xR4DRAMA

Extended Reality For DisasteR management And Media planning

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D5.4

Prototypes and mobile development v2

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Abstract

This deliverable documents the final versions of the xR4DRAMA platform and its architecture, the GIS system, and the xR environment and awareness apps. It covers the work of tasks T5.2 (Backend framework: Integration, communication and data management of xR4DRAMA system), T5.3 (3D GIS for navigation and data geo-localization) and T5.4 (Awareness apps for end users).

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Executive Summary

The deliverable D5.4 is documenting the final results of the development on two fronts of the xR4DRAMA platform: i) the system integration and more specifically the backend components, and ii) the awareness app for the public. It can be considered as the updated version of D5.3. The deliverable reports the achievements on the backend and the storage, as well as the Geographic Information System (GIS). The architecture of the connection among these components is also presented. The awareness app for the citizens, which serves the Disaster Management scenario has also reached its final version and is documented here. This deliverable does not report on the XR applications, as these are reported separately in the dedicated deliverables D4.7 (AR interactive environment and applications v2), D4.5 (VR environment and collaborative tools v2) and D4.6 (VR authoring tool v2).

Abbreviations and Acronyms

API	Application Programming Interface
AR	Augmented Reality
DEM	Digital Elevation Model
DIAS	Data and Information Access Services
DB	Data Base
DSS	Decision Support System
GNSS	Global Navigation Satellite System
HCI	Human Computer Interaction
IO	Innovation Objective
IMU	Inertial Measurement Unit
KB	Knowledge Base
OSM	OpenStreetMap
TO	Technological Objective
VR	Virtual Reality
WP	Work Package
XR	Extended Reality
PUC	Pilot Use Case
GIS	Geographic Information System
WFS	Web Feature Service
WMS	Web Map Service

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1 INTRODUCTION

1.1 Tasks & Objectives

This deliverable reports on three separate tasks of the WP5 - Platform development:

Task **T5.2** ("Backend framework: Integration, communication and data management of the xR4DRAMA system") regards the development of a backend infrastructure that helps in the management of data in a secure manner. The backend supports the integration of the components and is based on the architecture developed in T5.1. The backend manages all the videos, images, data, voice recordings and 3D models that can be accessed by the tools.

The scope of task **T5.3** ("3D GIS for navigation and data geo-localization") was to provide a geospatial database with 2D and 3D content (from T4.4) and a reference frame to be the underlying localization platform that allows all relevant data to be suitably placed in 3D space. The geographic information system (GIS) connects to all relevant processed data of WP3 and manages them in the geo-referenced system via geospatial queries, in order to support the AR interaction.

The scope of task **T5.4** ("Awareness apps for end users") was to develop the mobile application that, depending on the context, will inform citizens and users about likely threats, spanning from depicting geo-localised problematic areas to emergency guidelines.

The work described in D5.4 corresponds to the following innovation objective (IO):

IO3 - Develop enhanced interactive AR applications for outdoor media production and disaster management. This objective aims to deliver an integrated platform for remote outdoor observation and planning of tasks and actions. It corresponds to two innovation actions.

IA3.1 Visualization of DSS results in AR: Augmented Reality (AR) modules will augment the physical world via applying layers of information based on the first responders' needs, when operating on the field. This information will be streamed from available data sources into the xR4DRAMA platform: the stakeholders' "archives", the data captured during the response process by xR4DRAMA tools, i.e., news coverage, social media streams, visual data, prediction models and the results from the analytics in DSS. AR sensors and glasses will allow to position first responders' findings in real 3D space by seamlessly merging the real space with the virtual data connected to the GIS and, hence, the xR4DRAMA platform. This data to superimpose on the real world will be narrative information (e.g., history, protocols), real-time streamed data and 3D information, such as infrastructure, obstacles and restricted areas etc. The AR sensors will also provide real-time information and a view from the actor's viewpoint (1st responder, or local source). Stakeholders in the control room can use this information for support, supervision, and advise to the on-site personnel. In the media use case, this kind of interactive walkthrough can enhance the planning process.

IA3.2 Visual and GIS-assisted uninterrupted navigation for AR: This activity is responsible for deploying the appropriate technologies for supporting the 1st responders and journalists' navigation in the real world via the xR4DRAMA AR module. 3D models of the landscape and the infrastructures referenced to a GIS will be combined with appropriate sensors on the AR

device (GNSS, IMU, Gyro, WiFi) to fulfill this objective. Navigation is an important feature of the AR module as the quality of the user experience depends on this.

Work package 5 also serves the technological objective **TO2: Interactive Situation Awareness Platforms**, which corresponds to three Technological Activities (TA):

TA2.1 System development, integration, communication and data management: This activity will create first an architecture for the development, communication and integration of the platform that can manage all the data in a secure manner. The activity will then work towards the implementation of the architecture to integrate all the services developed. We plan to have a proper data management plan in this activity to ensure data security and GDPR compliance.

TA2.2 3D GIS for navigation and geo-localization: This task will develop a Geographic Information System (GIS) which will incorporate positioning and space scaling information for all assets of xR4DRAMA that are required to be positioned in the real world via the AR tools. The GIS will connect the 3D terrain with all assets that are requested from the field agents and the DSS to be projected in AR. Additionally, it will facilitate the need for spatial queries in the database to select information to be displayed in AR based on the location of the field agents (1st responders/ journalists).

TA2.3 Awareness apps for citizens: This activity will develop a situation awareness mobile application for the wider public. The mobile app will be able to detect the user context based on variables such as location, time and proximity to dangerous areas, and will inform the user about the event's current status, possible threats and alerts, presenting them coherently on a mobile AR environment, using input from TA1.3, TA1.4 and IA2.3.

1.2 Outline

The rest of the deliverable is as follows: Section 2 describes the backend and storage development. Section 3 describes the GIS services and its subcomponents. Section 4 is dedicated on the user requirements that were fulfilled. Section 5 reports the available geoportals in the GIS Service and Section 6 on the implementation details. Section 7 gives an overview of what it is done in the AR application, which is reported in detail in D4.7, and Section 8 describes the citizens' awareness mobile app.

2 PLATFORM BACKEND

The platform backend component consists of two subcomponents:

1. Data Storage module
2. REST API module

Both subcomponents are hosted on the same server but work as independent services in terms of the architecture. Both components were described in detail in sections 2.1 and 2.2 of deliverable D5.3, where the first version of the xR4DRAMA platform was documented.

2.1 REST API Module

The xR4DRAMA REST API provides the functionality necessary for front-end applications to query and retrieve assets from the xR4DRAMA platform. The RESTful API provides specific calls to query through any number of metadata fields, such as project information, data crawled from social media, analysed data and user generated data.

For integration purposes the developers of other components can use a swagger-based interface to integrate their module in the system. Figure 1, shows a screenshot of the swagger interface.

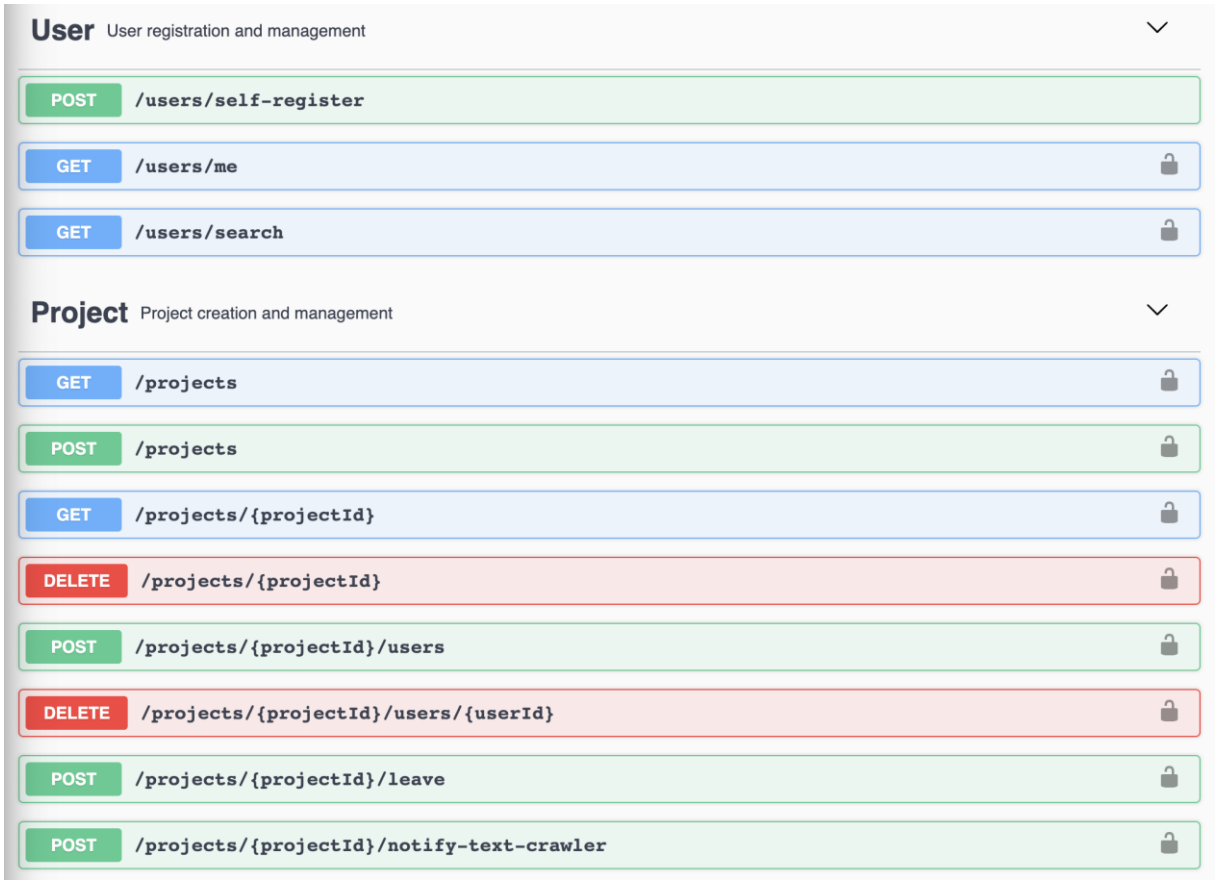


Figure 1: Screenshot of the REST API Swager

The swagger can be accessed at:

https://xr4drama-integration.nurogames.com/server/swagger/

The code of the tool is available on the Gitlab[1] of xR4DRAMA.

2.2 Data Storage

The data storage acts as the main data storage for the platform. All the project information, user information and user generated data is saved to the data storage. The module is a SQL table-based solution hosted on a cloud server. The data in the storage can be accessed and manipulated through the REST API module.

The code for the data storage is available on the xR4DRAMA GitLab.

[1] https://gitlab.com/xr4drama

3 GIS SERVICE

xR4DRAMA is a location dependent platform that aggregates georeferenced information from various sources as its knowledge base. The GIS Service describes the backend component that functions as a support to the AR app and, the Authoring and the VR frontend tools, by providing a geospatial database[2] with content of different modalities (2D and 3D visual content, audio files and generic data such as PDF files). It is also responsible for processing the georeferenced information, enabling various location-dependent functionalities (e.g., point-to-point navigation) to be accessible inside the platform. A detailed overview of the GIS Service was given in deliverable D5.3, where the first version of the xR4DRAMA platform was documented.

3.1 GeoService network

The ***GIS Service*** can be viewed as the central component of the ***GeoService*** network, an architecture logic that encapsulates all georeferenced components into a concrete end-to-end system. The **GeoService** network is responsible for overseeing the various requests originating from and to the **GIS Service**. It essentially serves as a wrapping bundle, containing all logic related to geolocation operations.

The ***GeoService*** architecture consists of the following services:

1. **GIS Service** is the main component of the GeoService architecture. It exposes an API that communicates with various open-source *Geoportals* to download geospatial information, builds the GIS database, and processes the database information to satisfy geospatial requests.
2. **Satellite Service** is an independent application that downloads and serves satellite data (satellite image or digital elevation model - DEM) from EU data and information access services - DIAS.

The communication between the various geo-related processes is managed by the deployed Redis[3] server. The following graph (Figure 2) shows the base architecture of the *GeoService:*

[2] https://en.wikipedia.org/wiki/Spatial_database

[3] https://redis.io/

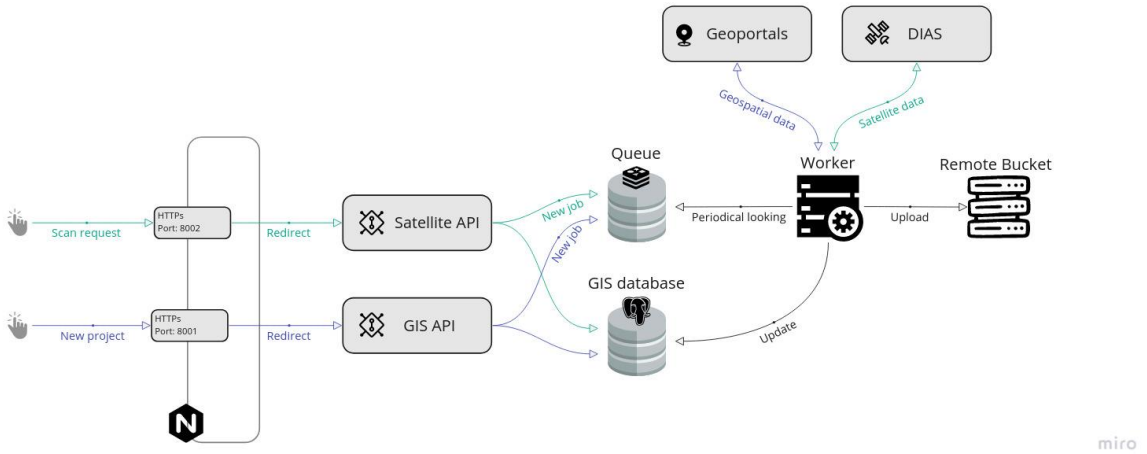


Figure 2: The base architecture of *GeoService*

3.2 GIS Service functionalities

Overall, the *GIS Service* provides the user with the following functionalities. It should be noted that these functionalities are tightly tied to the AR app, but also to the authoring tool and the VR collaboration tool, due to the fact that the frontend tools serve as the visualization medium in most cases, as well as the user interface for interacting with the GIS Service. Of course, the users can also connect to the GIS Service using typical desktop GIS tools.

1. Create a new project
2. Manage file storage
3. Get information on existing projects and data categories
4. Search engine
5. Create new and edit existing POIs
6. Organize task list
7. Navigate to a user-specified location
8. Send a risk report to mark a dangerous area
9. Estimates elements at risk

The aforementioned functionalities will be briefly described below.

3.2.1 Create a new project

When a new project is created, the *GIS Service* is responsible for downloading relevant geospatial information inside the project's boundaries. The information acquisition process aims to facilitate the two distinct use cases of the xR4DRAMA platform:

1. Civil protection in dangerous weather conditions (*Disaster Management* use case of AAWA, PUC1)
2. Media planning (*Media Planning* use case of DW, PUC2)

More specifically, the GIS Service collects geospatial data using various Geoportals, the most prominent of them being **OpenStreetMap**. Detailed information about the available Geoportals is presented in Section 5.

Depending on the location of each project, one or more of those portals will be synced and used during the data aggregation procedure. **OpenStreetMap** stands as the most flexible geoportal, able to generalize and provide accurate information in most cases. The remaining portals, although specialized, can greatly augment the knowledge base of projects that fall under their scope. After aggregating all relevant information provided by the geoportals, the data goes through a control stage, which is briefly described below.

Data filtering and validation

This particular stage is crucial for creating a new project, as this basic system matches the categories offered by the available Geoportals with the categories necessary for the users' requirements. Also, basic categories (name, description, etc.) are formatted by capitalizing the content and trimming white spaces and special characters to optimize them visually. Tools to validate of various data fields, e.g., phone and website are also provided.

Finally, since OpenStreetMap offers a wealth of information, most of which is not related to the project's requirements, the GIS collects it and stores it in dynamic structures. These are available to the clients under the name attributes, containing additional information about the POIs.

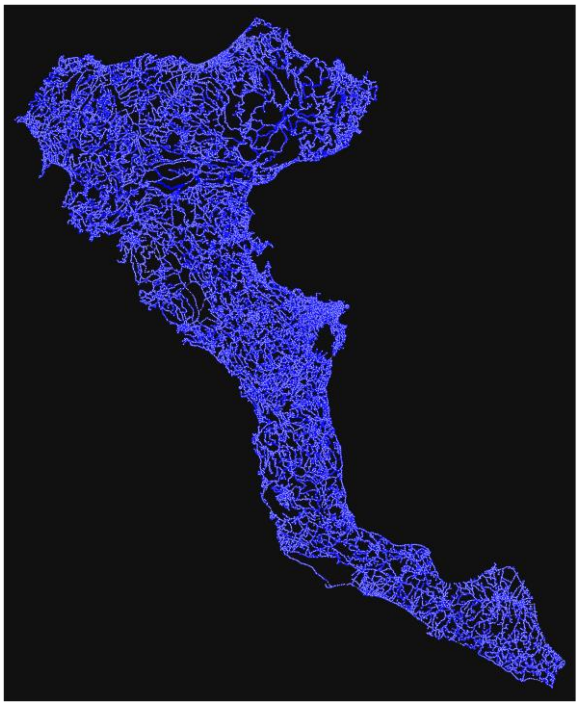
Prepare the streets network for navigation

When creating a new project, *GIS* also downloads the available streets for the area of interest. The streets offered by OpenStreetMap do not contain topological rules and therefore contain errors. The GIS corrects the topologies of the roads with the open source PgRouting library, which performs the following steps:

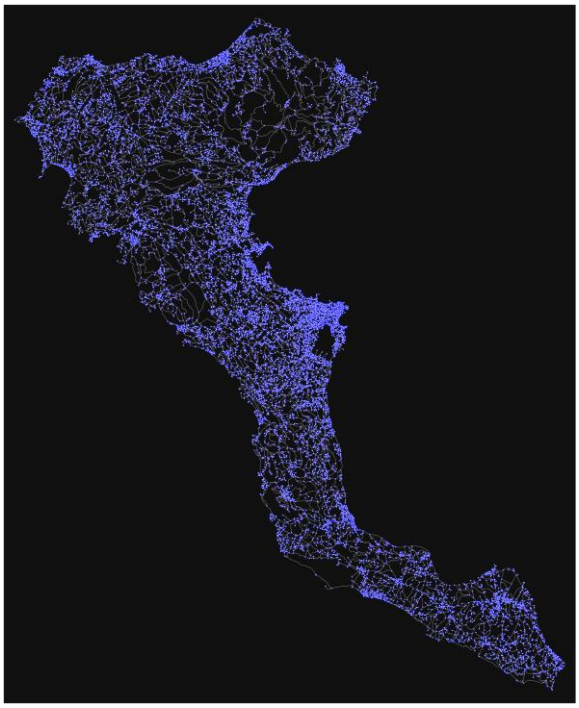
1. Assigns a source and target identifiers to each road link.
2. It can logically "snap" nearby vertices within a certain tolerance by assigning the same identifier.
3. Creates a vertices table related to it.

In addition, at this stage, the roads are divided into the two available navigation modes (walking and driving). Thus, the GIS separates roads through the type and access fields.

An additional step has been also added to ameliorate the performance during the shortest path estimation process. This step simplifies graph topology by removing all nodes that are not intersections or dead ends. A new edge is created directly between the endpoints. The geometry of the original edges is retained since it is saved as a new geometry attribute on the new edge.



MultiDiGraph with 212753 nodes and 428562 edges.



MultiDiGraph with 19982 nodes and 46886 edges (simplified graph topology).

Figure 3: Nodes and edges of street networks

3.2.2 **Manage file storage**

This section reports on the way the GIS manages the files of a project. In particular, the files that reach the GIS are processed, simplified (image or clip) and stored in a remote bucket. The following file categories are supported:

1. Images
2. Clips
3. Audio
4. General files (pdf, docs, etc.) for legal, background or weather information.
5. 3D content includes available 3D models for the Authoring tool and AR app.
6. Raw data providing drone images or video data for the 3D reconstruction service.

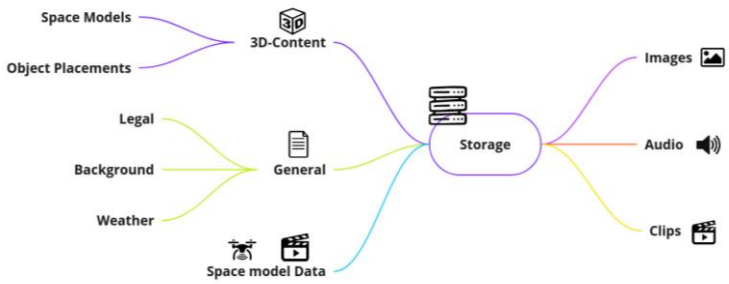


Figure 4: The base architecture of storage

To enhance user experience, CloudFront CDN (Computer Delivery Network) was used. It's a system of distributed servers that deliver web content to a user based on his geographic locations, the origin of the webpage and the content delivery server. When a user requests content, the request goes to the nearest edge location, significantly reducing transport time (Figure 5).

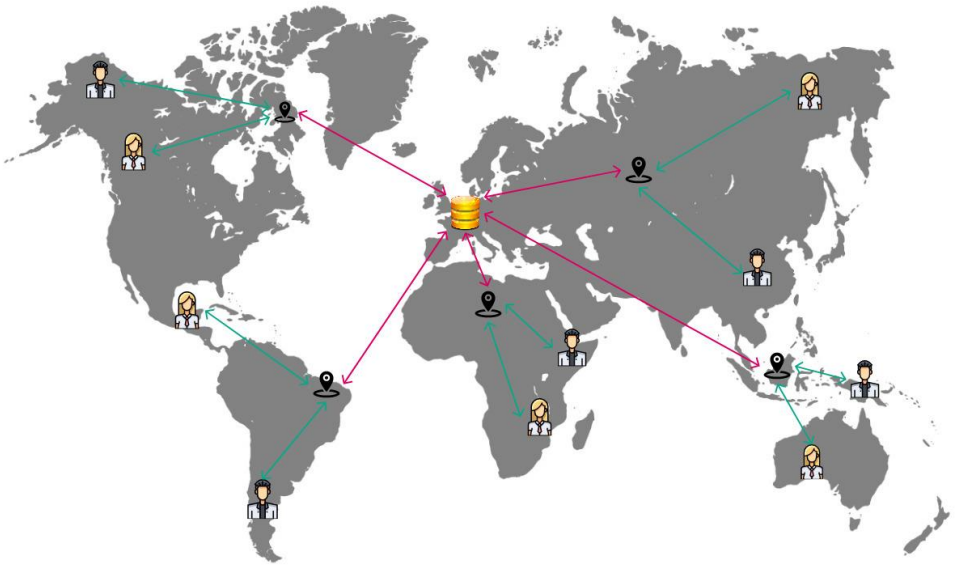


Figure 5: CloudFront CDN Edge locations

3.2.3 Get Information on projects and data categories

The GIS Service is responsible for serving available information on registered projects and various data categories to the requesting users. Mainly through the AR app, a user can query the GIS Service and gain access to all available information of the projects they are part of. Inside a project's scope, one can query the service on various data categories to view relevant geospatial landmarks, represented in the application as points on a two-dimensional map (points of interest, POIs).

GIS provides multiple parameters for filtering the data. Some of them are described below:

1. Get the POIs with some specific category or subcategory or list of them.
2. Get the POIs which are contained in some sub-area of the project.
3. Get the POIs which are in danger.
4. Get the POIs which have one or more tasks.

In addition, GIS automatically supports on runtime the conversion of complex geometries (LineString, Polygon, etc.) as points. This is achieved by calculating their centroid or by simplifying multiple geometries (MultiLineString, MultiPolygon, etc.) into a single one.

3.2.4 Search engine

GIS provides a search engine to filter a project's data by the name of POIs and ROIs, roads and places (village, hamlet, etc.). This feature was added to improve user experience as it can quickly search in over 50 categories of data. The main functionalities of the search engine are the following.

1. In addition to full-text search (FTS), this feature also works as an autocomplete, suggesting neighbouring words.
2. Correcting spelling errors through a dictionary.
3. Ignores special characters, lowercase and uppercase letters.
4. It uses rank vectors to sort the list of results.

3.2.5 Create new and edit existing POIs

As it was already briefly explained, the geospatial landmarks are represented inside the GIS Service as self-contained points of interest (POIs). Using the GIS Service API, a user can create new POIs as user specified landmarks, or even edit and append new data elements to existing ones. Figure 6 provides all available fields of the POI / ROI object.

Figure 6: Available fields of POI / ROI object

When creating a new POI, the user must specify the category and subcategory of the landmark. Those categories must be carefully selected, as they cannot be edited once the new POI is registered. More information about the categorization hierarchy of the landmarks is presented in section 5.3. None of the various data fields, presented above, is essential to register a new POI. Moreover, when editing an existing POI, the user can manipulate any of the aforementioned data fields freely.

Each POI supports multiple media files, which are uploaded to the GIS database. Those media files are tied to the chosen POI and serve as visual / acoustic descriptors of the landmark. Whenever media files are uploaded, the GIS Service is responsible for processing them to accommodate for a better user experience when interacting with them through the xR4DRAMA user interface endpoints. More specifically, the potential processing steps that can be applied depending on the type of the image files, are described below:

- Create a thumbnail of the prototype image or video with size 250 x 250 pixels.
- Resize the prototype image in *full HD* quality (1920 x 1080 pixels).

GIS also supports the categorization of general files, specifying one of the available categories:

1. Legal
2. Background
3. Weather

3.2.6 **Organize task list**

A basic feature supported by the GIS is task management. Essentially, tasks consist of instructions that guide workers on the actions to be carried out in the field. When creating a new task, the author can assign the task to a specific person. If this is the case, only that person can see the new task. Otherwise, it will be available for everyone. For better organization tasks are divided into categories.

1. Collect additional information for some specific category.
2. Verify or edit existing information.
3. Collect media information.

Upon completing a task, the worker can add a report via text and/or audio message.

3.2.7 **Navigate to a user-specified location**

This section presents the navigation function, which finds and suggests the optimal road route by calculating the shortest path between a source point (user location) and a user-specified destination point.

Nearest nodes

One of the most important procedures for calculating the shortest route is to find the closest vertices in the road network from the user's input points (start location and destination). The first step in finding the nearest vertex is to filter the edges using buffer zones around the entry point to reduce the number of edges involved in the search. Then, the data is sorted based on the Euclidean distance between the input point and the edge nodes to find the nearest neighbour.

Shortest path algorithm

Dijkstra's algorithm is used to calculate the shortest path. This graph search algorithm solves the minimum path problem for a graph with a non-negative path edge cost by producing the shortest path from a start vertex (start location) to an end vertex (destination). These points have been calculated during the procedure described in the Nearest nodes section.

Profiles

The user can choose between two profiles (walking and driving) for his/her means of transportation. The differences between the two profiles are that in driving, road types are taken into account, removing roads such as sidewalks, cycle paths etc., together with their directions in the case of one-way streets. In addition, in the case of driving, the cost of finding the shortest route is calculated in terms of road length at the maximum allowed speed (km/h). In the case of walking, the cost is divided by the road length by the average walking speed (5 km/h, which varies according to the type of road). Image 7 (above) shows the results of calculating the shortest route for the cases of walking and driving, respectively.

Travelling Salesman Problem

Briefly, GIS provides the possibility for the user to define points through which he wishes to pass, influencing the calculation of the shortest route. In the example below, the first image shows the optimal path between two points start location (green vertex) and destination (blue vertex). At the same time, the second image shows the corresponding way with the addition of two intermediate points (orange vertices).

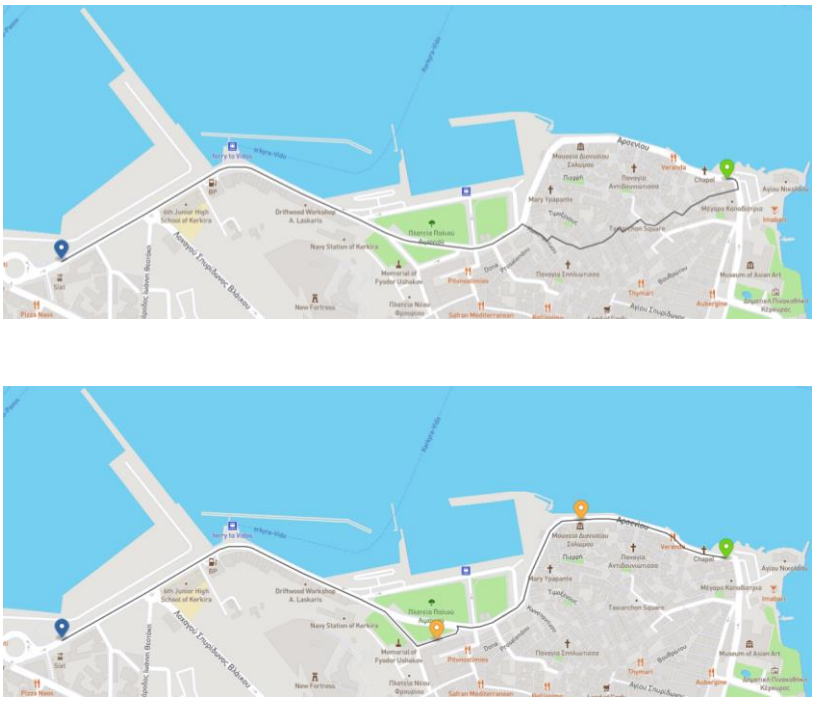


Figure 7: Shortest route calculation

Manoeuvre instructions

GIS provides information about what action a user needs to take to get from one step to the next along a route in manoeuvre instructions. This includes text instructions at defined locations along the route. Specifically, the structure of the manoeuvre instructions contains the following:

1. **Bearing after**: The clockwise angle from true north to the direction of travel immediately after the manoeuvre.
2. **Bearing before**: The clockwise angle from true north to the direction of travel immediately before the manoeuvre.
3. **Location**: The location of the turn.
4. **Driving side**: The legal driving side at the location for this step.
5. **Geometry**: The geometry of the route part.
6. **Distance**: The distance travelled by the route.
7. **Duration**: The estimated travel time.

3.2.8 Send a risk report to mark a dangerous area

GIS service enables the mapping of emergency information by associating a label with a designated geographic location, marking it as a hazardous area. The process begins when a user submits a risk report, triggering the system to activate the risk level (True/False) flag for each geographic feature (points of interest/regions of interest and streets) within the designated area, providing a comprehensive view of the affected region.
The Risk Report feature is a critical component of civil protection systems. Upon receipt of a risk report, the system identifies the elements within the designated hazardous area and updates the database to reflect their status as dangerous destinations. This information can modify the GIS navigation service's behaviour, ensuring users' safety during emergencies.

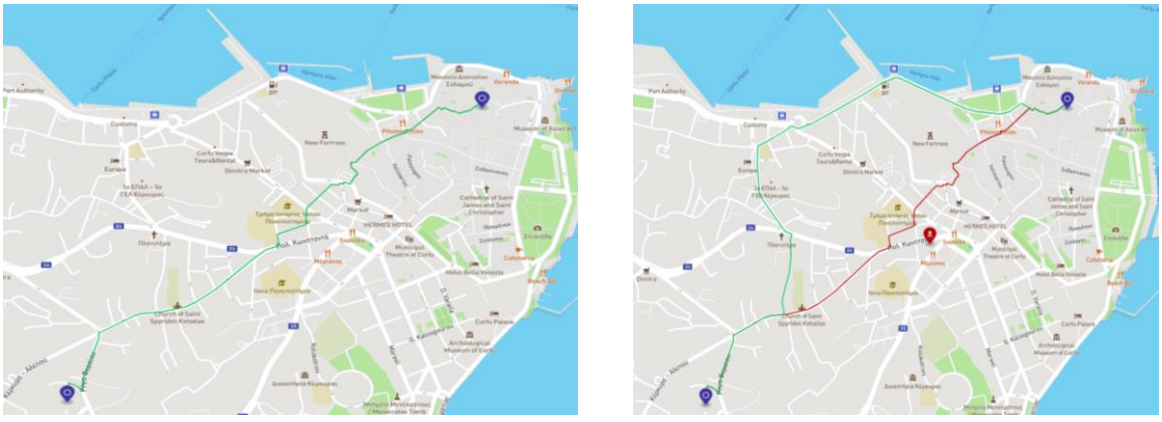


Figure 8**:** Left: estimation of the shortest path; Right: estimation of the shortest path taking into account the risk reports

3.2.9 **Estimate elements at risk**

GIS service estimates the elements that are susceptible to risk during an event using datasets from AAWA. This information is dedicated to buildings within the boundaries of AAWA's forecast models for water risk, depth, and velocity.

The estimation of elements at risk from AAWA datasets is performed through the following steps:

1. The system retrieves the raster file through a Web Mapping Service (WMS) protocol connection to the AAWA GeoServer.
2. The raster file is then vectorized, converting the pixel-based image into a vector format, which enables the extraction of accurate geometries and shapes for further analysis.
3. The system then obtains building data for the Vicenza municipality using a Web Feature Service (WFS) protocol connection to the AAWA GeoServer.
4. A spatial query is performed to determine the buildings intersect within a polygon on a vector map.

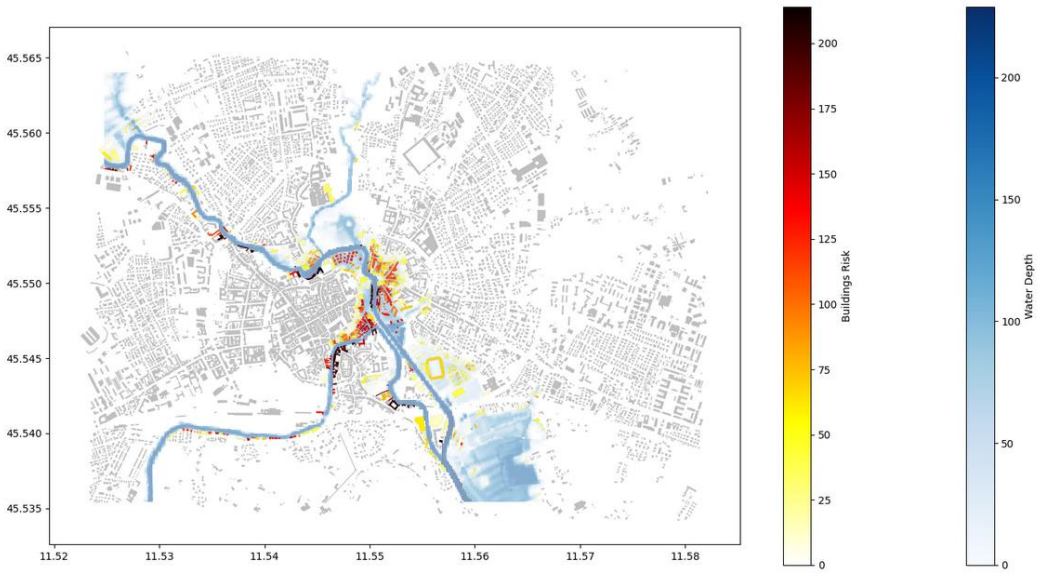


Figure 9: Buildings at risk in Vicenza municipality

3.3 Satellite Service Functionalities

The satellite service is an independent application to download satellite data from Data-Information-Access-Services (*DIAS*). Multiple functionalities are supported and targeted mainly to the authoring tool.

1. Download satellite data
2. Search for existing satellite data
3. Create a 3D model

More details on these functionalities are given below.

3.3.1 Download satellite Data

The satellite service is responsible for downloading information satellite data inside the project's boundaries. The information acquisition process aims to facilitate civil protection in a scenario of flood risk (*Disaster Management* use case of AAWA, PUC1) of the xR4DRAMA platform. In particular, the user can download satellite data by defining the bounding box of the area of interest, the time interval (start and end), and the raster types list (True-colour, Multispectral image and Digital-Elevation-Model). Also, it is possible to download satellite data for multiple timestamps by defining the timestamps parameter. Briefly, the collection of satellite data is carried out by defining the following parameters:

1. Bounding box
2. Timestamp
3. Time interval (start and end)
4. Raster types

Satellite data are organized into datasets called scan requests. A dataset of this type can contain multiple types of rasters for different time intervals that contain the same regions. The grouping of the data into data sets makes their search faster and greatly facilitates the user in selecting images and their corresponding DEMs during the 3D reconstruction.

3.3.2 Search for existing satellite data

The satellite service allows users to search for available data by defining the following parameters:

1. The bounding box of the area of interest
2. The raster type (optional)
3. The time interval (optional)

Once these parameters are defined the satellite service will filter all available satellite data and returns a list of results that meet the requirements of each request. Finally, the satellite data are returned as public links, linking to the storage files, which have an expiration time.

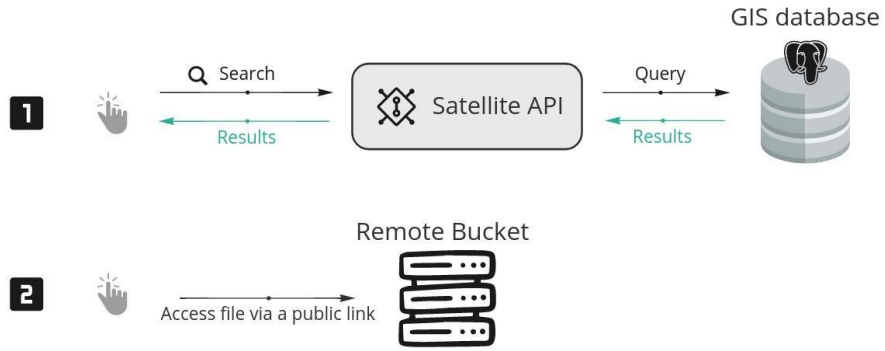


Figure 10: Searching for available satellite data

3.3.3 **Create a 3D model**

An additional functionality of the satellite service is the automatic reconstruction of 3D models through the available satellite data. In particular, users can choose a satellite image (True-Color or Multispectral) and a DEM from available datasets to generate their 3D model. The step of the 3D reconstruction model will be briefly described below.

Multispectral to RGB image conversion

In the first instance, multispectral images are converted to RGB. To improve the image's contrast, each band is equalized using the histogram equalization technique.

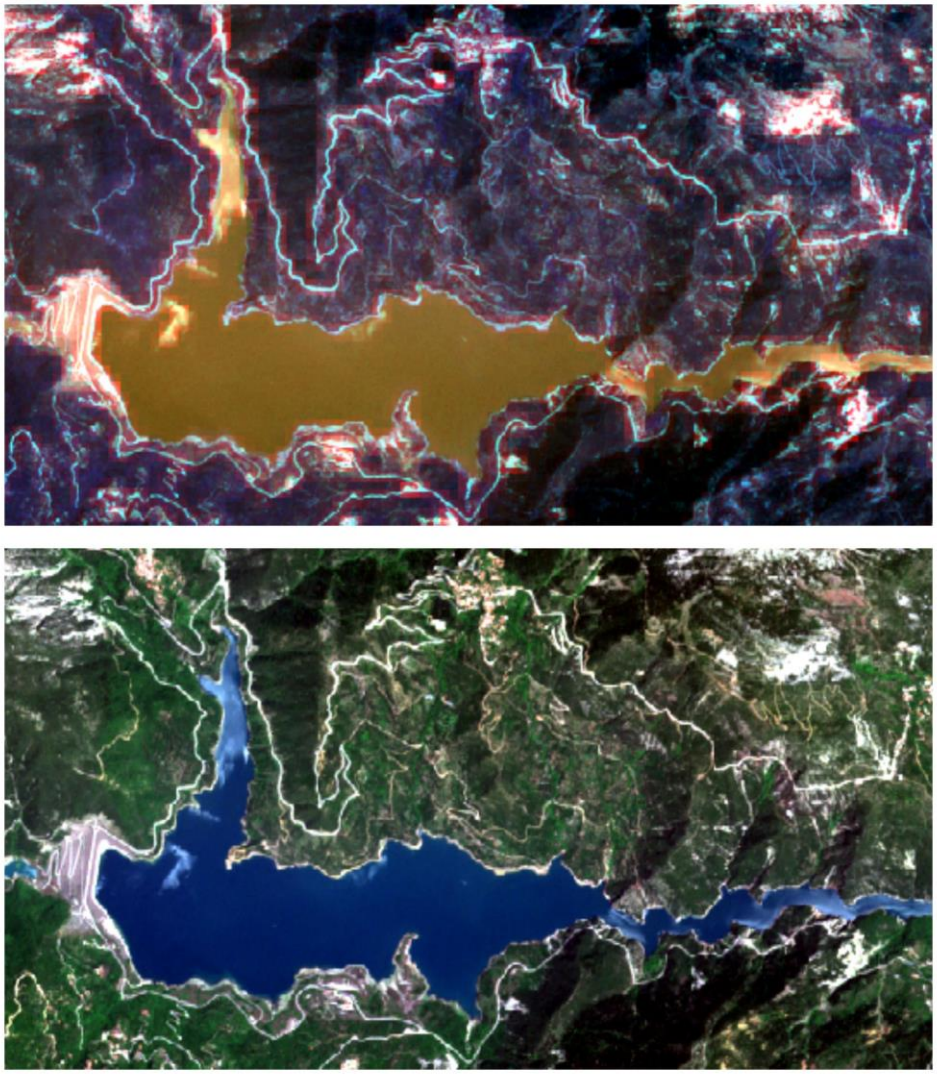


Figure 11: Satellite True-Color and Multispectral images

DEM resizing

The next step is to reduce the resolution of the DEM, which results in fewer vertices and, thus, fewer faces. The RGB image resolution remains unchanged, giving the model a realistic appearance (Fig.11).

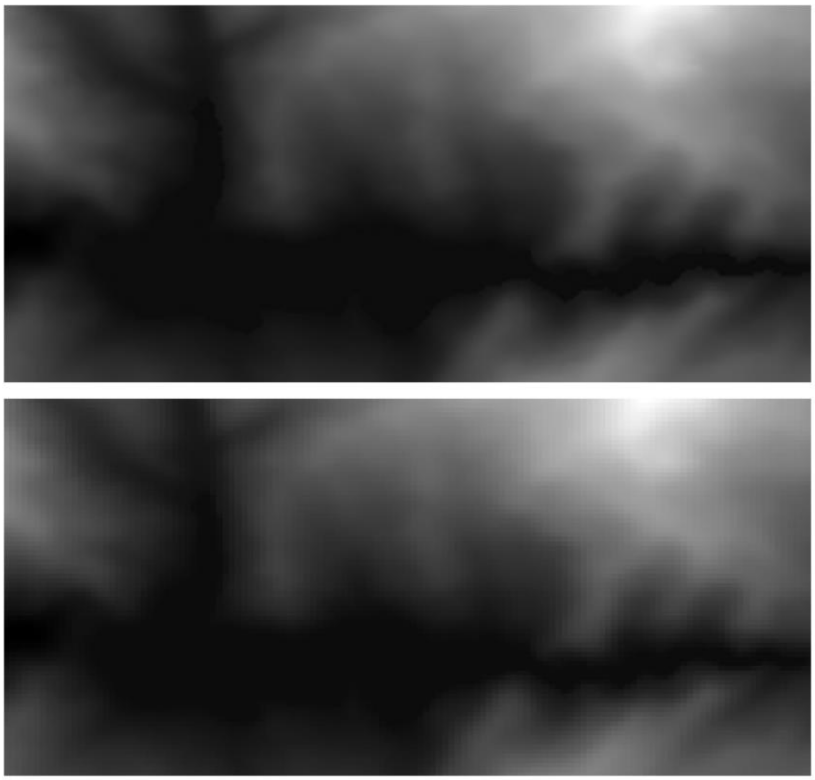


Figure 12: Digital elevation model resolution reduction

Altitude correction

If the DEM contains outliers, i.e., values that are negative and erroneously differ significantly from their neighbouring values, the altitude value is replaced with the average of the neighbouring altitudes.

Coordinate preparation

A 3D cartesian coordinate system must be used for the generated model to be displayed in most 3D model editing software. Therefore, grid coordinates are converted from WGS'84 or EPSG: 4326 (latitude, longitude, altitude) to WGS'84/World Mercator or EPSG: 3395 (easting, northing, altitude).

Model Creation

The following step is Delaunay triangulation to obtain a triangular 3D mesh model. Subsequently texture from the RGB image is applied to the triangulated model and the model is simplified to reduce the large number of redundant faces.

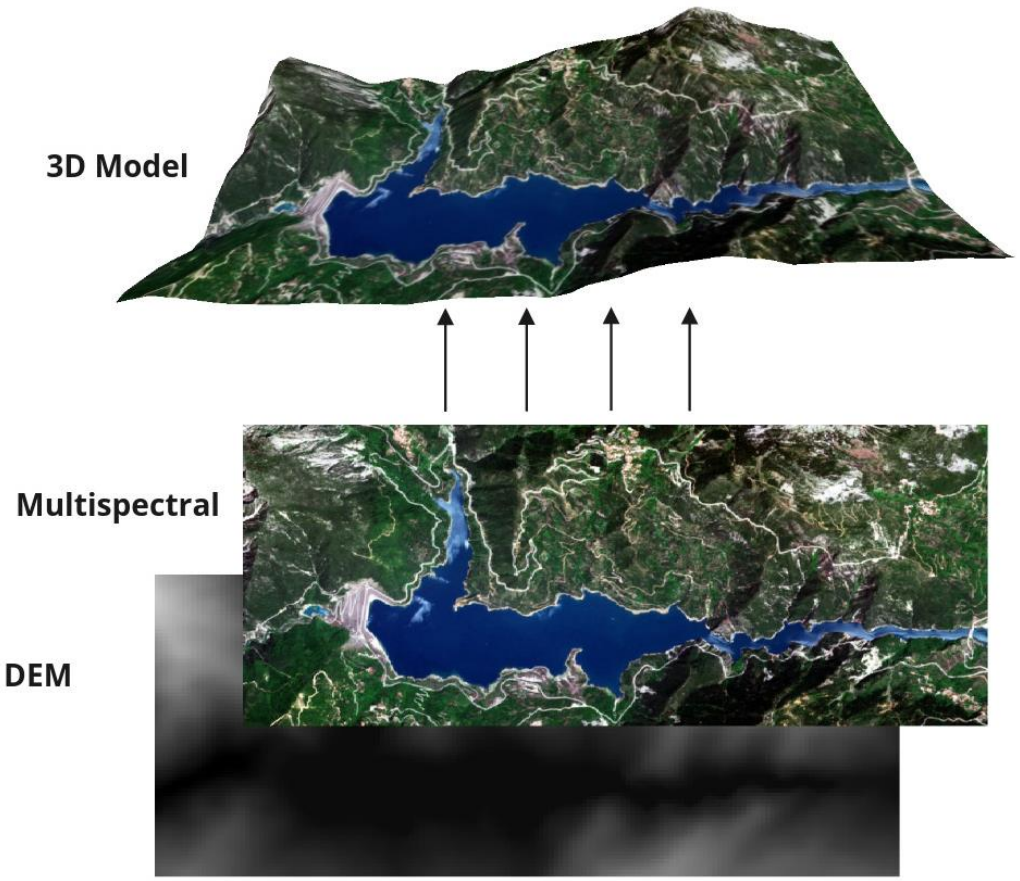


Figure 13: Model creation

The following images show example results of the 3D reconstruction service from satellite data for the cases of an entire island, an urban environment, but also areas that include large elevation variations. Also, it is important to emphasize that in several cases, due to weather conditions and differences in time intervals of capture, the results may show sharp variations in their brightness.

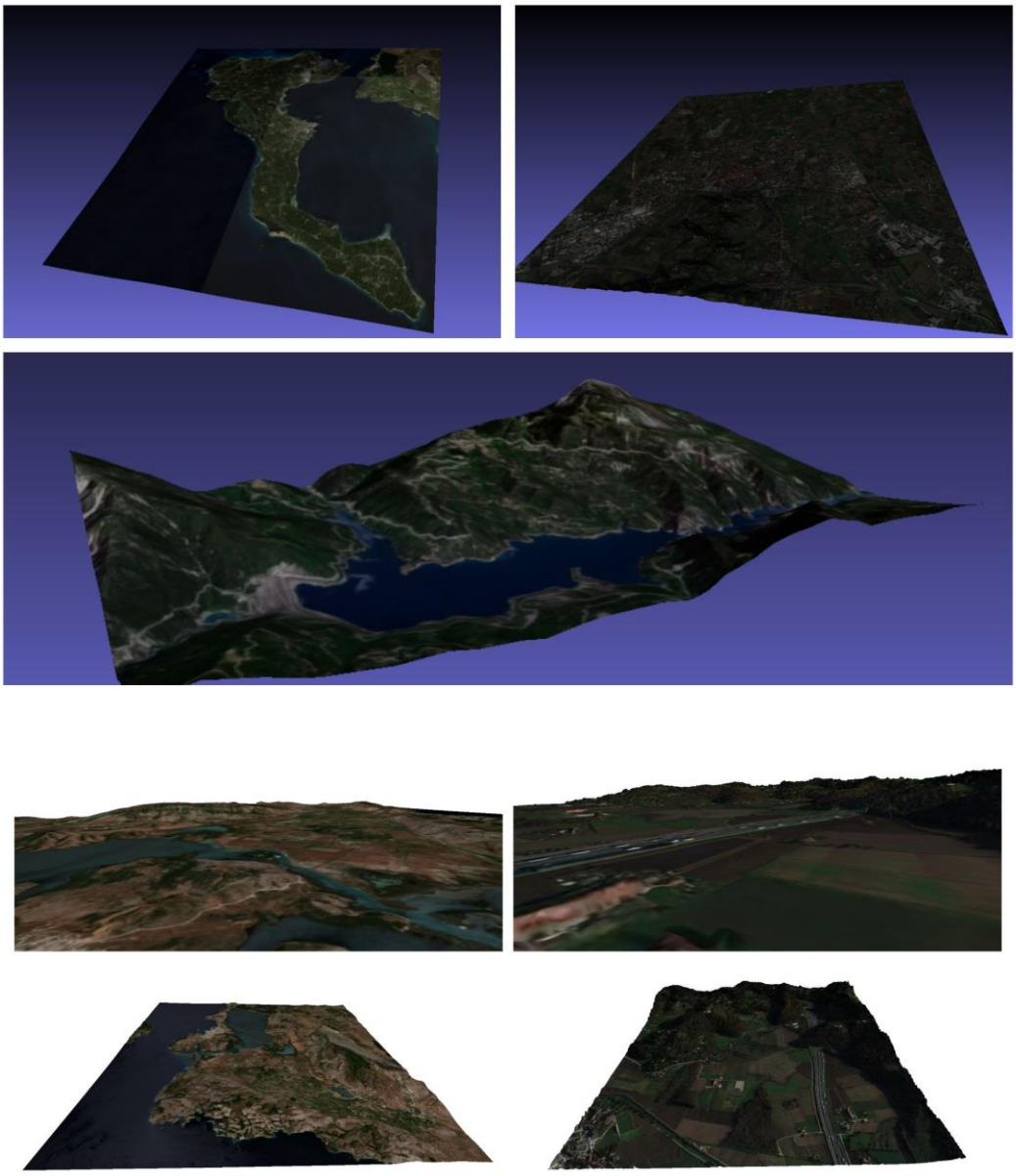


Figure 14: 3D models from satellite data

3.4 3D Reconstruction Service

3D-reconstruction service is an application to automatically generate 3D photorealistic models from image data. The user only needs to import the image files to create the 3D model. The primary use of the service is to create 3D models to facilitate the two Pilot Use Cases of the xR4DRAMA platform.

Overall, the 3D reconstruction Service provides the user with the following functionalities:

1. Create 3D model
2. Simplify an existing 3D model

3. Generate Level-of-Details (LODs)

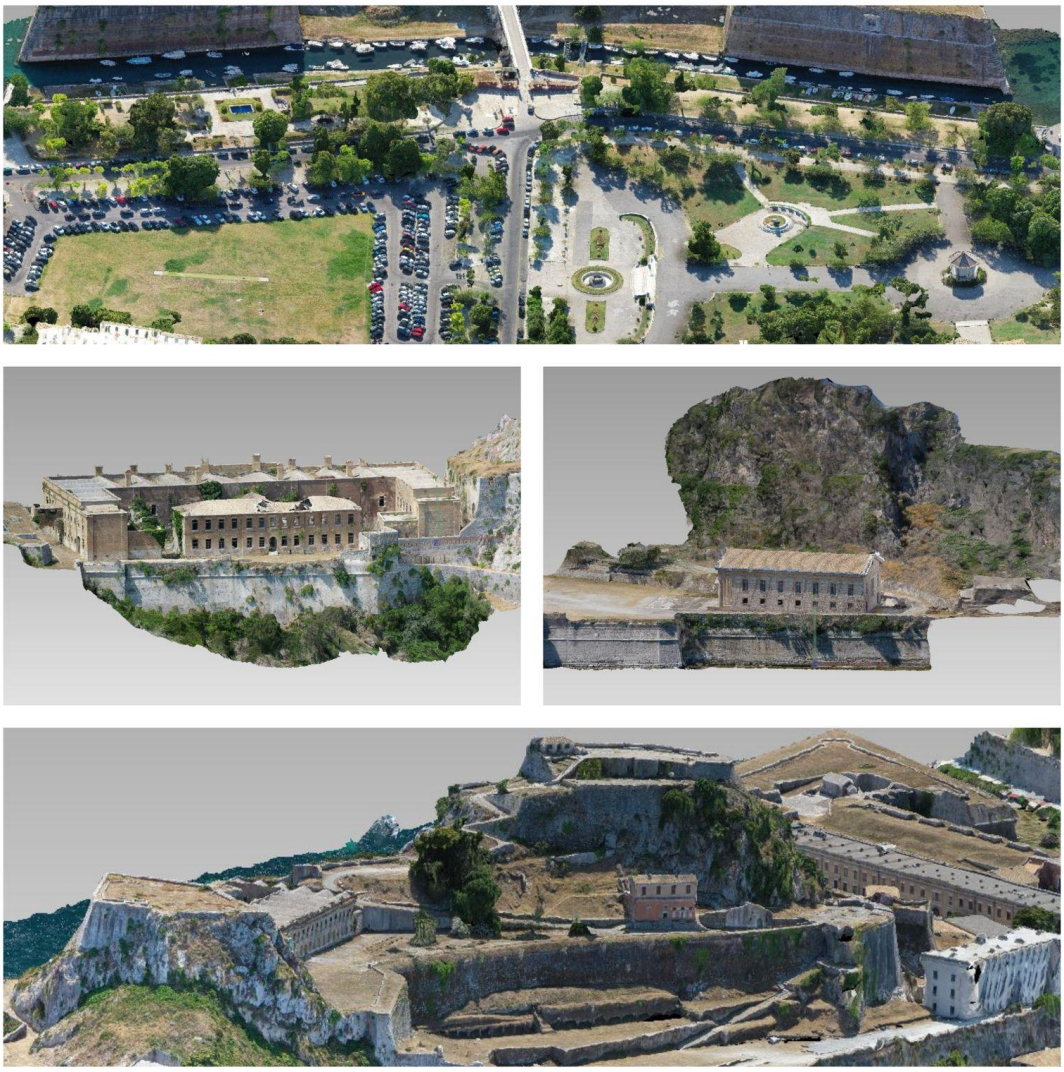


Figure 15: Examples of 3D models generated using the 3D reconstruction service

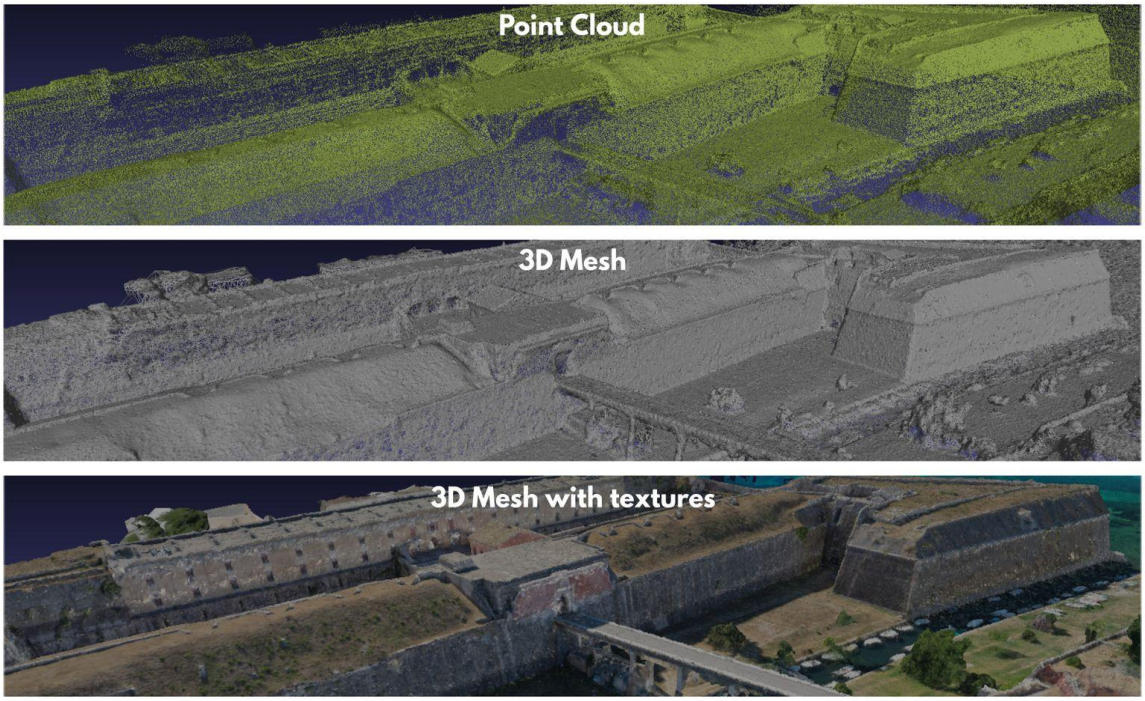
3.4.1 **Create 3D model**

Photogrammetric, or image-based, three-dimensional (3D) reconstruction is an image processing technique that allows the generation of digital 3D models from a series of two-dimensional images. To capture reality in 3D, a set of overlapping images, typically taken with hand-held cameras or unmanned aerial vehicles (UAVs), is required. Following a Structure from Motion (SfM) pipeline, the camera parameters and a sparse point cloud of the depicted 3D space are determined. MVS (Multi-View Stereo) algorithms are subsequently applied to densify the sparse point cloud, which is then triangulated into a 3D digital model called a mesh. Lastly, the mesh is textured using the images. Concisely, a typical image-based 3D reconstruction pipeline includes the following steps:

1. Feature detection
2. Keypoints Matching
3. Bundle Adjustment
4. Multi-View Stereo Matching
5. Model Fitting
6. Texture Mapping

For the algorithmic implementation, *AliceVision*[4,5] & *Meshroom*[6] software libraries were used.

The default pipeline consists of two main stages, SfM and MVS, each consisting of several nodes, including camera initialization, feature extraction, image matching, feature matching, SfM, depth mapping (including the steps of preparation, mapping, and filtering), meshing, and mesh filtering. A mesh decimation step was also added, following the mesh filtering step, during which the resulting model is simplified by 70% (default value).



[4] Jancosek, M., & Pajdla, T. (2011). Multi-view reconstruction preserving weakly-supported surfaces. In CVPR 2011 (pp. 3121-3128). IEEE.

[5] Moulon, P., Monasse, P., & Marlet, R. (2013). Adaptive structure from motion with a contrario model estimation. In Computer Vision–ACCV 2012: 11th Asian Conference on Computer Vision, Daejeon, Korea, November 5-9, 2012, Revised Selected Papers, Part IV 11 (pp. 257-270). Springer Berlin Heidelberg.

[6] Griwodz, C., Gasparini, S., Calvet, L., Gurdjos, P., Castan, F., Maujean, B., ... & Lanthony, Y. (2021). AliceVision Meshroom: An open-source 3D reconstruction pipeline. In Proceedings of the 12th ACM Multimedia Systems Conference (pp. 241-247).

Figure 16: 3D reconstruction steps

3.4.2 Simplify an existing 3D model

The user can simplify the model by a certain percentage after the basic 3D reconstruction process, following two steps.

1. **Mesh decimation**: Reducing the number of faces while trying to keep overall shape, volume and boundaries.
2. **Texture mapping**: Recreate the texture coordinates (UVs) to apply texture to the simplified 3D model.

3.4.3 Generate Level-of-Details (LODs)

The user can generate four LODs meshes, where LOD0 corresponds to the original mesh and LOD3 is the mesh with triangles reduced up to 25%.

Figure 17: 3D models generated from the 3D Reconstruction Service

3.5 Memory data store

This section describes the communication logic between the various components of the GeoService network and the services that are part of the xR4DRAMA platform.

In particular, the Redis broker is the component of the GeoService network architecture responsible for managing communication between the various geo-related processes. Redis is a flexible communication framework that organizes and simplifies asynchronous communication between subscribed processes. In the scope of the GeoService network, Redis is meant to enable efficient communication between the inner processes of the network. This is useful for operations that need to happen after a request, but the client doesn't have to be waiting for the operation to complete before receiving the response (e.g. project creation). Overall, Redis allows:

1. Communication between services as an event bus system (Pub/Sub)
2. Data caching for faster response

3. The background execution task of the service

The following architecture diagram visualizes the role and functionality of the Redis server. Each new request is stored in queues at the memory data store, which workers undertake to implement in order of priority. The supported workers are:

1. Project handler for project creation and deletion
2. Scan request handler, which manages the satellite data collection from DIAS
3. Space model parser for retrieving the information from the 3D reconstruction service

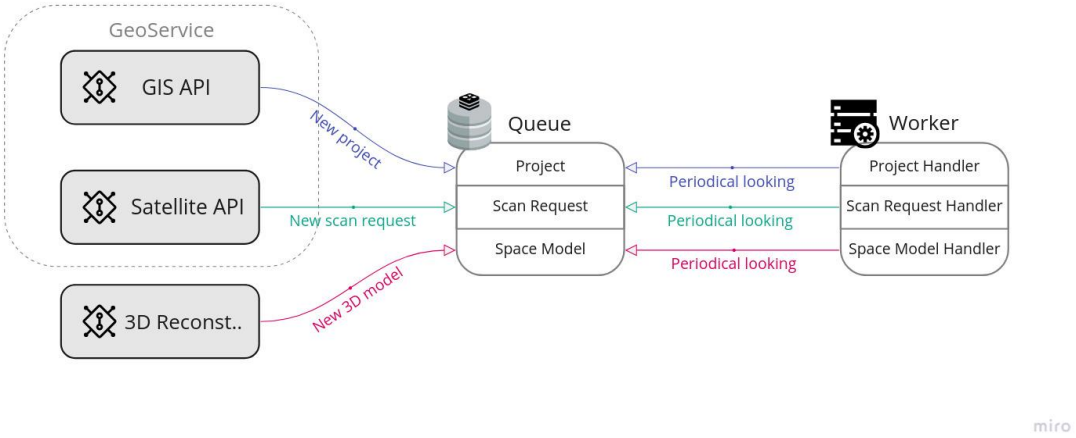


Figure 18: Asynchronous tasks via Redis server

4 USER REQUIREMENTS FULFILLED

Table 1, Table 2, Table 3 and Table 4 document the User Requirements (UR) that are supported and related to the GIS Service. Table 1 refers to the system requirements addressed by the GIS Service; Table 2 shows the general information requirements that relate to the GIS Service and Table 3 and Table 4 refer to the PUC specific requirements. All POIs can be updated with info from the user.

Req ID	Name	Description
SYS-2	End-user interface	An HCI that allows end-users to easily communicate with the system
SYS-3	Location ingest	Possibility to define a specific location
SYS-4	Location-query	A functionality of the system that allows end-users to initiate a query regarding a specific location in web- and cloud services
SYS-5	Aggregation of query status and results	The capacity of the system to observe the query and aggregate the identified content (e.g. videos, images, text) in an organised manner (categories, clusters, order)
SYS-6	Immersive visual representation	A functionality that visualises the location and additional information to enhance situation awareness (e.g., VR, AR)
SYS-10	Add own data	Control room staff can add images, videos, models or scans to improve data, or change certain data points that might not have been available, e.g., availability of public parking
SYS-12	Mobile application	An application that allows for operating the system in and from the field
SYS-14	Remote access to Level 1 situation awareness	The capacity of the system to grant remote users (e.g. location scout) access to a Level 1 situation awareness representation (partly or in total) via the mobile application. Citizens (PUC 1 only) should receive useful information such as alerts, risk zone warnings about areas at risk, position of safe areas, sand-bag distribution, shelters.

Table 1: System related requirements addressed by the GIS Service

ID	Category	Info ID	Subcategory	Level Information	Source of Information
		PUC2-09	Toilets	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Water Supply	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		PUC2-08	Power Supply	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		PUC2-08	Internet Access	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Gas Stations	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
GC-01	Facilities	PUC2-08	Charging Stations	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Tourist Offices	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Police Stations	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Fire Departments	Level 1: Information via GIS data	OpenStreetMap
		G-02, PUC2-06	Public Buildings	Level 1: Information via GIS data Level 2: Research by location scout	Vicenza.gov.it
GC-02	Public Services	-	Cemeteries	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		PUC2-08	Pharmacies	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
GC-03	Medical	PUC2-08	Doctors	Level 1: Information via GIS data	OpenStreetMap

		PUC2-08	Hospitals	Level 1: Information via GIS data	OpenStreetMap
		G-01, PUC2-03	Parking	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		G-01	Taxi	Level 1: Information via GIS data	OpenStreetMap
		G-01	Public Transport	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		G-01	Car Rentals	Level 1: Information via GIS data	OpenStreetMap
		G-01	Bike Rentals	Level 1: Information via GIS data	OpenStreetMap
GC-04	Transportation	G-01	Air Travel	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		G-02, PUC1-17	Sights	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		G-02, PUC1-17	Museums	Level 1: Information via GIS data	OpenStreetMap
GC-05	Cultural	G-02, PUC1-17	Venues	Level 1: Information via GIS data	OpenStreetMap

Table 2: Information-related requirements (General information) addressed by the GIS Services

ID	Category	Info ID	Subcategory	Level Infromation	Source of Information
		PUC1-16, PUC1-17	Warnings	Level 2: Research by location scout	-
		PUC1-16, PUC1-17	Flooded Reports	Level 2: Research by location scout	-
AAC-01	Disaster Management	PUC1	Risk Areas	Level 2: Research by location scout	-

		-	Civil Protection	Level 2: Research by location scout	-
		PUC1-03	Civil Protection Distribution Places	Level 2: Research by location scout	-
		PUC1-03	Safety Areas	Level 1: Information via GIS data Level 2: Research by location scout	OpenStreetMap
		PUC1-02	Manholes	Level 1: Information via GIS data Level 2: Research by location scout	OpenStreetMap
		PUC1-02	Pipelines	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		PUC1-02	Embankments	Level 1: Information via GIS data	Vicenza.gov.it
		PUC1-02	Power Grids	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		PUC1-02	Factories	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		PUC1-02	Antennas	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
AAC-02	Infrastructure	PUC1-02	Aqueducts	Level 1: Information via GIS data	Vicenza.gov.it
		-	Flood Results From Model	Level 2: Research by location scout	-
AAC-03	Flood Forecasts	PUC1-07	Elements at Risk	Level 2: Research by location scout	-
AAC-04	Natural Elements	PUC1-01	Water Bodies	Level 1: Information via GIS data	Vicenza.gov.it

		PUC1-03	Parks	Level 1: Information via GIS data	OpenStreetMap
		PUC1-03, PUC2-04, PUC2-05	Natura 2000 Sites	Level 2: Research by location scout	-
		-	Nurseries	Level 1: Information via GIS data Level 2: Research by location scout	Vicenza.gov.it
		-	Kindergartens	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		-	Primary Schools	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
		-	Secondary Schools	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it
AAC-05	Education	-	Universities	Level 1: Information via GIS data	OpenStreetMap, Vicenza.gov.it

Table 3: Information-related requirements for PUC1 (Disaster management)

ID	Category	Info ID	Subcategory	Level Infromation	Source of Information
		PUC2-14	Source of Pollution	Level 2: Research by location scout	-
		PUC2-04, PUC2-05	Restricted Areas	Level 1: Information via GIS data	OpenStreetMap
		PUC2-11	Props and Gear	Level 2: Research by location scout	-
DWC-01	Production Planning	New	Snapshots	Level 2: Research by location scout	-

.

		PUC2-10	Cafés	Level 1: Information via GIS data	OpenStreetMap
		PUC2-10	Restaurants	Level 1: Information via GIS data	OpenStreetMap
DWC-02	Food and Dring	PUC2-10	Bars and Pubs	Level 1: Information via GIS data	OpenStreetMap
		-	Hotels	Level 1: Information via GIS data	OpenStreetMap
		-	Apartments	Level 1: Information via GIS data	OpenStreetMap
DWC-03	Accommodation	-	Campsites	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Groceries	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Clothing	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Electronics	Level 1: Information via GIS data	OpenStreetMap
DWC-04	Commerce	PUC2-08	Other Shops	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	ATMs	Level 1: Information via GIS data	OpenStreetMap
		PUC2-08	Exchange Offices	Level 1: Information via GIS data	OpenStreetMap
DWC-05	Finance	PUC2-08	Banks	Level 1: Information via GIS data	OpenStreetMap

Table 4: Information-related requirements for PUC2 (Media production planning)

5 AVAILABLE GEOPORTALS IN THE GIS SERVICE

In this section the available GeoPortals used by the GIS Service to extract geospatial information will be briefly described.

5.1 Supported GeoPortals

The following GeoPortals are currently considered when populating the GIS DB at project creation. However, the number of portals used during the creation processes depends tightly on the project's geographic location:

1. OpenStreetMap (OSM), from which geographical data on points of interest (POI), road networks and place names are collected.
2. Vicenza authorities and AAWA portal (which includes sandbags, shelters, risk maps, flood maps, etc.)[7]. This portal hosts the GeoServer that serves the geospatial data which are extracted from the XR4DRAMA platform for the case of disaster management. Their extracted data include forecasting models, public services, and buildings among other. The extracted geospatial data are used to create a detailed and accurate view of the affected area in the event of a disaster, enabling emergency responders to plan and execute rescue operations more effectively.
3. Sentinel Hub[8] service for receiving satellite data such as true-color images and multi-spectral and digital elevation models (DEM).

Each specific portal needs to be treated by creating a specific interface to populate the xR4DRAMA GIS Service DB.

5.2 Geospatial information category hierarchy

The geospatial information provided by the available GeoPortals during project creation is organized by the GIS Service in a two-level category format. Each information element essentially contains a main and subcategory tag, representing its thematic footprint. The following table briefly depicts the available categories and their subcategory divisions. The category hierarchy below, aims to match the "Final user requirements" of D6.2 presented in Section 4. It should be noted that hierarchy includes some main categories and subcategories that were not explicitly described in D6.2 but are derived through discussions with other partners of the xR4DRAMA project (Table 5).

[7] http://amicoalpiorientali.eu/geoserver/wms

[8] https://www.sentinel-hub.com/

Category	Subcategory
	Toilets
	Water Supply
	Power Supply
	Internet Access
	Gas Stations
Facilities	Charging Stations
	Tourist Offices
	Police Stations
	Fire Departments
	Public Buildings
Public Services	Cemeteries
	Pharmacies
	Doctors
Medical	Hospitals
	Parking
	Taxi
	Public Transport
	Car Rentals
	Bike Rentals
Transportation	Air Travel
	Sights
	Museums
Cultural	Venues
	Source of Pollution
Production Planning	Restricted Areas

	Props and Gear
	Snapshots
	Cafés
	Restaurants
Food and Drink	Bars and Pubs
	Hotels
	Apartments
Accommodation	Campsites
	Groceries
	Clothing
	Electronics
Commerce	Other Shops
	ATMs
	Exchange Offices
Finance	Banks
	Warnings
	Flooded Reports
	Risk Areas
	Civil Protection
	Civil Protection Distribution Places
Disaster Management	Safety Areas
	Manholes
	Pipelines
	Embankments
Infrastructure	Power Grids

	Factories
	Antennas
	Aqueducts
	Flood Results From Model
Flood Forecasts	Elements at Risk
	Water Bodies
	Parks
Natural Elements	Natura 2000 Sites
	Nurseries
	Kindergartens
	Primary Schools
	Secondary Schools
Education	Universities

Table 5: List of the *Categories* and *Subcategories* as organized in the GIS Service. These categories divisions are presented to the user inside the AR app and the authoring tool

6 DEPLOYMENT

6.1 General Info

The main services under the GeoService network architecture are documented in the following Swagger links (Figure 19 and Figure 20):

- GIS Service → https://geoservice.xr4drama.up2metric.com:8001/swagger
- Satellite Service → https://geoservice.xr4drama.up2metric.com:8002/swagger

The code for the GIS Service can be found at the following link:

- https://bitbucket.org/up2metricPC/geoservices/src/master/

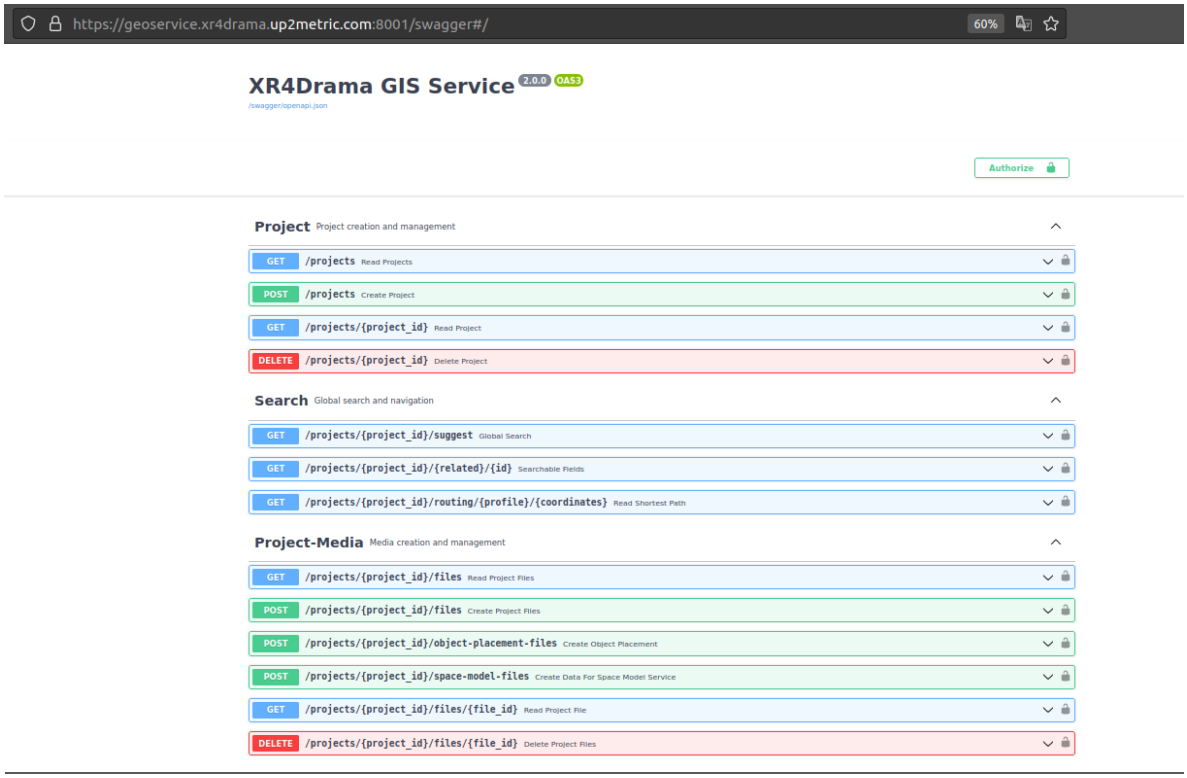


Figure 19: Online documentation (Swagger) for the GIS Service

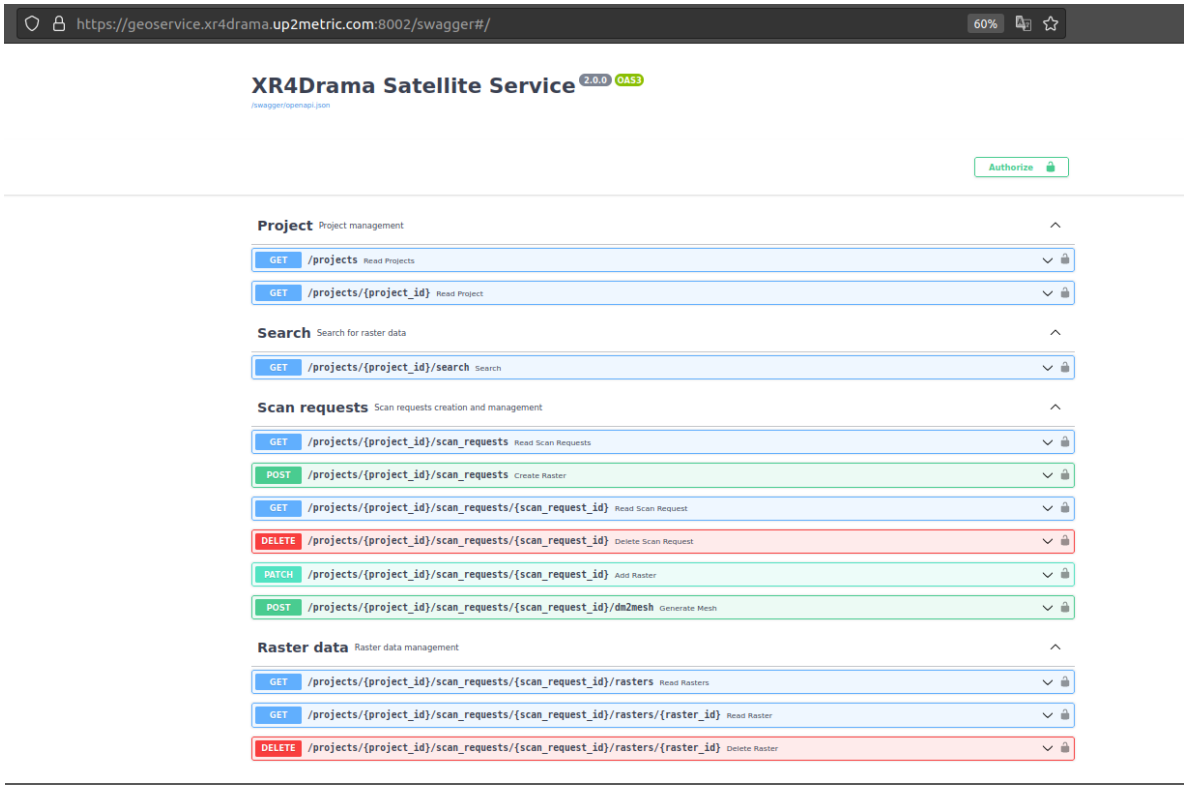


Figure 20: Online documentation (Swagger) for the Satellite Service

6.1.1 Hardware Requirements

To deploy the GIS services, the system should follow the requirements in Table 6.

	Requirements
Operating System	Linux/UNIX
CPU power	1,8 GHz or higher
vCPU	2 or higher
RAM	4 GB or higher
Disk storage	64 GB or more

Table 6: Hardware requirements for running the GIS Services

7 AUGMENTED REALITY APPLICATION FOR LOCATION SCOUTS AND FIRST RESPONDERS

The final version of the Augmented Reality (AR) application – AR app – is documented in detail in the deliverable D4.7 “AR interactive environment and applications v2”. Here a snapshot of the main screens of the ARapp is included.

Figure 21: Overview of the main screens of the ARapp

8 AWARENESS APPLICATIONS FOR THE CITIZENS

8.1 Citizen awareness application

Task T5.4: “awareness application for end users”, focuses on the development of the situation aware mobile application designed for the wider public. The aim for this application is to create the habit for a citizen to become cautious about a possibly harmful situation and facilitate the authorities by acting according to their planning for the disaster management. The citizen awareness application is able to detect the context for the user based on location, time and proximity to the event, and is accordingly informing and alarming the user about likely threats, from location-based ones to evacuation alerts and more. Another functionality supported by the application enables the user to report an ongoing situation or make an emergency request via text, audio, image or video to the authorities that handle the disaster management. Finally, the citizen application includes a separate mode for the first responders only, in which the first responder can connect the mobile application with the SMARTEX garment equipped with sensors and share their physiological signals (described in D2.4 – “Data collection from smart clothes sensors v2”) to the xR4DRAMA platform. These signals are used for analysis and prediction of the first responder stress levels by the tools developed in WP3. The first responder mode is integrated in the citizen application as part of T5.4 and is considered a separate mode, which the wider public cannot access due to lack of authentication credentials.

The prototype version of the citizen awareness app, also known as version 1.0, was released on M13 with D5.4 – “Prototypes and mobile development v1”. An intermediate version of app, which included most of the identified functional requirements, also known as version 1.5, was released on M23 with the intention of participating in the STEREOPSIA event (M24) together with the rest of the xR4DRAMA frontend and backend tools. The final version, which included all the foreseen functional requirements, also known as version 2.0, was released on M27 with this document, D5.4 – “Prototypes and mobile development v2”. The summary of the functional requirements that all three versions support are outlined in subsection 8.2.

The integration of the application within the xR4DRAMA architecture as well as its foreseen involvement in the upcoming PUC1 second pilot on M29 on Vicenza are described in subsections 8.3 and 8.4. Finally, a detailed description that focuses on all the functionalities of the final version of the citizen awareness app is provided alongside a link for a demo repository on subsection 8.5.

8.2 List of updates and functionalities per version of the citizen awareness application

After examining the end user requirements on D6.2 – “Final User Requirements”, a list of functionalities to be supported by the citizen awareness application has been derived and was summarised in subsection 8.2 of D5.4 including the references to the system-related requirements (Table 12 of D5.3) and case specific information requirements (Table 13 of

D5.3). Below there are three lists which indicate which functional requirements were included in each version of the citizen awareness app.

8.2.1 Version 1.0 functional requirements

The functionalities that the prototype version of the citizen application supported are:

- Citizen text report creation and submission to the xR4DRAMA platform.
- Citizen audio report creation and submission to the xR4DRAMA platform.
- Citizen image report creation and submission to the xR4DRAMA platform.
- Automatic attachment of geo location of the user to the submitted reports.
- Situation aware notification system (text alerts) to inform the user regarding the event status.
- Inclusion of a first responder mode that connects and organizes the physiological signals to the xR4DRAMA database.
- Authentication for first responders.
- Multilingual support (English and Italian).

8.2.2 Version 1.5 functional requirements

All functional requirements of version 1.0 are included in version 1.5. The updates that were added to the intermediate version of the citizen application are:

- Citizen video report creation and submission to the xR4DRAMA platform.
- Improved situation aware notification system (text alerts) including a notification centre for text notification archiving and alert for presence of unread notification by the user.
- Addition of map showing exact user location.

8.2.3 Version 2.0 functional requirements

All functional requirements of versions 1.0 and 1.5 are included in version 2.0. The updates that were added to the final version of the citizen application are:

- Improved situation awareness by showing the registered danger zones from the rest of the front-end tools (Authoring tool and AR app) on the map of the application.
- Improved situation awareness by showing all registered disaster management POI subcategories (Flood Reports, Risk Areas, Civil Protection, Civil Protection Distribution Places, and Safety Areas) on the map of the application.

Apart from the main functional requirements, each version went through minor quality of life updates. For instance, adding similar icons and colour schemes to be compliant with the rest of the xR4DRAMA front end tools, adding a sidebar navigation menu and better in-app notifications for different cases (e.g. summary for submitting a media emergency report, fail of service due to poor connection, etc.). Moreover, from version 1.5 and after the citizen awareness app properly support different screen sizes (e.g. suited for larger tablet screens).

Finally, there were also various bug fixes after receiving end user feedback during different testing sessions after each development cycle.

8.3 Integration architecture

The final version of the citizen awareness app can take input from citizens and first responders. As a result, there are two distinct modes for each role that are called citizen mode and first responder mode. The citizens can produce text, audio, image or video reports. The media reports are sent to the backend and/or the frontend tools. The first responders can record their physiological signals by wearing the garment equipped with sensors provided by SMARTEX. The physiological signals are provided to the stress detection module of the xR4DRAMA platform.

Regarding the citizen mode, the citizens are able to use the mobile phone onscreen keyboard, the mobile phone microphone and the mobile phone camera to produce their media reports (text, audio, image or video) and then submit these reports through the xR4DRAMA backend. The connection between the backend and the mobile application is performed by posting a different JSON file for each media type to a specific endpoint. An example of the JSON file that is sent from the mobile application for the text reports is:

```
{
  "reportType": text,
  "latitude": 40.599359,
  "longitude": 22.9756621,
  "textContent": "test report",
  "networkType":"4G",
  "networkStrength":1
}
```

The geolocation of the citizen is automatically attached to the JSON file. Another type of information that was requested by the end users was the network type (e.g. 4G, 5G) and strength (integer value from 1 to 4).

In case the type of the report is audio the “textContent” field is being replaced with “audioUrl” which includes a URL that downloads the audio file when opened. The URL has been prepared by the backend by uploading the audio file that has been sent by the citizen application. The URL is protected by basic authentication and the files cannot be accessed without credentials. An example of the JSON file that is sent from the mobile application for the audio reports is:

```
{
  "reportType": audio,
  "latitude": 40.599359,
  "longitude": 22.9756621,
  "audioUrl":
"https://xr4drama.iti.gr:5002/download/citizen_audio/bfd38726-d41a-4bbc-8a9a-
61888aead9b3.3gp",
  "networkType":"4G",
  "networkStrength":0
}
```

The integration for image and video report types are similar to the audio as both image and video have the “imageUrl” and “videoUrl” JSON fields for the files to be accessed by the backend. An example of the JSON files that are sent from the mobile application for the image and video reports are:

```
            {
              "reportType": image,
              "latitude": 40.599359,
              "longitude": 22.9756621,
              "imageUrl":
       "https://xr4drama.iti.gr:5002/download/citizen_images/9b30bebd-c34b-4683-
a2c9-a2eee17e7051.jpg",
              "networkType":"4G",
              "networkStrength":4
            }
```

```
            {
              "reportType": video,
              "latitude": 40.599359,
              "longitude": 22.9756621,
              "videoUrl": "
https://xr4drama.iti.gr:5002/download/citizen_videos/aecdd266-335e-41e2-ab4d-
6081f141a0c6.mp4",
              "networkType":"4G",
              "networkStrength":4
            }
```


Regarding the notification system, which would allow the professionals in the control room to broadcast information related to the disastrous event to all the citizens, the mobile app listens to a specific endpoint, which will respond with an appropriate text alert when the professionals choose to produce it. If available, it will pop up as a message in the Android's notification tray at any place within the application. More information about how these notifications look like can be found in subsection 8.5. The complete high-level architecture of the citizen mode system architecture is presented in Figure 22.

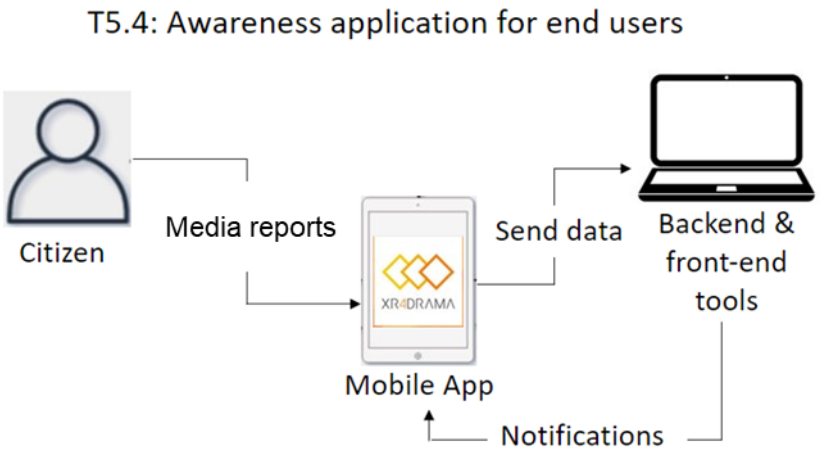


Figure 22: Citizen mode system architecture

In the first responder mode, the RUSA device transmits the physiological measurements via a Bluetooth connection. The Bluetooth connection takes place within the mobile app which runs on first responders' mobile devices. As soon as the mobile app receives the data from the RUSA device it transmits them to the physiological signals database (DB) via the internet. The physiological signals database is developed using the MongoDB software. MongoDB is a

source-available cross-platform document-oriented database program. Classified as a NoSQL database program, MongoDB uses JSON-like documents with optional schemas.

The physiological signals database is connected via an API that can receive requests and can control the DB in order to provide the corresponding data to specific endpoints. These requests are performed by the Physiological Signals Stress Detection Module of the xR4DRAMA system, which in turn will predict the first responder's stress level at a specific timestamp. The backend API and frontend tools can also gain access to the physiological signals through the same endpoints. The technical details of the integration of the RUSA device with the mobile application and the mobile application with the physiological signals database have been described in detail in subsection 3.2.2 of D3.1 – "Sensor data analysis for situation awareness – v1". The complete high-level architecture of the first responder system architecture integration is presented in Figure 23.

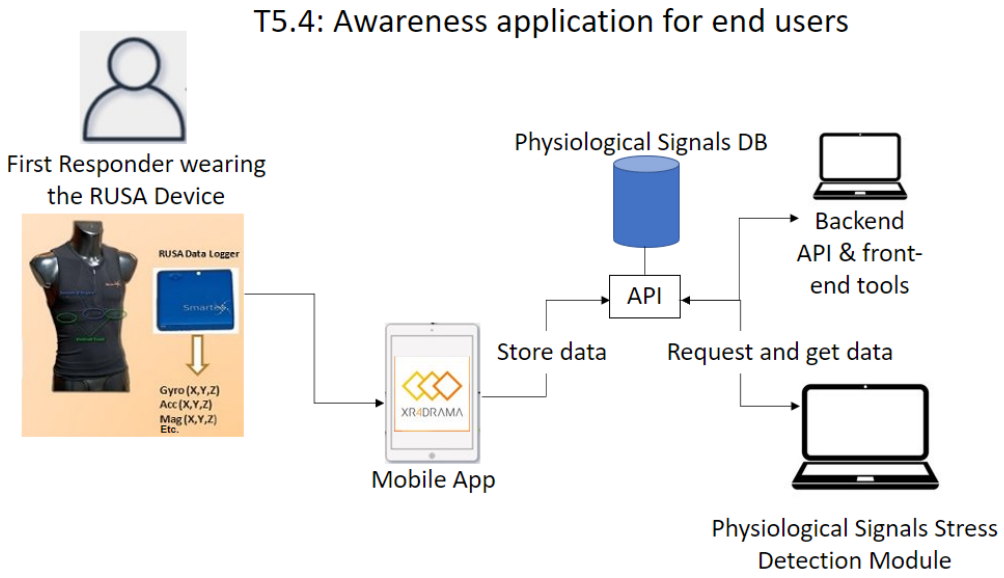


Figure 23: First responder mode system architecture

8.3.1 iOS Integration architecture for the first responder mode

A specific integration architecture is designed to support the use of iOS mobile devices for first responders. The library that supports the Bluetooth streaming of physiological data between the RUSA data logger and the mobile devices is working only on Android. Re-purposing this library to support iOS devices is not feasible within the time constraints. Thus, the solution for the case of iOS devices is to save the physiological data to a file locally inside the RUSA data logger during the mission and then later transfer this file via USB cable to the Authoring tool in order to facilitate storing and processing of the saved data. There is an option for the RUSA device to save the data locally without connecting to a mobile device. The Authoring tool supports a file upload system in order to send these physiological signals to the API that is connected with the physiological signals DB. After post processing to convert the proprietary format of WWSX that the RUSA device produces to a more suitable format like CSV the physiological signals gathered from the first responders using the iOS are now stored to the Physiological signals DB and can be processed by the stress detection

module or be utilized by the rest of the tools. The complete high-level architecture of this specific case is presented in Figure 24.

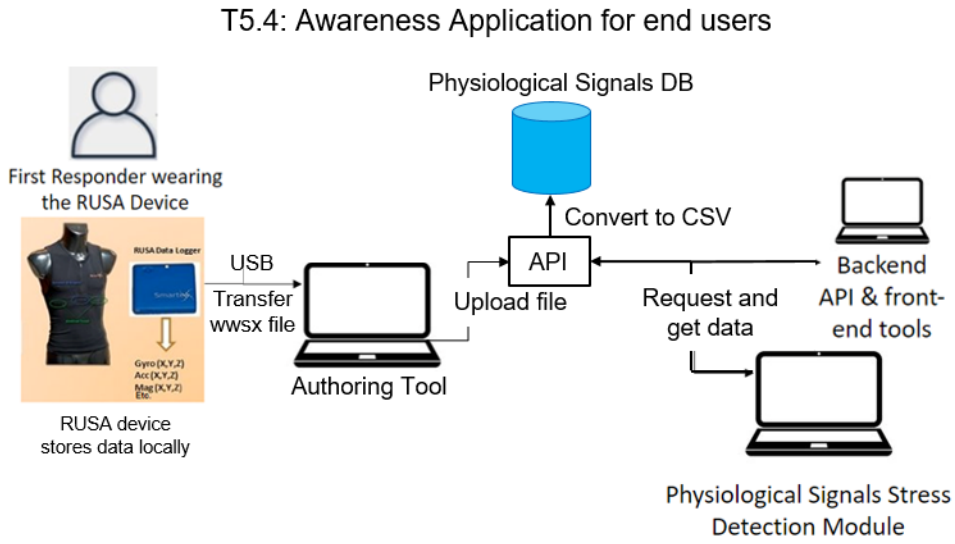


Figure 24: First responder mode system architecture for iOS devices

8.4 Citizen awareness application evaluation pipeline

The citizen awareness app is expected to work during Phase 2 and Phase 3 of the PUC1, the disaster management use case, which are the time during the disastrous event, is taking place (Phase 2) and the emergency management (Phase 3). Its main purpose is to provide information to the xR4DRAMA platform gathered from both citizens and first responders. A detailed description of the evaluation pipeline for the citizen awareness app is shown in Table 7 for the first responder mode and Table 8 for the citizen mode. This evaluation pipeline was followed during the 1st pilot in Vicenza. The results were documented in D6.3 – "Evaluation of the 1st prototype and updated user requirements". In summary, the prototype version of the citizen awareness app was able to provide text, audio and image reports from the citizens and was able to receive text notifications from the professionals in the control room. As far as the first responder mode, the authentication part was working together with the streaming of physiological signals, however there were some issues with some devices where the streaming of data was interrupted and thus it was marked as partially working. Nevertheless, the issues were identified and fixed in later versions of the app.

First Responder Mode evaluation pipeline
1. A first responder logs into the app (first responder mode). 2. A first responder activates the RUSA for the acquisition of physiological data.

Table 7: First Responder mode evaluation pipeline during Phase 3 of PUC1

Citizen Mode evaluation pipeline
1. A citizen opens the app. 2. A citizen displays his/her position on the map to be sure of being correctly geolocated before sending any reports. 3. A citizen reports a critical issue by writing a text and sending it. 4. A citizen sends an audio recording to report a flood related issue. 5. A citizen sends an image to report a flood related issue. 6. A citizen sends a video to report a flood related issue. 7. A citizen checks a summary of his/her send reports. 8. A citizen receives a notification. 9. A citizen checks the presence of unread notifications. 10. A first responder notifies a citizen.

Table 8: Citizen mode evaluation pipeline during Phase 2 of PUC1

8.5 Final version of citizen awareness application

8.5.1 Initial screen

The user can start the application by selecting the xR4DRAMA icon on their phone (see Figure 25 left side). The welcoming screen of the application presents the user with two options which differentiate which of the two supported modes will be selected to continue (see Figure 25 right side). Both citizen and first responder modes are described in detail in the following subsections.

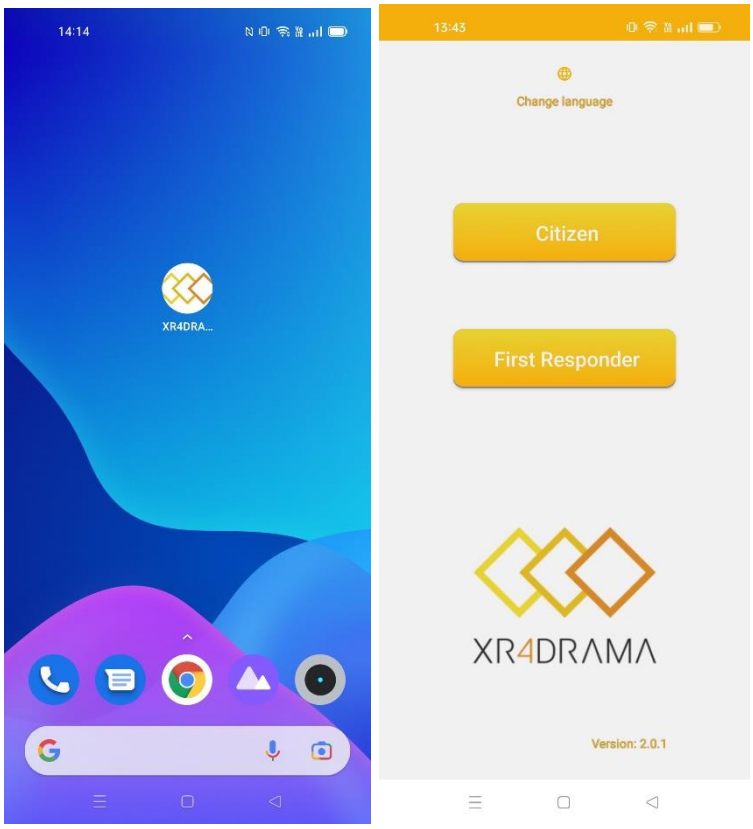


Figure 25: (Left side) Citizen application icon. (Right side) Initial screen of the app

8.5.2 **Citizen Mode**

By selecting the “Citizen” button of the initial screen (Figure 25 right side), the user enters the citizen mode of the app. The citizen mode of the app offers the user the ability to submit a text, an audio, an image or video report (Figure 26 right side) to the xR4DRAMA platform so that the professionals can interact with the information provided by the wider public regarding the ongoing situation of the disastrous event. Furthermore, the app offers the user the ability to open the map by clicking on the map icon ( ) on the top right of the app or while using the sidebar navigation menu (Figure 26 left side) and check his/her location as well as see relevant information about the disastrous event on it (e.g. registered danger zones and disaster management POIs). Moreover, the app offers the user a notification centre (can be found on the top right of the app) which archives all the text notifications that are broadcasted by the professionals in the control room. Another feature of the final version of the app is a sidebar navigation menu (see Figure 26 left side when opened) which is added to all screens of the citizen mode so that the user can switch between different screens easier.

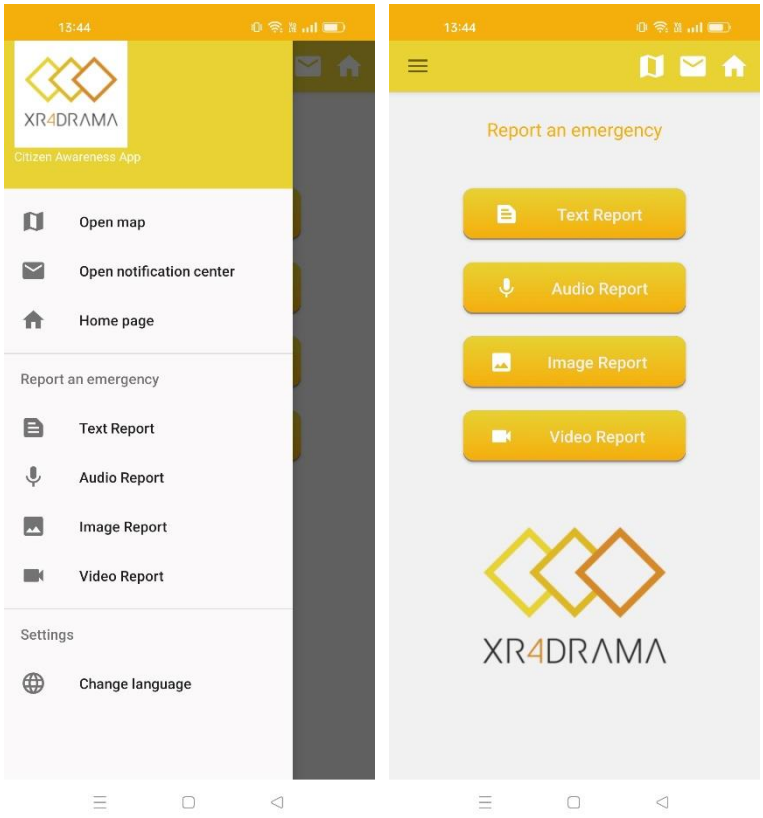


Figure 26: (Left side) Sidebar navigation menu. (Right side) Citizen mode main screen

8.5.3 Citizen text report creation and submission to the xR4DRAMA platform

By selecting the "Text Report" button of Figure 26 the user enters the text report screen, which can be seen in the first figure from the left on Figure 27. The users can now type their report and then press the "Send" button to submit the report to the xR4DRAMA platform. An example of typing the text report is shown on the second figure of Figure 27. Once the send button is pressed a progress bar is shown until the report is uploaded to the XR4DRAMA platform (third figure of Figure 27). Finally, a summary screen appears indicating the user that his/her report has been successfully uploaded (fourth figure of Figure 27). The citizen text report is automatically geotagged meaning that the location of the user (latitude and longitude) is provided to the xR4DRAMA platform. The citizen text report is forwarded to the rest of the xR4DRAMA frontend tools and backend APIs for further processing (e.g., WP3 services, KB server for raw data storage and/or sharing with the xR4DRAMA authoring tool). For example, a text report is analysed by the text analysis and text generation modules of WP3. If the result indicates an emergency related to a flood scenario (PUC1) a "Flood Report" POI is automatically created on the backend and can be seen on the location of the citizen on the map of the front-end tools (e.g. AR app) with the text analysis results as well as a more informative description presented by the text generation module.

A specific example using a text report from the 1st PUC1 pilot but from different location (just to show the functionality) can be seen in the left side of Figure 28 in the AR app. A text report in Italian namely "*parco querini allagato SOS aiuto soccorso help*" which asks for help in park Querini due to a flood, has produced the selected citizen generated flood report POI

of left of Figure 28 and the results of text generation can be seen on the attributes of the POI on the right side of Figure 28.

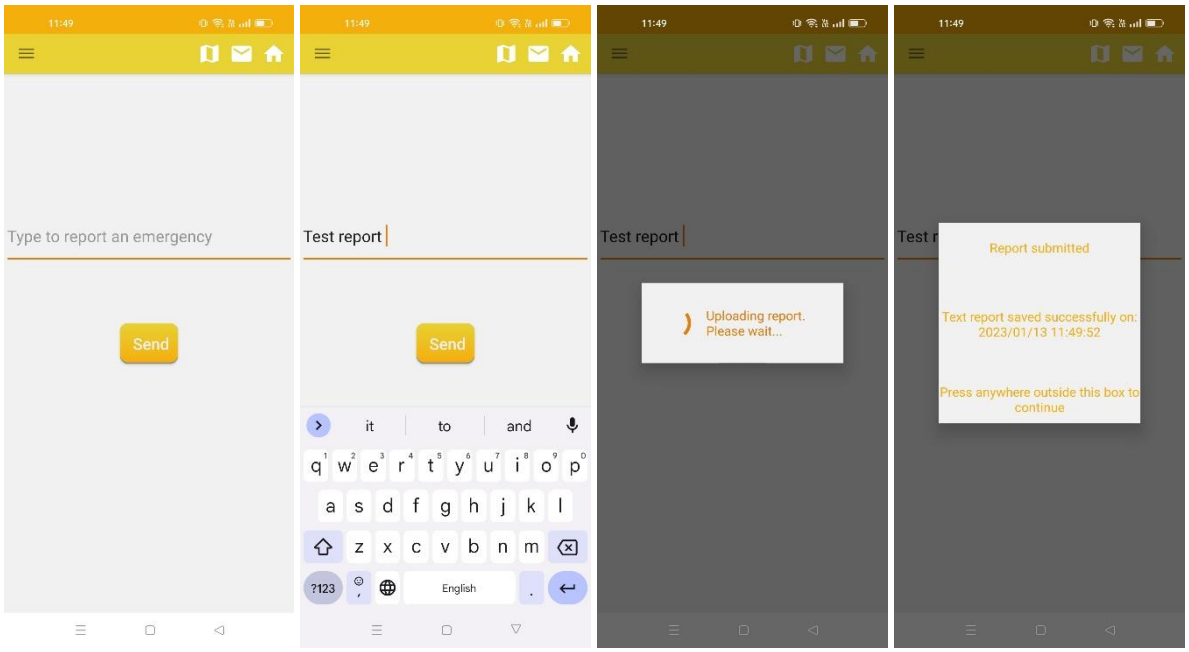


Figure 27: (1st from left) Text report main screen. (2nd from left) Text report creation. (3rd from left) Upload progress bar. (4th from left) Summary screen

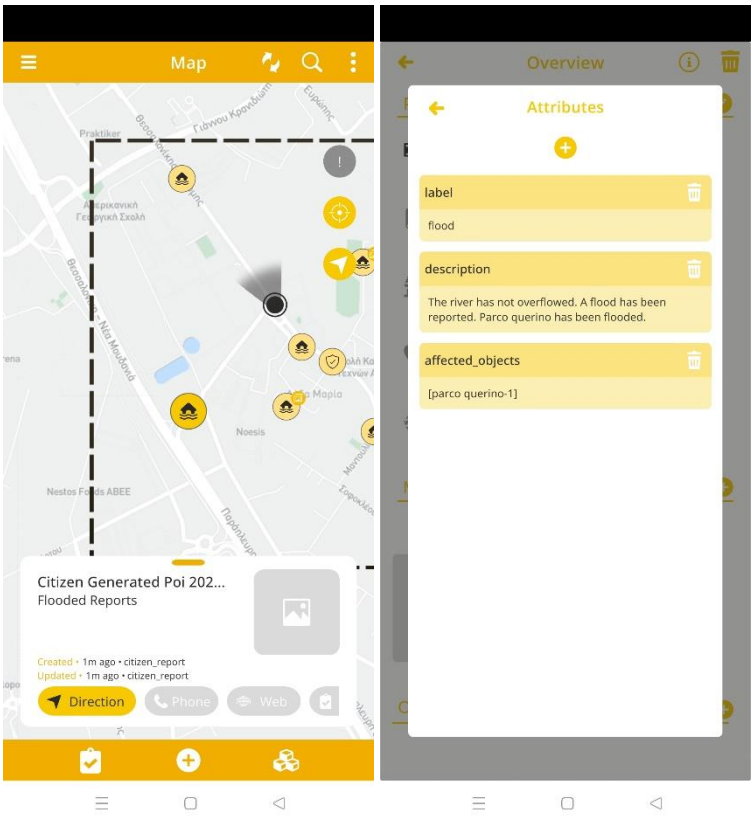


Figure 28: (Left side) Flood report Citizen Generated POI shown in AR app. (Right side) Attributes of POI with results from text analysis and text generation based on the citizen text report

8.5.4 Citizen audio report creation and submission to the xR4DRAMA platform

By selecting the "Audio Report" button of Figure 26 the user enters the audio report screen, which can be seen, on the first figure from the left side of Figure 29. The user can now record his/her self-talking by pressing the centred microphone button. When the microphone button is pressed it turns orange to indicate that the audio recording functionality has started, and the timer shows how long the recording already lasts. In order to stop the recording, the user needs to press on the microphone button again when they are finished. An example of an audio recording taking place is shown in the second figure from the left of Figure 29. The microphone button is orange, which indicates a live recording, and the timer is working.

In order to select and submit the audio report to the xR4DRAMA platform the user needs to press the "File List" button next to the microphone button. This opens the audio list file viewer and media player (see on the third figure from the left of Figure 29) where the user can select which audio file they want to submit. The user can listen to his/her recording before deciding which to submit by selecting the play button on the media player and can submit the audio report by pressing the "Send" button on the media player. Finally, a summary screen appears indicating the user that his/her report has been successfully uploaded (fourth figure from the left of Figure 29). The citizen audio report is also geotagged and is forwarded to rest of the xR4DRAMA frontend tools and backend APIs for further processing (e.g., WP3 services, KB server for raw data storage and/or sharing with authoring tool).

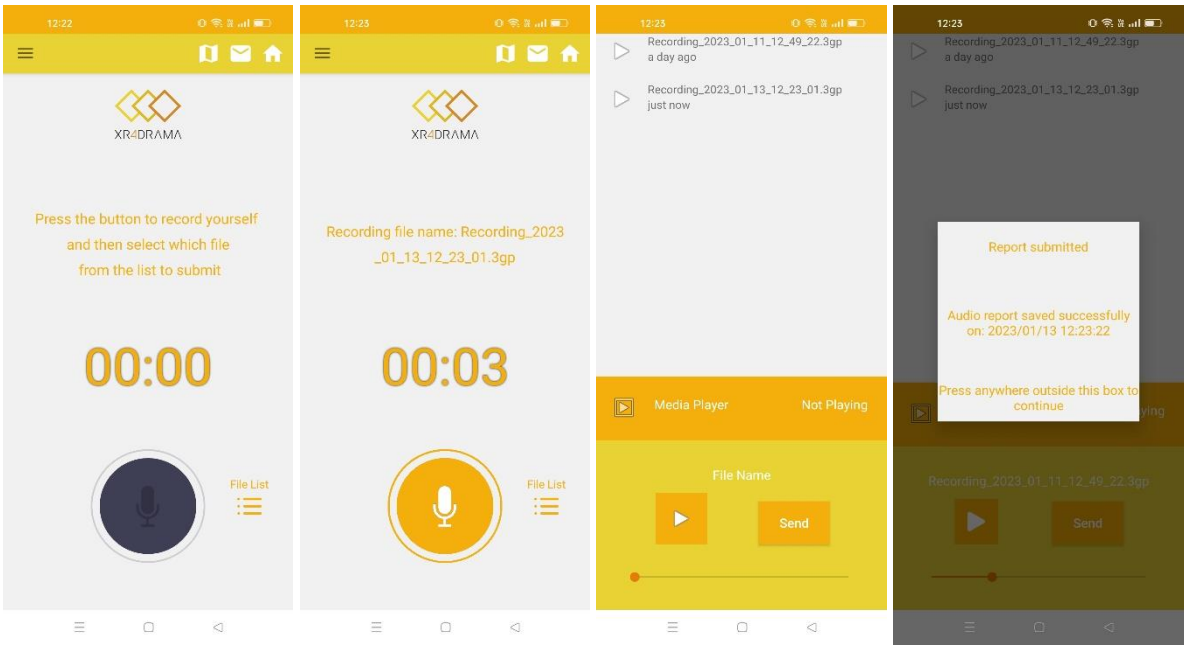


Figure 29: (1st from left) Audio report main screen. (2nd from left) Audio recording example. (3rd from left) File list and media player (right side). (4th from left) Summary screen

8.5.5 Citizen image report creation and submission to the xR4DRAMA platform

By selecting the “Image Report” button of Figure 26 the user enters the image report screen, which can be seen, on the first figure from the left side of Figure 30. The user can use their camera to take a picture by pressing the camera button or select one from the gallery by pressing the gallery button. After taking or selecting an image from the gallery, it can be seen as a preview replacing the xR4DRAMA logo in the middle of the screen. An example of uploading an image is shown in the second figure from the left of Figure 30. Finally, a summary screen appears indicating the user that his/her report has been successfully uploaded (third figure from the left of Figure 30). The image report is geotagged and is forwarded to rest of the xR4DRAMA frontend tools and backend APIs for further processing (e.g., WP3 services, KB server for raw data storage and/or sharing with authoring tool). For example, an image is analysed by the visual analysis module of WP3. If the result indicates an emergency related to a flood scenario (PUC1) a “Flood Report” POI is automatically created on the backend and can be seen on the location of the citizen on the map of the front-end tools with the visual analysis results as well as a more informative description presented by the text generation module.

A specific example using the image report from Figure 30 but from different location (just to show the functionality) can be seen in the left side of Figure 31 in the AR app. The example image with the flooded cars under the bridge has produced the selected citizen generated flood report POI of left of Figure 31 and the results of visual analysis can be seen on the attributes of the POI on the right side of Figure 31.

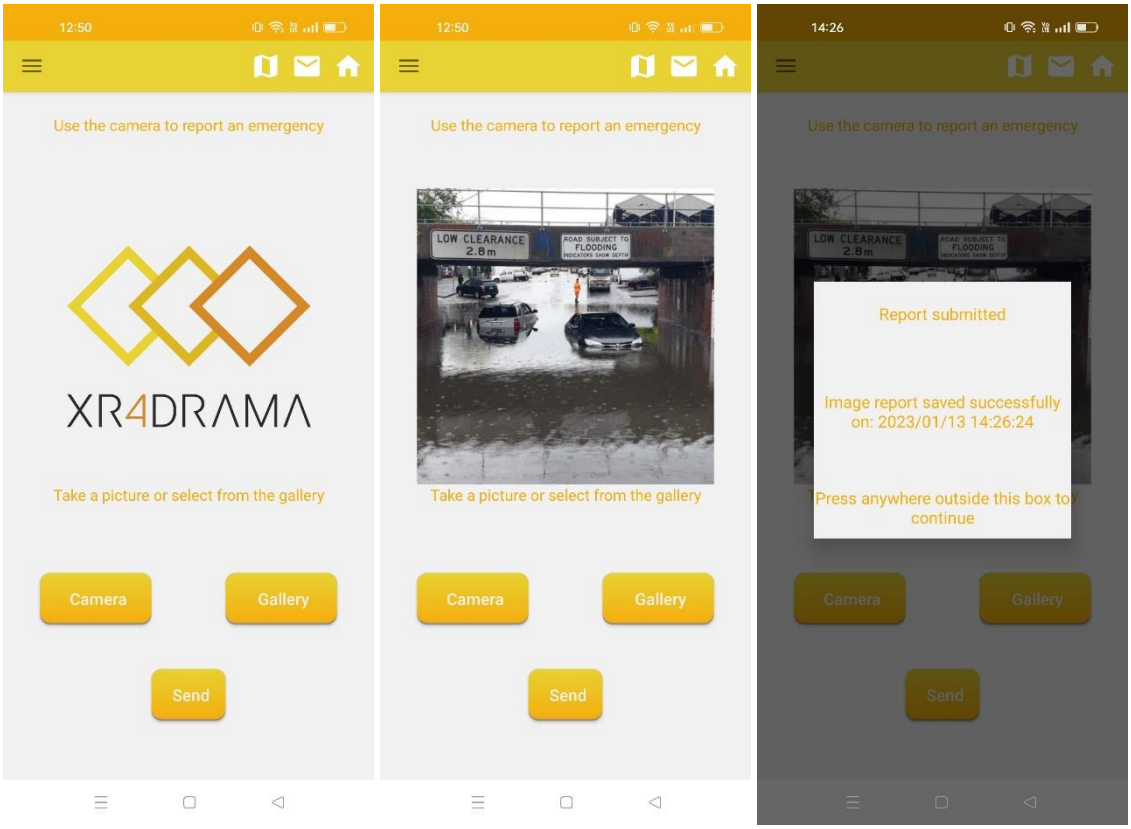


Figure 30: Image report main screen (left side). Image uploading example (middle). Summary screen (right side)

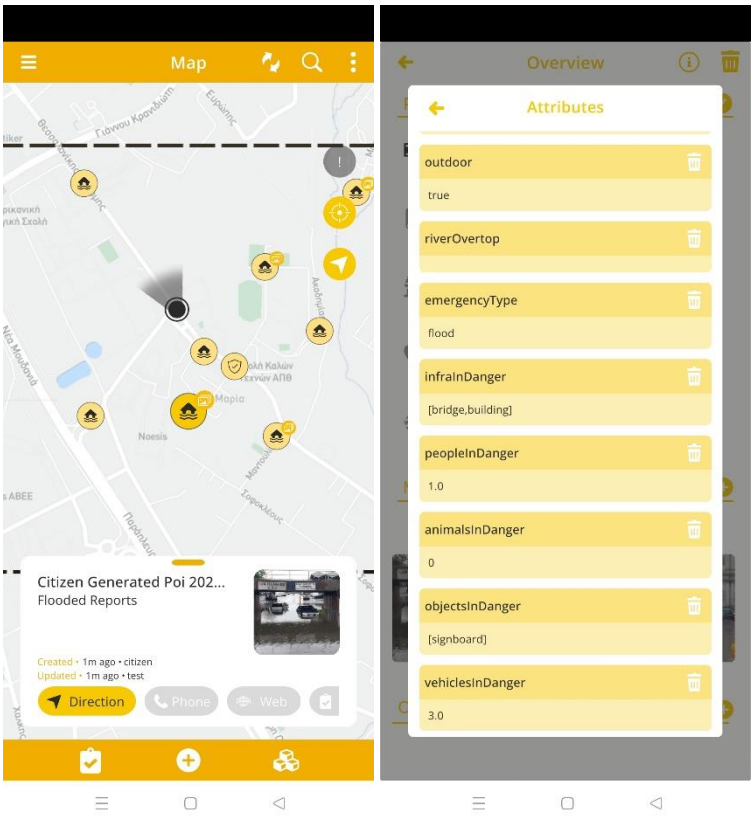


Figure 31: (Left side) Flood report Citizen Generated POI shown in AR app. (Right side) Attributes of POI with results from visual analysis based on the citizen image report

8.5.6 Citizen video report creation and submission to the xR4DRAMA platform

By selecting the “Video Report” button of Figure 26 the user enters the video report screen, which can be seen, on the first figure from the left side of Figure 32. The user can use their camera to record a video by pressing the record button or select one from the gallery by pressing the gallery button. The user can record 30 seconds or less video to simplify file size upload speed and processing time. After recording or selecting a video from the gallery it can be seen as a preview replacing the black square placeholder in the middle of the screen. An example of uploading a video is shown in the second figure from the left of Figure 32. Finally, a summary screen appears indicating the user that his/her report has been successfully uploaded (third figure from the left of Figure 32). The video report is geotagged and is forwarded to rest of the xR4DRAMA frontend tools and backend APIs for further processing (e.g., WP3 services, KB server for raw data storage and/or sharing with authoring tool). For example, a video is analysed by the visual analysis module of WP3. If the result indicates an emergency related to a flood scenario (PUC1) a “Flood Report” POI is automatically created on the backend and can be seen on the location of the citizen on the map of the front-end tools with the visual analysis results as well as a more informative description presented by the text generation module. Specifically, for the Figure 32 the visual analysis does not recognize any flood incident and thus there is no trigger in the backend for a POI creation.

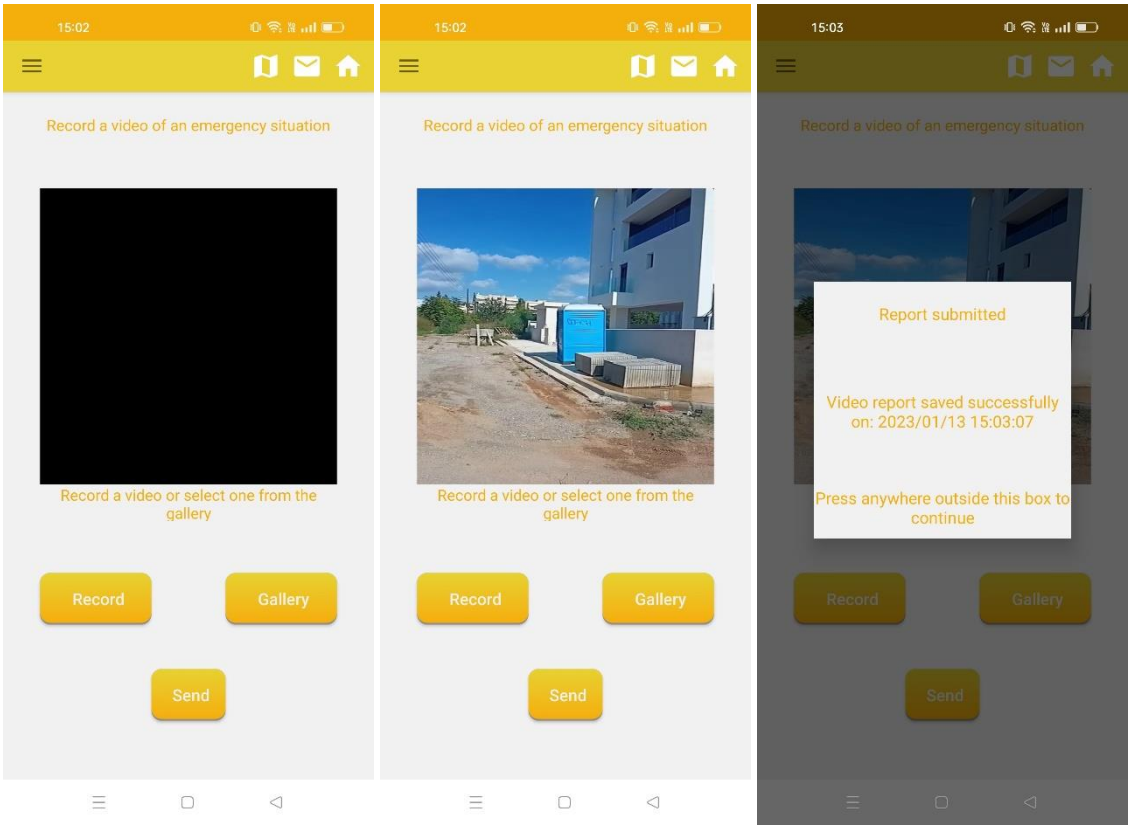


Figure 32: Video report main screen (left side). Video uploading example (middle). Summary screen (right side)

8.5.7 **Situation aware notification system**

When in citizen mode the user can receive a text notification by the professionals at any time. These notifications can include directions or general updates over the on-going situation. The text notification will appear in Android's system notification tray and the user can click on it to read it. The notification is also archived in the citizen awareness app notification centre, which can be accessed from all citizen mode screens on the top left. The text notifications can be broadcasted by the professionals in the control room to all citizens who have the citizen awareness app on their phones while using the xR4DRAMA Authoring tool. An example of a text notification received when browsing on the citizen mode is presented on the left of Figure 33. The notification also appears next to the phone clock (16:02) and inside the notification centre with a changed icon ( ) to indicate the presence of an unread notification (see middle on Figure 33). The notification centre is presented on the right side of Figure 33, the unread notification which was just received appears in bold and when the user clicks on it, it will change to normal. Finally, the notification creation and broadcast part from Authoring tool is shown in Figure 34. In the project dashboard there is a broadcast icon next to the project name which after being pressed opens a window which prompts the user to type a text notification for the citizens.

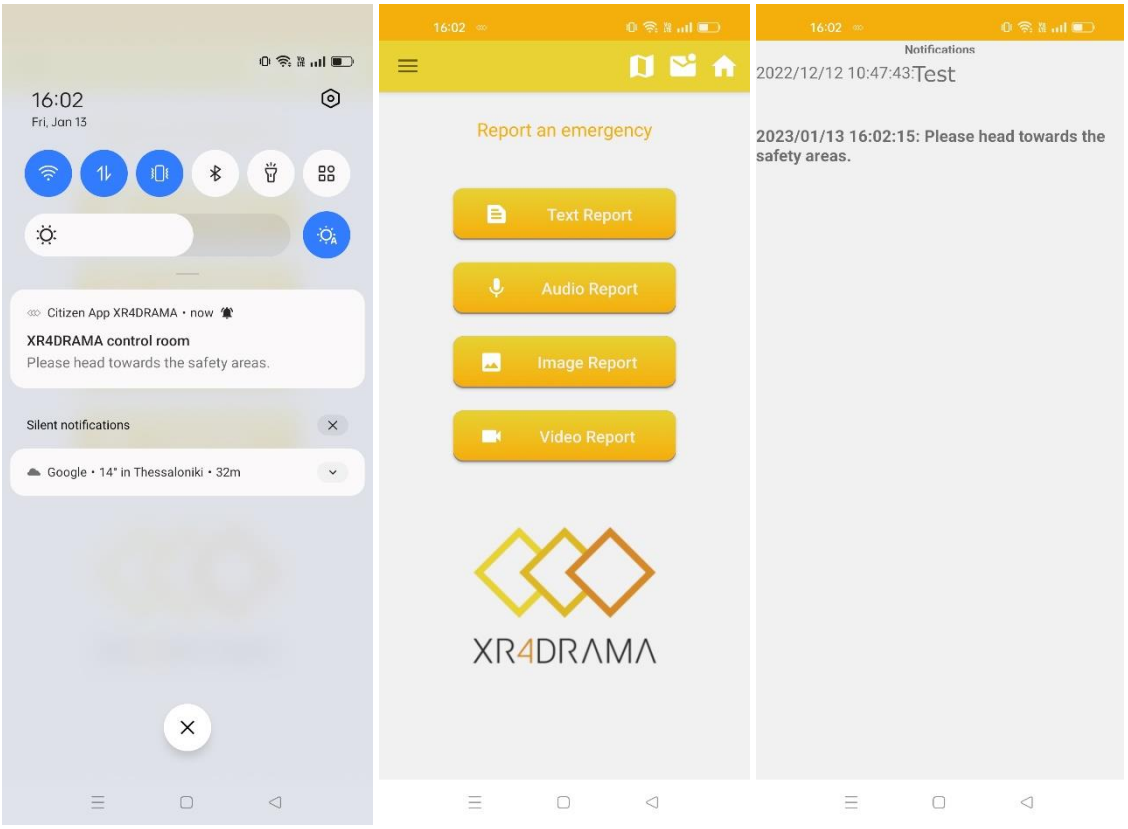


Figure 33: (Left side) Notification text alert example. (Middle) Unread notification inside the app. (Right side) Unread notification inside the notification centre

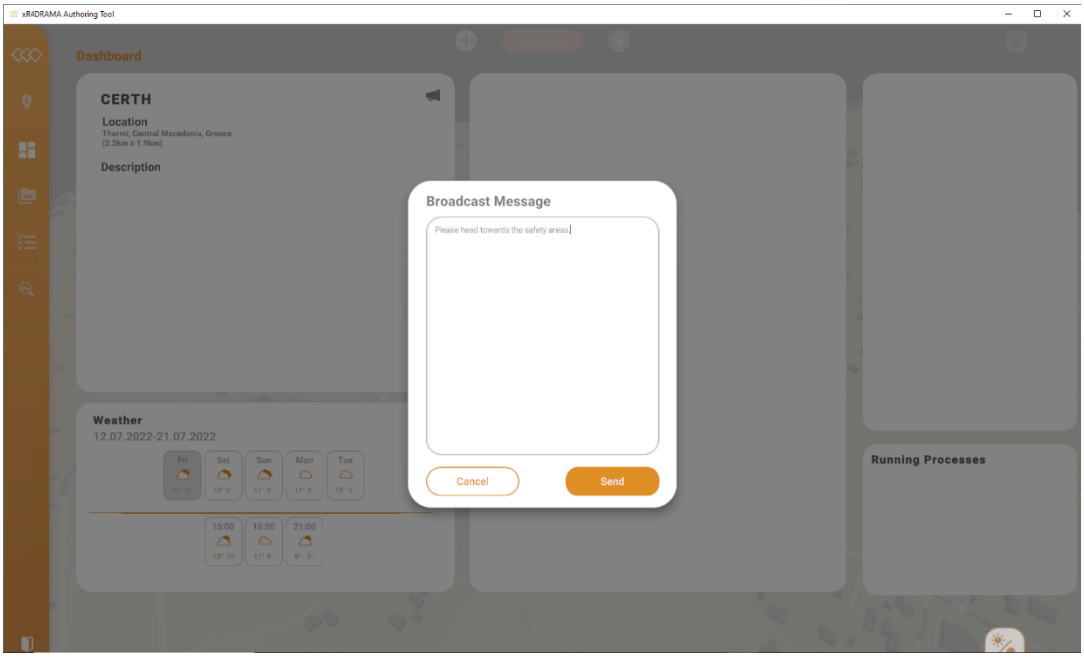


Figure 34: Create a notification from Authoring tool and broadcast it to all citizens

8.5.8 Citizen awareness app map features

The user can access the citizen awareness app map by clicking the map button on the top right of the app (e.g. Figure 26 right side) or through the sidebar navigation options (Figure 26 left side). When the map opens (Figure 35 left side), the user can check his/her location and then look for information related to the disastrous event or go for an emergency report by click the "+" button which expands into the four media report types (Figure 35 right side). For example, the user can see nearby registered danger zones and thus look to avoid them during an evacuation, or check POIs related to the disaster management in order to plan his/her next moves.

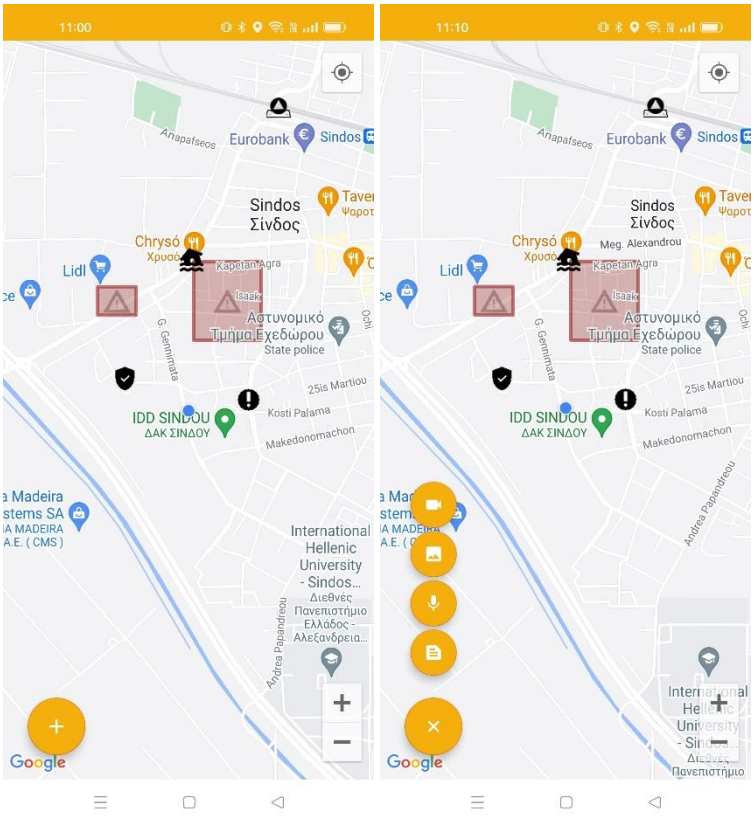


Figure 35: (Left side) Citizen awareness map opens. (Right side) Map with media report options expanded

Danger zones appear as red rectangles with a danger icon in the middle. They only show if the user is nearby (a larger rectangle registered in the Authoring tool defines the disastrous event limits and if the user is inside then can see all the disaster management info on his/her map). Danger zones are clickable and turn orange when clicked and show some informative text as a pop-up message about the danger zone (see Figure 36 left side). Finally, danger zones are registered in the front-end tools and backend (e.g. Authoring tool). Apart from the danger zones, the citizen awareness app map shows disaster management POIs. These POIs appear in black colour and when clicked show their category name as a pop-up text. They are created on the front-end tools (e.g. Authoring tool and AR app) but a citizen emergency report can also create a specific category, namely the Flood Reports, when analysed by the WP3 tools. Table 9 shows all disaster management POIs categories supported by the citizen

awareness app and their icons. An example of a clicked POI on the map is shown on the right side of Figure 36.

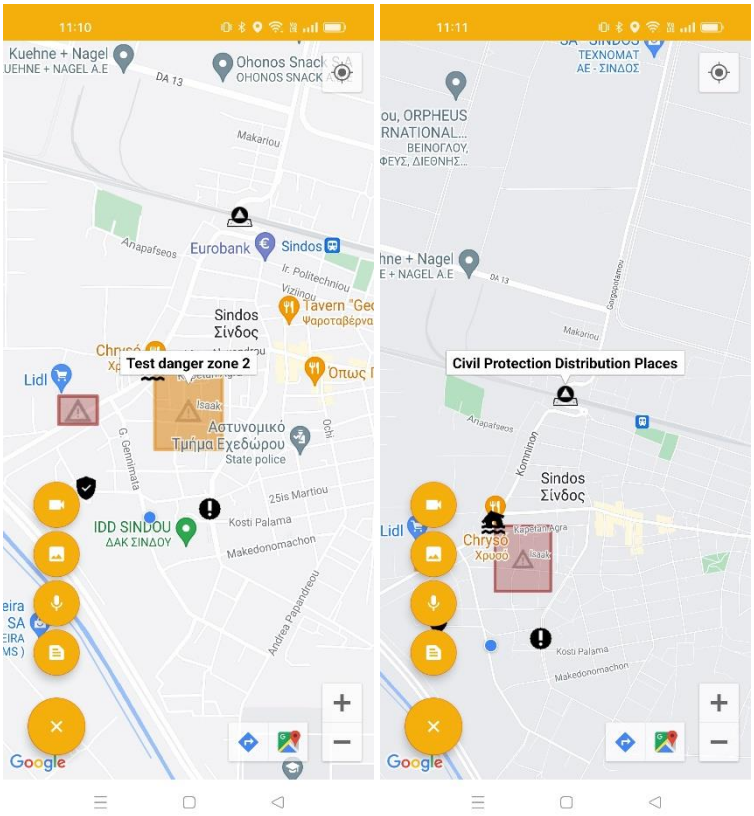


Figure 36: (Left side) Danger zone clicked. (Right side) POI clicked

Disaster Management POIs sub-categories	
	Flood Reports
	Warnings
	Safety Areas
	Risk Areas
	Civil Protection
	Civil Protection Distribution Places

Table 9: Disaster Management POI subcategories

8.5.9 **First Responder Mode**

By selecting the “First Responder” button of the initial screen (Figure 25 right side) the user enters the first responder mode of the app (see Figure 37). The first responder mode is offered exclusively for the first responders who wear the SMARTEX (STX) garment equipped

with sensors and provides the functionality of a Bluetooth connection between the phone and the RUSA device (processing unit of the sensorised garment) as well as sharing of the physiological signals recorded from the first responder to the xR4DRAMA platform. When the user presses the “First Responder” button of the initial screen (Figure 25 right side), they will be prompted to provide authentication credentials to continue using the first responder mode of the app. The authentication is being cross checked with the rest of the xR4DRAMA tools (e.g., AR app, authoring tool) and the user can access all applications with the same credentials. Once the authentication is complete, the user can see the main screen of the first responder mode (middle of Figure 37). Here the user can connect via Bluetooth to the RUSA device and start streaming the physiological signals to the xR4DRAMA platform. In order to connect with the RUSA device, the user needs to press the “Start Streaming” button which will pop up a new window that lists all of the available nearby devices with Bluetooth connection enabled (see right side of Figure 37). By selecting the appropriate name of the RUSA device (which can be found on the back of the RUSA logger) the application connects to the garment equipped with sensors and the streaming of the physiological signals begins. An example of physiological signals streaming via the application is presented in the left of Figure 38. The channel name for each signal that is being transferred appears on the logger below the “Start recording” and “Stop streaming” buttons. The user can pause the streaming by pressing the “Stop streaming” button and can resume by pressing the “Start recording button”. The physiological signals are being organised to a DB and are being utilized by the stress detection tools of WP3. The integration and implementation of the DB is being described in D3.1 – “Sensor data analysis for situational awareness”. The right side of Figure 38 shows the stress level results on the AR app, which is a circle with the stress levels (0-100) that when clicked shows an appropriate text message.

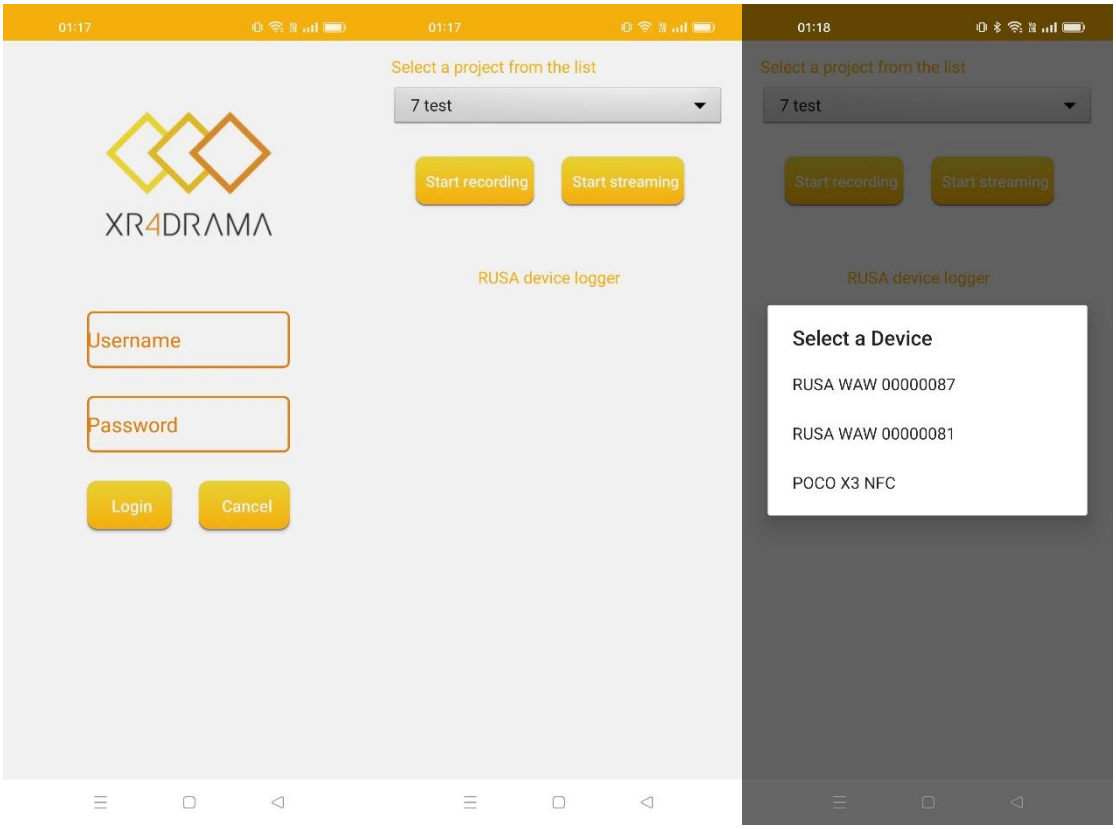


Figure 37: First responder mode login screen (left side). First responder mode main screen (middle). Bluetooth connection with RUSA device (right side)

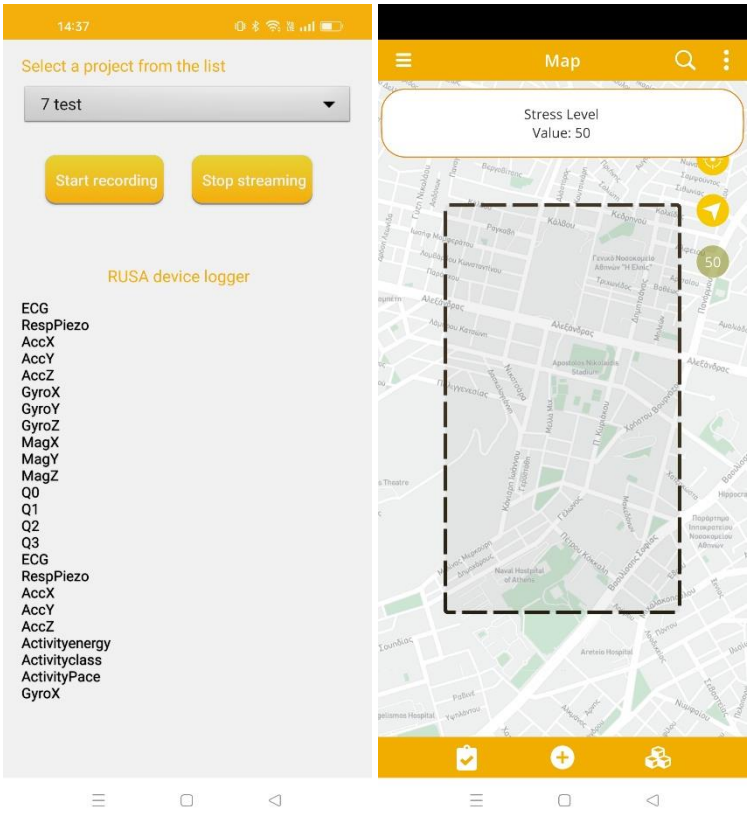


Figure 38: (Left side) Physiological signals streaming to the xR4DRAMA platform. (Right side) Stress level results visualized on the AR app

8.5.10 **Citizen Awareness App Demo**

Here is a link for a demo of all functionalities of the citizen awareness app: https://drive.google.com/drive/folders/1ewao2vyxuWKGis2jAcW8kt7qeGiQlOmQ?usp=share_link.

9 CONCLUSIONS AND NEXT STEPS

The development of the backend of the system in task T5.2 was successfully concluded and managed to deploy the final versions of all the tools and services. It provides and absorbs data coming from various modules for the entire platform to run in coherence. The backend also provides user and project management capabilities which acts as a foundation to the entire system.

The work progress achieved in T5.3 (“3D GIS for navigation and data geo-localization”) has contributed to the final version of the GIS, the Satellite and the 3D reconstruction services as well as the AR application.

The work carried out within T5.4 (“awareness application for end users”) has produced the final version of the citizen application which provides a tool for the wider public to increase awareness during an emergency but also allow for direct communication between the citizens and the professionals. Furthermore, the application enables sharing of the physiological signals of the end users (first responders) with the xR4DRAMA platform. In the following months, the focus will shift on maintaining the services and supporting the xR4DRAMA PUC1 second pilot in Vicenza.