowledge for the choice of company location or new business opportunities with regard to the condition of the buildings (e.g., better adjustment of budgets based on the actual conditions of the buildings
SE3	More information on building stock energy demand and on opportunities for energy renovation
SE4	-
SE5	-

Stakeholder group: Facility managers	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓			
Benefits for the stakeholder group						
SE1	Optimised facility management with semi-automated or automated maintenance and operation					
SE2	Better knowledge of the state of the envelope of the building stock and informed decision-making on strategies for the energy and general renovation of buildings					
SE3	More information on building stock energy demand and on opportunities for energy renovation					
SE4	-					
SE5	Better knowledge and preparedness on flood events risk, Better knowledge about the locations of the city with the highest urban flood events risk					

Stakeholder group: Constructors and contractors	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
		★				✓
Benefits for the stakeholder group						
SE1	Provide the comparison between the as-design vs as-is condition of the built facility					
SE2	Better knowledge of the state of the building envelope and informed decision making on energy and general building renovation strategies, with more realistic and accurate budgets					
SE3	More information on building stock energy demand and on opportunities for energy renovation					
SE4	Identification of urban areas for improvements related to heat resilience					
SE5	-					

Stakeholder group: Investors	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★		✓			
Benefits for the stakeholder group						
SE1	-					
SE2	Better knowledge of the state of the building envelope and informed decision making on energy and general building renovation strategies, with more realistic and accurate budgets					

SE3	More information on building stock energy demand and on opportunities for energy renovation
SE4	Identification of potential areas for investments focused on improvements related to heat resilience
SE5	Better knowledge about the locations of the city with the highest urban flood events risk

Stakeholder group: Other (EU projects, committees, innovation centres, etc.)	Role		Pilots			
	End-users	Technology providers	RPR	MoP	IMZI	MOS
	★	★		✓		

Benefits for the stakeholder group	
SE1	-
SE2	-
SE3	Information on building stock energy demand and opportunities for energy renovation
SE4	-
SE5	-

While the identification of related running and starting projects will be as well a living task during the whole project, an initial identification has been done in this first stage, considering partners' relationship and knowledge on the existence of related projects, and the projects that come from the same call than BUILDSPACE. In the continuous search of stakeholders and potential users, links with these kinds of projects will be prioritised, in order to be able to establish potential collaborations in the future.

Table 18. List of running and starting projects identified so far to establish links and relationship with BUILDSPACE project.

Project acronym	Full name	Call	Dates, duration	Link
SWIFTT	Satellites for Wilderness Inspection and Forest Threat Tracking	HORIZON-EUSPA-2021-SPACE-02-51	1 Nov 2022 - 31 Oct 2025	https://cordis.europa.eu/project/id/101082732
BirdWatch	BirdWatch - a Copernicus-based service for the improvement of habitat suitability of farmland birds via satellite-enabled monitoring, evaluation and optimisation of CAP greening measures	HORIZON-EUSPA-2021-SPACE-02-51	1 Feb 2023 – 31 Jan 2026	https://cordis.europa.eu/project/id/101082634
100K TREEs	Decision Toolbox for cities to improve air quality, biodiversity, human wellbeing and reduce climate risks by planting more trees in our cities	HORIZON-EUSPA-2021-SPACE-02-51	1 Dec 2022 – 30 Nov 2025	https://cordis.europa.eu/project/id/101082551

Project acronym	Full name	Call	Dates, duration	Link
MAGDA	METEOROLOGICAL ASSIMILATION FROM GALILEO AND DRONES FOR AGRICULTURE	HORIZON-EUSPA-2021-SPACE-02-51	1 Nov 2022 - 30 Apr 2025	https://cordis.europa.eu/project/id/101082189
RESPONDENT	Renewable Energy Sources Power FOrecasting and SyNchronisation for Smart GriD NEtworks MaNagemenT	HORIZON-EUSPA-2021-SPACE-02-51	1 Nov 2022 - 30 Apr 2025	https://cordis.europa.eu/project/id/101082355
CLUG 2.0	CLUG Demonstration of Readiness for Rail	HORIZON-EUSPA-2021-SPACE-02-51	1 Feb 2023 – 31 Jan 2025	https://cordis.europa.eu/project/id/101082624
OVERWATCH	Integrated holographic management map for safety and crisis events	HORIZON-EUSPA-2021-SPACE-02-52	1 Nov 2022 - 31 Oct 2025	https://cordis.europa.eu/project/id/101082320
EWOKS	Enabling EWS/GalileO MarKet Uptake in widespread PWS Solutions	HORIZON-EUSPA-2021-SPACE-02-52	1 Nov 2022 - 31 Dec 2025	https://cordis.europa.eu/project/id/101082555
CHRISS	Critical infrastructure High accuracy and Robustness increase Integrated Synchronization Solutions	HORIZON-EUSPA-2021-SPACE-02-52	1 Nov 2022 - 31 Oct 2025	https://cordis.europa.eu/project/id/101082440
SPACE4GREEN	Trusted and Green traceability through EU Space Technologies	HORIZON-EUSPA-2021-SPACE-02-53	1 Nov 2022 - 31 Oct 2024	https://cordis.europa.eu/project/id/101082630
CERTIFLIGHT	Certified E-GNSS Remote TrackIng of Drone and Aircraft FLIGHTs	HORIZON-EUSPA-2021-SPACE-02-53	1 Nov 2022 - 30 Apr 2025	https://cordis.europa.eu/project/id/101082484
EGeNiouSS	EGNSS-based Visual Localisation to enable AAA-PNT in small devices & applications	HORIZON-EUSPA-2021-SPACE-02-53	1 Dec 2022 – 31 May 2026	https://cordis.europa.eu/project/id/101082128

6.3 Co-creation sessions planning

For the planning of the co-creation sessions, both principles and procedure steps have been taken into consideration, as well as a consultation made to all project partners to know the needs for feedback and co-creation they might have in their tasks and WP.

As the co-creation sessions are planned in the context of Task 2.3, with the aim to be held at the beginning of the project and gather input on user needs and “pains” to serve as basis for the definition of the platform services and related potential business opportunities, other needs for further interactions with the “stakeholder community” that is being created in BUILDSPACE will be done under the umbrella of other tasks and not with the intention of “co-create” as such, but more related to the obtention of feedback to the already developed services (e.g., Tasks 4.2 and 4.3, in which live events will be organised for real demonstration of services; Task 4.4, which is for the stakeholder engagement and social acceptance, and Task 6.4, where the capacity building programme will be deployed).

The spreadsheet launched to the project partners to gather their inputs and needs contained different columns in a template mode, to add the related task or WP, the partner, the objective or feedback that is intended to get from external stakeholders in co-creation spirit sessions, as well as what they want to consult/contrast/validate with them, the best or ideal time in the project to perform that consultation, suggestion on the type of interaction, as well as the format in which they want to obtain the feedback.

From the discussions and agreements internally, it was decided that the co-creation sessions should be condensed in the minimum possible number of sessions, so that stakeholders do not feel overwhelmed. Cocreation sessions, also need to be developed in a joint way for all pilots and services, so that the process is more enriched and can serve at a later stage as a way to create synergies between them and see the possibility to apply different functionalities. Also, according to the previous statements and decisions, the sessions will therefore need to be in a virtual/online mode and in English language.

In the table below, the initial planning for these sessions can be seen, along with the proposed date, the objective of the session and the expected outcome, so that it is clear enough before preparing the sessions. A more updated version will be provided in the next deliverable (D2.2), together with the outcomes of the sessions that have already taken place at that stage.

Table 19. Co-creation sessions initial planning.

No.	Date	Task	Objective of the Session	Expected outcome from the Session	Type of interaction, format
#1	**M6** July 2023	**T2.3**	To **co-create** the **technical uses cases** (derived from the **needs** from users and stakeholders), including definition of **relevant data** (incl. data sources) and **scenarios**.	Further understanding of **users' needs** to then build technical use cases (possibility to add more functionalities to the services – taking as basis the services' description). Additional **data** (and data sources) **and scenarios** to consider in the services, or agreement with data already proposed.	**Online meeting, 1- or 2-hours** duration. Tools to be explored during session preparation, e.g., ***Miro Board***
		T2.4	To know how **end-users would like to visualise results**	To know **formats** (e.g., map, dashboards, graphs, tables, download or export raw data…) and find **similarities** between different **users and services**.	
		T2.4	To know if users want to **switch between different services**	To have clarity on **how often** users will switch between services, how this can be done **user-friendly**, and how the **relation with** the higher level base BUILDSPACE **platform** can work.	
#2	**M8** Sep 2023	**WP3 & T2.4**	To know the **information** they want **to see** in the different services.	It will inform the service developers when further designing the **functionalities**, as well as to the production of **mock-ups and wireframes** of the services.	**Online meeting**, duration to be defined (1- or 2-hours).

No.	Date	Task	Objective of the Session	Expected outcome from the Session	Type of interaction, format
		T2.4	To know the **devices** that the end-users will use when consulting the applications	Information on devices is important to **design** and develop the different **screen sizes and touchscreen services**.	Can be done during the session or afterwards through an **online survey** send after the session
#3	**M10** Nov 2023	**WP3 & T2.4**	Obtain **feedback** on a quite final version of the **wireframes**	**Validation** of the wireframes, **feedback** if **more functions** can be added, the place where the functionalities are **located**, as well as to the **format of the maps**.	**Online meeting**, duration to be defined (1 hour).

Once the co-creation session approaches, a detailed agenda will be clearly defined, and relevant stakeholders from the identified ones will be invited to the session. This information will be reported in the next deliverable D2.2, to be submitted by November 2023 (M10).

It is worth noting that the stakeholders participating in the meeting will not be in charge of actually helping the partners draft the use cases, since this is something technical. However, with the objective in mind to finalise the use cases, they can be asked questions to detect more clearly what their needs are, and then be able to represent this in the use cases.

7 Introducing Technical Use Cases

This deliverable has introduced the different steps followed to elicit user requirements and technical specifications derived from user stories. It has also defined how to interact and engage users and stakeholders down the line. This section introduces the next required technical step: the generation of technical use cases. This will facilitate the development of services in the BUILDSPACE project and will establish a link with WP3 “BUILDSPACE location-based and remote sensing applications development”.

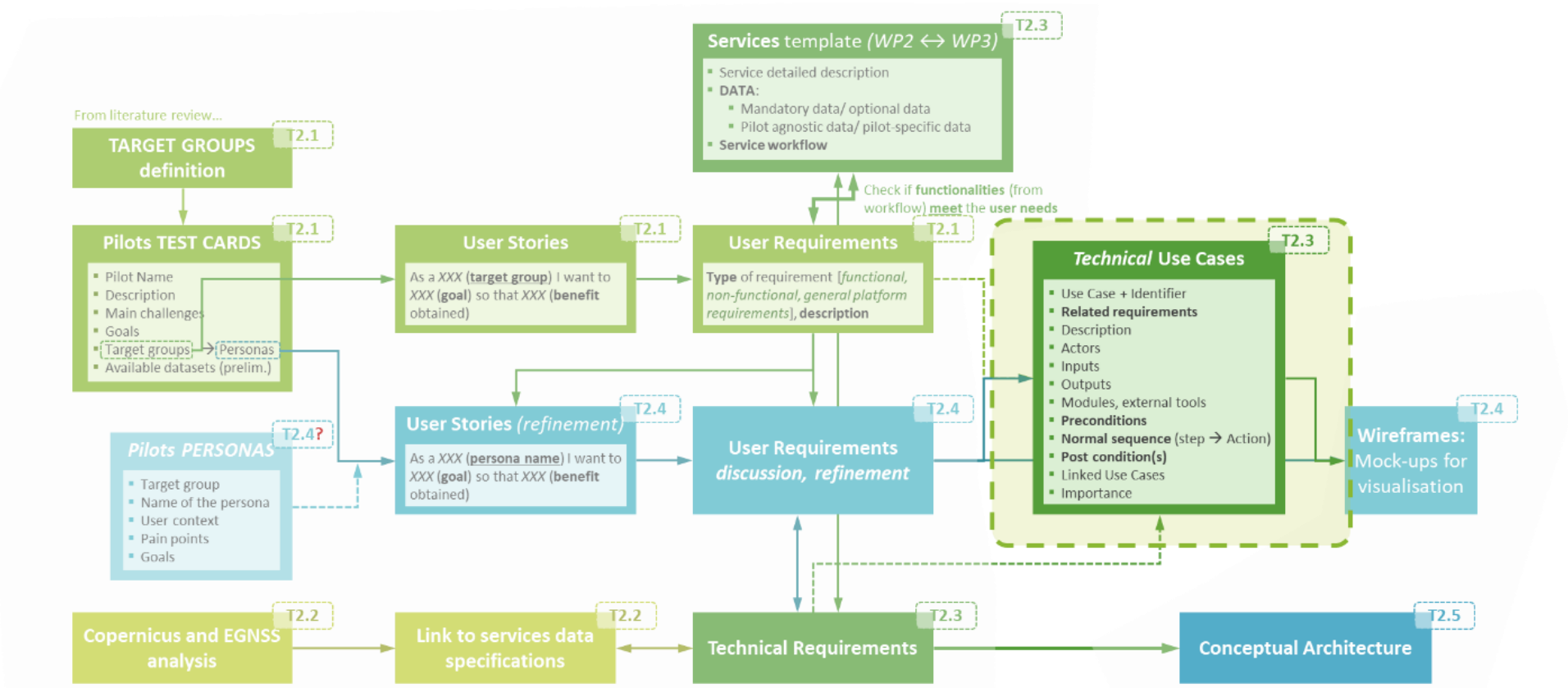

Figure 2. Where the Technical Use Cases fit under the whole WP2 methodology.

7.1 Approach for technical use cases

Defining the approach for the technical use cases is the following natural step after having defined who the main users and beneficiaries of the services will be [target groups & personas], as well as the challenges they might face [user stories], and what does this imply for the services development [user & technical requirements].

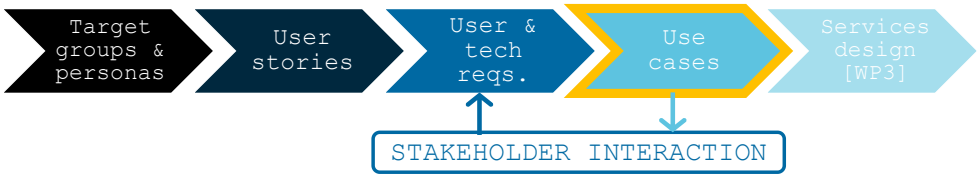

Figure 3. Approach for technical uses cases placed in the process of the BUILDSPACE methodology.

Use cases capture the interrelationships between data, users, modules and repositories that actively participate in the platform operation. They represent a functionality which should fulfil a requirement or a set of requirements. Use cases define a series of steps that need to be followed to cover a specific functionality of the platform or service considered. In this line, not only the interactions with end-users are observed, but also with other actors within the platform, such as repositories, external services, APIs, etc.

At this stage of the project, the template to capture use cases has been defined (presented in next subsection), and use cases will be reported in the next WP2 deliverable, namely: D2.2 "Use cases and design of application's dashboards". As it can be derived from the figure above, the use cases will be co-created with end users through the stakeholder co-creation sessions, as explained in **Section 6**.

7.2 Template for technical use cases

The template defined so far for the definition of the technical use cases is presented below (**Table 20**). As commented before, the filled in templates together with a scheme connecting related use cases, and a list of all considered use cases will be provided in the next WP2 deliverable.

Table 20. Template with instructions for the technical use cases.

Use case	Identification of the Use Case through its code and name (**UCX – Name of the Use Case**)	
Identifier	**Further identification of the Use Case**, to be referred to in the development process.	
Related requirements	**Functional**	*List of the related functional requirements linked to the use case.*
	Non-functional	*List of the related non-functional requirements linked to the use case.*

Description	*Brief description of the actions to be carried out in the use case.*	
Actors	*Identification of which actors interact in this use case. An actor can be a specific end user, but also a repository, time, etc.*	
Inputs	*What inputs are required for this use case to be carried out.*	
Outputs	*What outputs are obtained once the Use Case has been executed.*	
Modules / external tools	*Identification of involved modules or external tools (if any).*	
Preconditions	*Identification of actions that should have taken place or conditions that should be met before the present use case.*	
Normal sequence	**Step**	**Action**
	1	*Step 1 to be followed when executing the Use Case.*
	2	*Step 2 to be followed when executing the Use Case.*
	…	…
	n	*Step n to be followed when executing the Use Case.*
Post condition	*Condition(s) that should be met after the use case has been executed.*	
Exceptions	**Related step**	**Action**
	X.X	*In case any of the previously defined steps can follow an alternative path, it will be indicated in this field of the table. For instance, if step 2 has an alternative, the description of step 2.1 will be presented in this field.*
	X.X	
Linked Use Cases	*Insert the use cases that are linked to the present use case. They could be linked because they need to be executed previously, or because they happen just afterwards the present use case is executed.*	
Importance	*The degree of importance of the use case will be assessed in this field (low-medium-high), depending on how critical the execution of the use case will be, and if it would block the execution of a following step or not.*	

8 Conclusions

This deliverable provides an overview of the BUILDSPACE user requirements, which constitute an initial step towards the definition of the BUILDSPACE solution. The document explains the overall methodology that will be used in WP2 to deliver the design and specification of BUILDSPACE services. Following this methodology, the deliverable reflects an initial iteration of the requirements elicitation, as collected

during the pilot user consultations and an early mapping between the identified user requirements and the expected technical requirements together with initial services description. Potential gaps between user requirements and technical requirements have been identified and will feed a feedback loop for the design of the use cases to be delivered in the context of the BUILDSPACE project. Finally, this document provides insights on the Copernicus and EGNSS services considered in the context of the BUILDSPACE project and defines an initial strategy for stakeholder engagement and the establishment co-creation process. Overall, D2.1 is a key deliverable that presents initial results of all WP tasks and provides a basis for an iterative process for the design and specification of BUILDSPACE services.

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Annexes

Table 21. Detailed presentation of the feasibility assessment for the elicited user requirements.

Related User Story	User Requirement ID	Description of user requirement	Feasibility of User Requirement	Related Technical Requirement	Description of technical requirement	Mitigation measures required
US1	RQ01	Connect district heating consumption data in apartment buildings with available building information (e.g., area, volume, etc.)	✓	TR20	District heating consumption data linkage with building information	×
				TR21	Support importing datasets in different formats	
	RQ02	Calculate energy efficiency rating of buildings that are connected to the district heating network	✓	TR27	Support importing datasets in different formats	×
	RQ03	Visualise building's energy efficiency rating	✓	TR01	Energy efficiency visualisation	×
				TR02	Visualisation of building's energy efficiency rating	
				TR03	Must provide data visualisation tools and functionalities	
	RQ04	Link "bad" energy efficiency rating buildings with recommended solutions	×	-	-	✓
US2	RQ05	Identify all chimneys by using satellite thermography images	✓	TR22	Chimneys' identification	×
	RQ06	Connect every "hot" chimney to building and heated area data	✓	TR04	Support importing datasets in different formats	×
	RQ07	Connect every "hot" or used chimney to heat source used in the building	×	-	-	✓
	RQ08	Create a list of heated buildings and used heat source	✓	TR28	Must provide data visualisation tools and functionalities	×
	RQ09	Calculate building's heat consumption	×	-	-	✓
	RQ10	Calculate air pollution for each heat source	✓	TR29	Support importing datasets in different formats	×

US3	RQ11	Measure the roof area that is available for solar energy generation	✓	TR23	Measure the roof area that is available for solar energy generation	×
				TR24	Support importing datasets in different formats	
	RQ12	Measure the shaded roof area	✓	TR30	Support importing datasets in different formats	×
	RQ13	Calculate the yearly output of solar panels	✓	TR31	Support importing datasets in different formats	×
	RQ14	Calculate the available amount of solar energy (solar energy potential of the building)	✓	TR32	Support importing datasets in different formats	×
US4	RQ15	Visual representation of the progress of construction works on daily/weekly basis	✓	TR05	Construction works monitoring	×
				TR06	Visualisation of progress monitoring	
US5	RQ16	Identify quickly and accurately hazards that are associated with groundwater levels, taking also into account the weather changes	×	-	-	✓
US6	RQ17	Visual representation of green energy production and related savings	×	-	-	✓
US7	RQ18	Visual identification of thermal bridges of the buildings	✓	TR25	Visual identification of thermal bridges of the buildings	×
US8	RQ19	Detect cracks in the building structure or displacement of the building or surrounding buildings	✓	TR26	Detect cracks in the building structure or displacement of the building or surrounding buildings	×
US9	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	✓	TR33	Support importing datasets in different formats	×
	RQ21	Provide a baseline indicator value for the thermal performance, as well as a procedure to replicate on more municipal or other buildings	✓	TR34	Support importing datasets in different formats	×
	RQ22	Measure the impact of interventions at building scale	×	-	-	✓

	RQ23	Measure the impact of interventions at city scale	×	-	-	✓
US10	RQ24	Provide a baseline indicator value for the social vulnerability to urban heat	✓	TR07	Social vulnerability indicator to urban heat	×
				TR08	Support importing datasets in different formats	
	RQ25	Measure relevant heat indicator values at any time	✓	TR09	Heat indicator at any time	×
				TR10	Support importing datasets in different formats	
				TR11	Must provide data visualisation tools and functionalities	
	RQ26	Acquire necessary expertise and equipment to perform building and city level heat analysis at any time, at any building	✓	TR12	Expertise and equipment for performing heat analysis, both at building and city level	×
	RQ27	Identify specific areas where urban heat is significantly higher than the rest of the city	✓	TR13	Identification of specific areas where urban heat is significantly higher than the rest of the city	×
				TR14	Support importing datasets in different formats	
				TR15	Must provide data visualisation tools and functionalities	
	RQ28	Measure the impact of interventions at the city level regarding urban heat and social vulnerability	✓	TR16	Interventions impact at the city level regarding urban heat and social vulnerability	×
				TR17	Support importing datasets in different formats	
				TR18	Support importing datasets in different formats	
				TR19	Must provide data visualisation tools and functionalities	
US11	RQ29	Develop an online version of the already existing Flood Damage Assessment Methodology (FDAM) tool	×	-	-	✓
	RQ30	Upgrade FDAM to address the expected damage in urban	✓	TR35	Support importing datasets in different formats	×

		flooding caused by short-term extreme rainfall events, while also allowing engagement of end-users		TR36	Must provide data visualisation tools and functionalities	
	RQ31	Make the upgraded FDAM more user-friendly in terms of eliminating the needs for GIS and requiring programming skills by the end-users	×	-	-	✓
	RQ32	Visualise flooding hotspots by combining available off-line flooding altitude data, satellite urban floods images and satellite terrestrial altitude data	✓	TR37	Support importing datasets in different formats	×
				TR38	Must provide data visualisation tools and functionalities	
	RQ33	Calculate the flood damage per m2 of urban area	✓	TR39	Support importing datasets in different formats	×
	RQ34	Calculate the flood damage per m of urban infrastructure	✓	TR40	Support importing datasets in different formats	×
	RQ35	Calculate the flood damage per building	✓	TR41	Support importing datasets in different formats	×
	RQ36	Build evidence of urban planning events by enabling to make individual georeferenced inputs by the end users	×	-	-	✓
	RQ37	Calculate the terrestrial altitude from satellite LIDAR DEM model with open source softwares: QGIS, LAStools, FUSION, SAGA and make a kind of intersection of them	✓	TR42	Support importing datasets in different formats	×
US12	RQ38	Calculate the average Normalized Difference Vegetation Index (NDVI) per buildings or buildings‘ plots	✓	TR43	Support importing datasets in different formats	×
	RQ39	Assess how blue-green is a building or a building's plot	✓	TR44	Support importing datasets in different formats	×
	RQ40	Identify where are the critical points in view of high urban flooding risk	✓	TR45	Support importing datasets in different formats	×
	RQ41	Create NDVI trends over seasons and years	✓	TR46	Support importing datasets in different formats	×
	RQ42	Monitor existing blue-green infrastructure measures by attaching photos and writing	×	-	-	✓

		some connected text/descriptions				
	RQ43	Calculate the terrestrial altitude from satellite LIDAR DEM model with open source softwares: QGIS, LAStools, FUSION, SAGA	✓	TR47	Support importing datasets in different formats	×
	RQ44	Combine available terrestrial with satellite data in order to identify potential flooding hotspots	✓	TR48	Support importing datasets in different formats	×
				TR49	Must provide data visualisation tools and functionalities	
				TR50	Support importing datasets in different formats	
	RQ45	Analyse the effects of blue-green infrastructure measures on flooding resilience of buildings	✓	TR51	Support importing datasets in different formats	×

BUILDSPACE

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