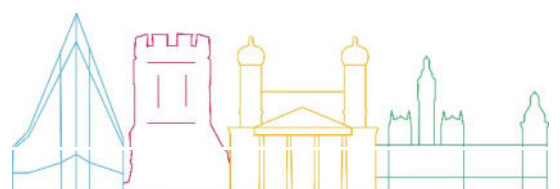




ARCH D4.2

Historic Area Information System



Deliverable No.	D4.2
Work Package	WP4
Dissemination Level	PU
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Due date	2021-05-31
Actual submission date	2021-07-08
Status	Final (after internal peer-review)
Revision	1.0
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This document has been prepared in the framework of the European project ARCH – Advancing Resilience of historic areas against Climate-related and other Hazards. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 820999.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 820999.

Executive Summary

This deliverable has been prepared for the European Commission-funded research project ARCH: Advancing Resilience of historic areas against Climate-related and other Hazards. It is the key output of Task 4.2 “Information Management about Historic Areas” within work package 4 “Hazard & Object Information Management System”. The aim of Task 4.2 was the development of the systems and tools to structure, query and analyse data related to the historic area and the elements it contains.

By considering historic areas as complex Social-Economic Systems, the different domains of these systems have been analysed, focusing the attention not only on the historic area itself, but also on the larger system in which it is included. The georeferenced information has been selected and structured in the Historic Area Information System with reference to the built and natural environment, the cultural heritage elements, and the social-economic context. Data and information to characterize the heritage assets and to assess their state are provided to support the subsequent vulnerability analyses (WP5), also taking into account that these indicators depend on the potential hazards.

In addition, a specific relational database has been developed to store information at building/object scale about the heritage assets and to relate information to each other.

Three specific tools have been designed and implemented - an operational guide is provided in this deliverable - to allow access to the dataset:

- GIS Dashboards enabling users to obtain info using intuitive and interactive maps;
- Building/Object electronic sheets to query structured data included into the database
- 3D Viewers to navigate 3D models produced for the constructions and objects

In addition, a methodology has been developed for automated acquisition of 3D models from automatically operated drones, followed by automated 3D model creation, leading to the Machine Learning (ML) processing of information for automated analysis and detection of structural and material degradations, employing neural-network co-processing for both more accurate and faster processing.

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List of abbreviations

Abbreviation	Meaning
3D	Three dimensional (models)
3MF	3D Manufacturing Format
AeDES	Agibilità per edifici ordinari nell'emergenza post-sismica
AI	Artificial Intelligence
ANN	Artificial Neural Network
ATECO	Classification of Economic Activity (ATTività ECONomiche)
BIM	Building Information System
BMS	Building Management System
BTH	Bottom Hat Transform
CH	Cultural Heritage
DB	DataBase
DSLR	Digital Single-Lens Reflex
DSS	Decision Support System
DWT	Discrete Wavelet Transform
ELC	Emergency Limit Condition
FBX	Filmbox (3D format from Autodesk)
GIS	Geographical Information System
GLCM	Gray-Level Co-occurrence Matrix
GPU	Graphical Processing Unit
GUI	Graphical User Interface
HA	Historical Area
HARIS	Historic Areas Information System
HUL	Historic Urban Landscape
IDE	Integrated Development Environment
ILSVRC	ImageNet Large Scale Visual Recognition Challenge

INSPIRE	Infrastructure for Spatial Information in Europe
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
ISTAT	Istituto Nazionale di Statistica
JSON	JavaScript object notation
KPI	Key Performance Indicators
LoD	Level of Detail
DInSAR	Differential SAR Interferometry
MINOAS	Marine Inspection Robotic Assistant System
ML	Machine Learning
OBJ	OBJect (3D format from Wavefront)
RDBMS	Relational Database Management System
REST	Representational State Transfer WEB service
SDK	Software Development Kit
SES	Social-Ecological System
SGD	Stochastic Gradient Descent
SGD	Stochastic Gradient Descent
SOA	Service-Oriented Architecture
SOAP	Simple Object Access Protocol
SQL	Structured Query Language
SRI	Subsidence-Related Intensity
THIS	Threats and Hazard Information System
UAS	Unmanned Aerial System
UGV	Unmanned Ground Vehicle
UML	Unified Modelling Language
UUV	Unmanned Underwater Vehicle
WP	Work package

4. Web tools and operational guide

To make the data and information accessible to users, as already described in D7.5 “Interface specification and system architecture” and graphically reported in Figure 19, three tools have been developed:

- **GIS Dashboards** enabling users to obtain information by location-based analytics, using intuitive and interactive data and maps to be viewed on a single screen.
- **Building/Object Sheets** to query and visualise structured data included in the database, for example providing information about assets and objects in the historic areas; these web-sheets will be used also for editing and data entry performed by authorised users.
- **3D model viewer** to visualise the three-dimensional models of assets and objects, also enabling users to extract a subset of three-dimensional data.

Three tools are interconnected, such that the user can use the GIS dashboard to navigate different information levels and through links can get access to electronic sheets and the 3D viewer. The overall design of the information system platform of ARCH follows specific guidelines to allow an easy understanding for the users, and to facilitate the accessibility to all functionalities. The GUI is designed to be easy-to-use by non-expert users and users not familiar with GIS applications as it targets not only CH professionals, but also any employee that deals with the protection of the CH.

4.1. How to access information systems

In this section, these tools (version v1.2021) are presented and a quick user manual is illustrated. Currently, the landing page of the information systems (Figure 20) can be reached to the web link <http://www.cs.ingv.it/ARCHPortal/>.

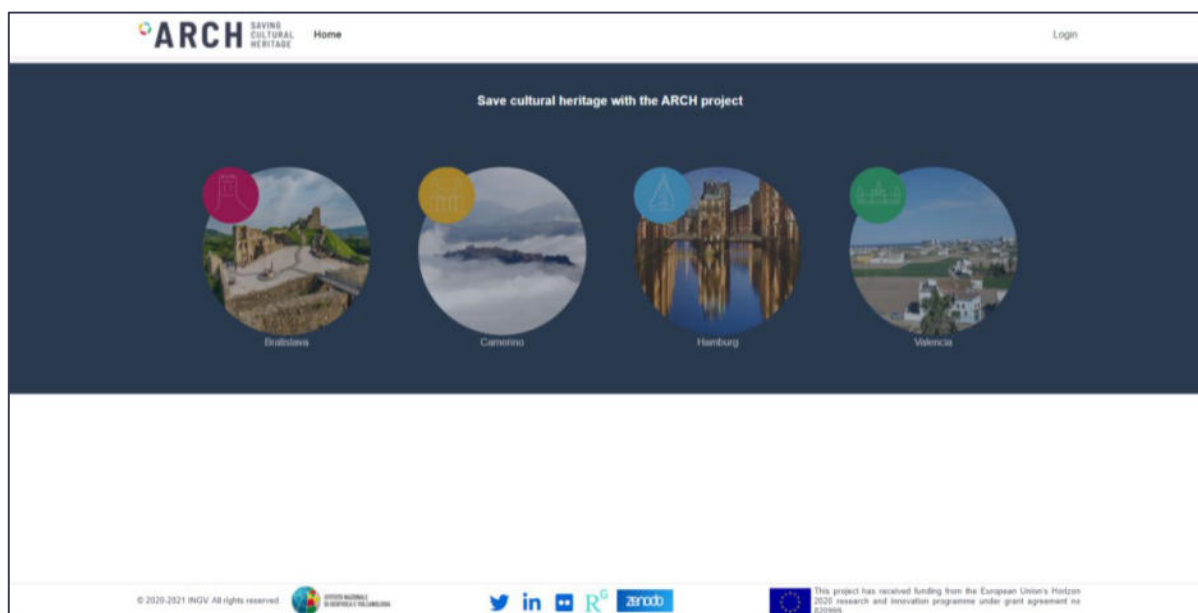


Figure 20: Front page of the Information System platform

Figure 21: Login to the information systems

After clicking on the button at the top right in the landing page, the user can login (Figure 21), if registered, otherwise she\he can request the registration of a new account (Figure 22), that will be managed by INGV before granting it. This control process is necessary as the authorised user has access to all functionalities; with the possibility also of modifying information concerning the assets of her\his own historical area. However, the unregistered user can have access in consultation mode to all public information contained in the systems.

Currently all pages in HARIS are available without registration, and the login is used only to modify the information; however, specific details on the assets may later be made available only after the user registration.

Figure 22: Registration of new account



Figure 23: GIS dashboard of HARIS (example for the case of Hamburg)

In the landing page, the image of the city lights up when the mouse pointer is positioned over it and, at this point, the corresponding GIS dashboard (Figure 23) is loaded with a simple click. Once this new page has been loaded, a menu in the header (1 in Figure 23) allows accessing to the tools of the information platform, always remaining available so that the user can easily change her/his choice. This menu reports the follow link:

- “Home” to return to the landing page and choose another city;
- “GIS dashboard” to obtain the tool to query the cartographic layers (Section 4.2);
- “Construction\Object Sheet” to consult the information on the assets (Section 4.3);
- “Geocatalog” to browse and search metadata and link related to GIS web-services and datasets in HARIS and THIS. This functionality is being developing in Task 4.4 and will be described in Deliverable 4.4 “Knowledge information management system for decision support”, including how services and data can be reached by other systems.

4.2. GIS Dashboard

The GIS dashboards allow users to query and visualise the cartographic layers on built and natural environment, the position of the heritage assets, but also the social-economic information available in the ARCH repository or, directly, through external services.

The main page of the GIS dashboard is reached directly from the landing page of the information systems (Figure 20) as soon as the city was chosen. Once GIS Dashboard tool is loaded, two drop-down menus appear (2 in Figure 23) in order to choose different available products related to HARIS and THIS. In particular, all pages in HARIS have the same structure, as example the map GUI related to the information on the HA (Hamburg in Figure 23) can be divided into three main areas:

- **Map panel** (③ in Figure 23), where the information layer on the map is displayed and, by clicking on the features, the information windows are opened; the map can be navigated using a mouse, however the zoom, orientation and return to the initial view can be managed using the buttons at the bottom right. The map can be enlarged by making the left boxes (④ and ⑤) disappear using the arrow button.



Figure 24: GIS dashboard 3D map of HARIS (example for the case of Hamburg)

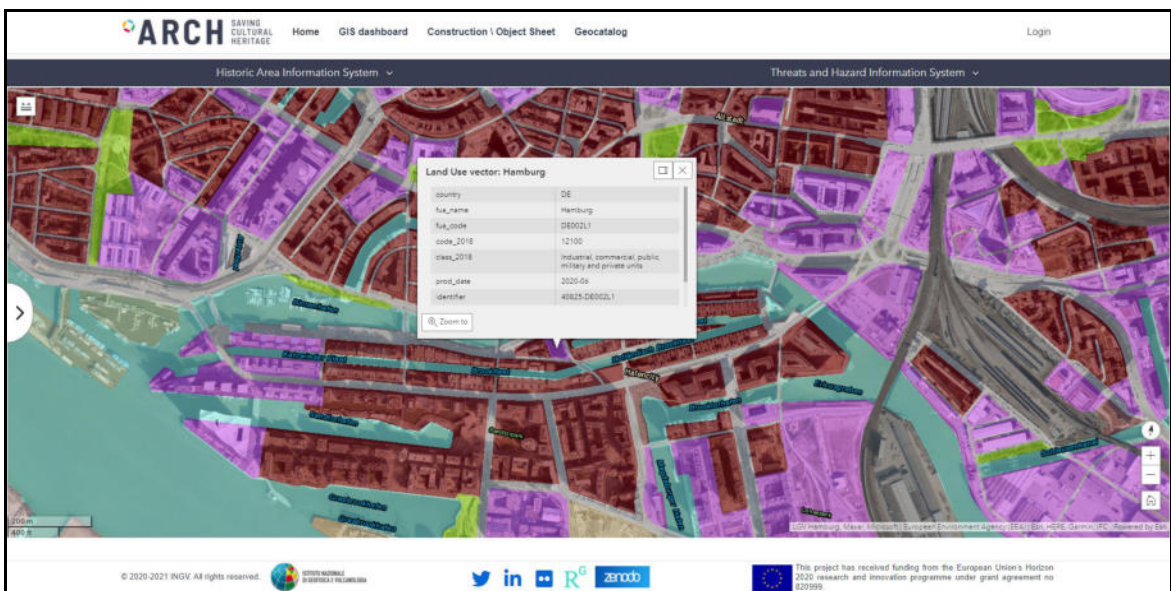


Figure 25: Land Use and Land Cover in HARIS obtained from Copernicus Land Monitoring Services (example for the case of Hamburg).

- **Layers panel** (④ in the Figure 23), where the information layers can be activated (or deactivated) to be displayed (or made to disappear) from the area in the Map Panel

- **Legend panel** (5 in the Figure 23), where information about each active layer is illustrated, this area can be extended with the arrow button to allow the user to have a view of more represented elements.
- **The button to switch on the 3D map** (6 in the Figure 23), with representation of the terrain model and the height of the elements of the cultural heritage (Figure 24) or the whole urban elements, where this information is available.

The other informative maps can be obtained through the drop-down menu (2 in the Figure 23), such as the land use/land cover in the urban area (Figure 25). By clicking on an element of the map opens a popup with the main features and information about it.




4.3. Electronic sheets

The electronic sheets allow user to visualise and update information about constructions and objects in the historic areas. The user can have access to the information stored on the database in two ways:

- by clicking on the feature in the map of the CH assets (Figure 26) and then on details in the pop-up (Figure 27), thus the sheet relating to the element opens up directly in another window (Figure 28).



Figure 26: Electronic sheet of the GIS dashboard for accessing the construction data

- by clicking on "Construction / Object Sheet" on the menu in the header (1 in the Figure 23) the construction list appears (Figure 29), and then the user can select "Objects" (or "Construction") from the menu immediately below. Once the user has chosen what to query, she/he can search for a specific item using the icon  at the top right and filtering by: construction name, address, sheet and parcel. In addition, a specific sheet can be opened through the button  (Figure 29) or, directly, in edit mode using button  (Figure 29). In any case, it is possible to pass in edit mode by clicking the "edit" button directly in the sheet.

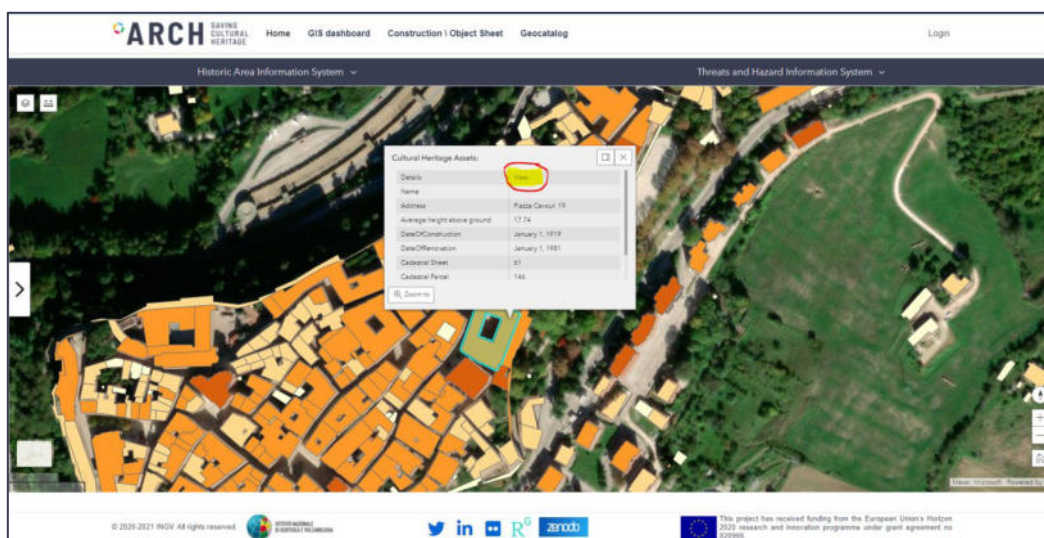


Figure 27: selection of a specific construction in the electronic sheet of the GIS dashboard.

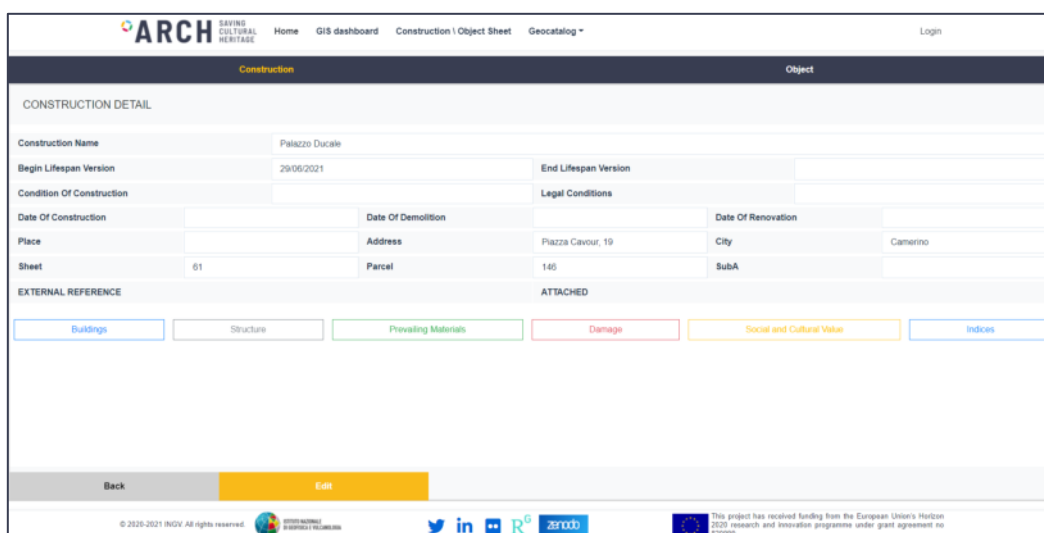


Figure 28: Link to a related sheet when accessing the construction electronic sheet of the GIS dashboard.

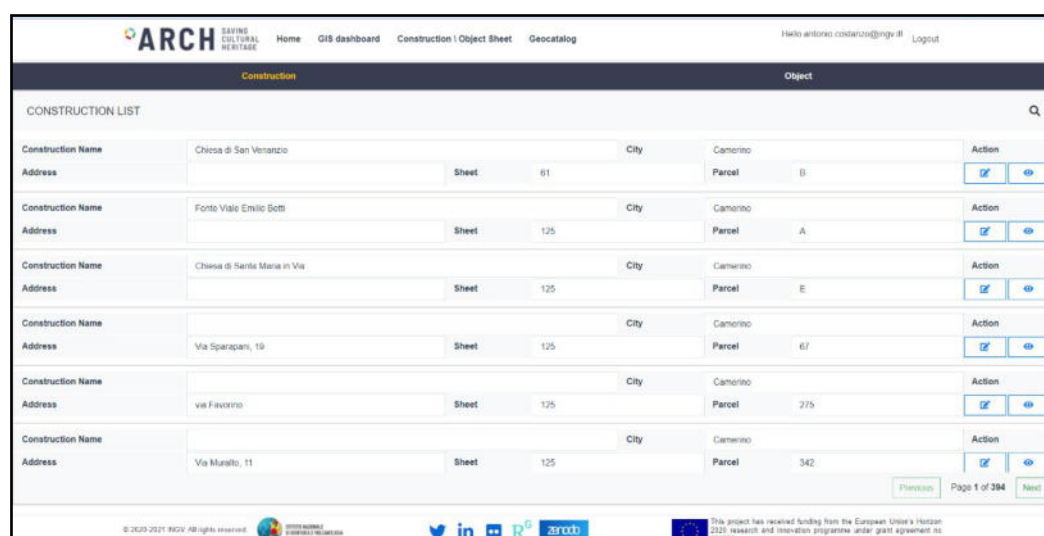


Figure 29: List of the constructions

Figure 30: General view of the electronic construction sheet.

Once a construction electronic sheet is loaded, the overall info can be viewed (Figure 30). The tabs in the lower part of the window can be used to obtain available info about:

- buildings which compose the construction
- the structure and its components
- prevailing materials
- damage framework
- coefficients representing historical, aesthetic, social, religious and recreational value
- Summary indices about the quality of construction materials, social-cultural value and usability classification assigned to the construction

After logging in, the user can operate in edit mode in order to change fields in the tabs of the sheet or include web links and attachments (e.g. pictures, technical drawings, reports) related to the asset (Figure 31). At the end, the same attachments are available to be viewed on the web-browser or downloaded (as the technical drawings in Figure 32).

Figure 31: Edit mode of the electronic construction sheet.

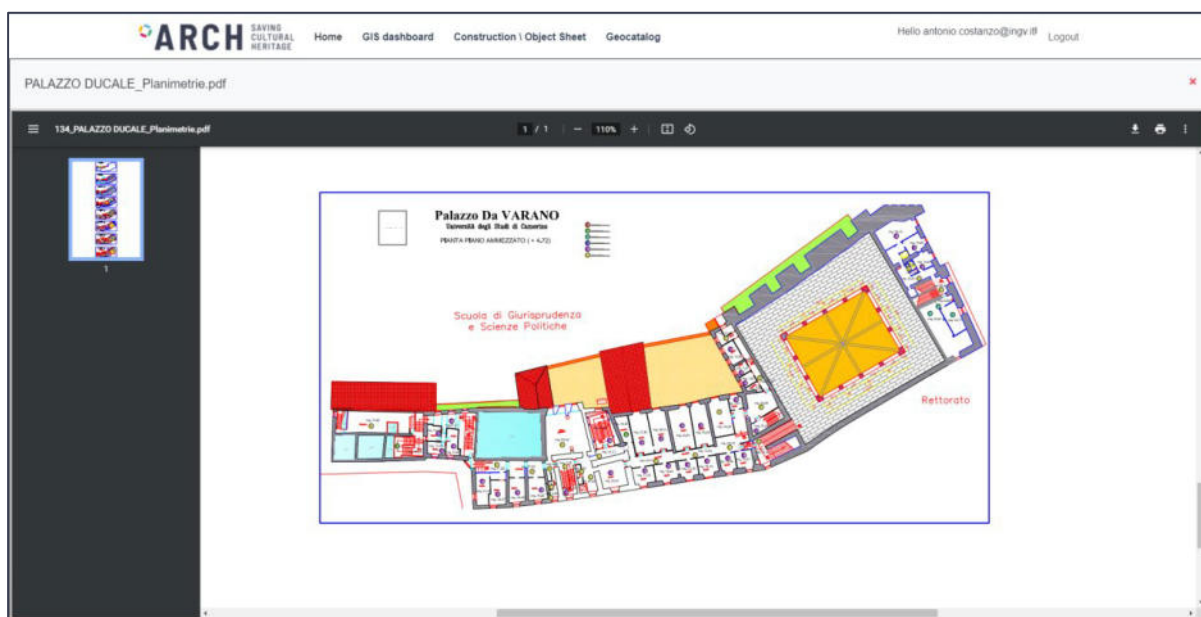


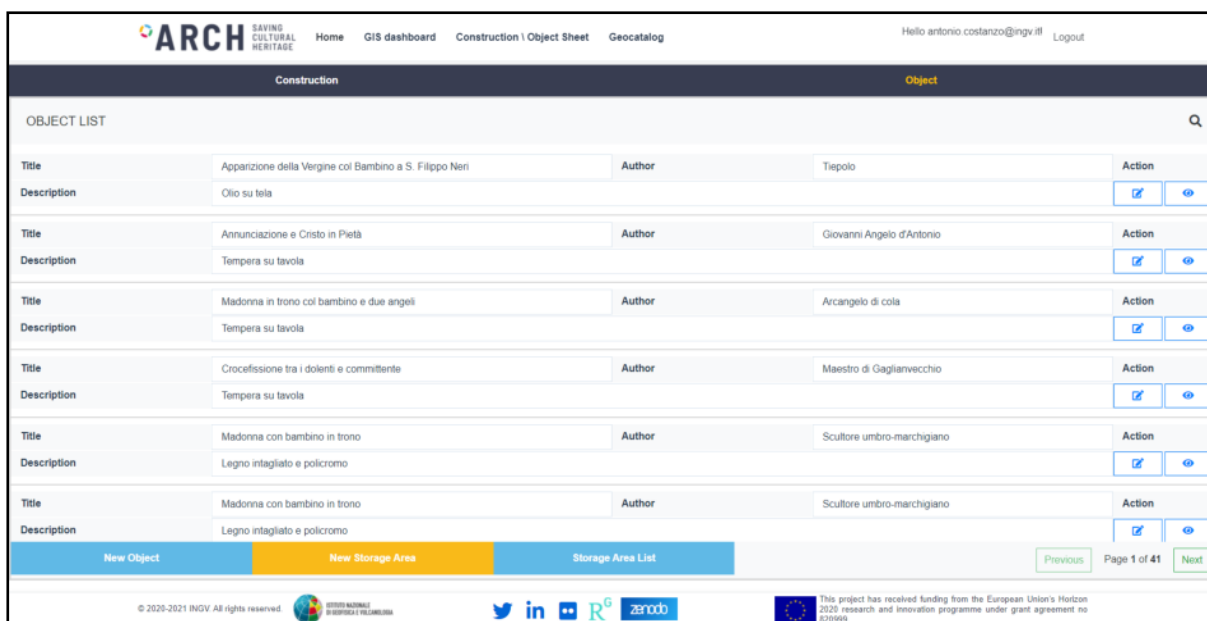














Figure 32: Visualization of an attachment in the electronic construction sheet: view.

Instead, to reach the object list, the user needs to choose “Object” from menu. In this case too, the user clicks the button  (Figure 33) to obtain the information sheet in view mode (Figure 34a) or, directly, button  (Figure 33) to access in edit mode (Figure 34b). It is possible to pass from view mode to the edit mode directly with the button “Edit” (Figure 34a). At this point, it is possible to make changes to the fields or to insert a web link and upload a file. After saving it, the user can obtain the information directly from the sheet (e.g. the picture in Figure 34c). In addition, the logged user can also add a new event (Figure 35a) or a necessary intervention (Figure 35b) related to the specific object, it simply by filling the respective tables.



OBJECT LIST		Author	Action
Title	Apparizione della Vergine col Bambino a S. Filippo Neri	Tiepolo	 
Description	Olio su tela		
Title	Annunciazione e Cristo in Pietà	Giovanni Angelo d'Antonio	 
Description	Tempera su tavola		
Title	Madonna in trono col bambino e due angeli	Arcangelo di cola	 
Description	Tempera su tavola		
Title	Crocefissione tra i dolenti e committente	Maestro di Gaglianvecchio	 
Description	Tempera su tavola		
Title	Madonna con bambino in trono	Scultore umbro-marchigiano	 
Description	Legno intagliato e policromo		
Title	Madonna con bambino in trono	Scultore umbro-marchigiano	 
Description	Legno intagliato e policromo		

At the bottom of the table, there are buttons for 'New Object', 'New Storage Area', and 'Storage Area List'. On the right, there are 'Previous' and 'Next' buttons, and a page indicator 'Page 1 of 41'.

Figure 33: List of the objects for accessing the Electronic Sheet: in view and edit mode.

ARCH SAVING CULTURAL HERITAGE Home GIS dashboard Construction | Object Sheet Geocatalog Hello antonio.costanzo@ingv.it Logout

Construction Object

ARTEFACT DETAIL

Title	Apparizione della Vergine col Bambino a S. Filippo Neri			Author	Tiepolo	Quantity	1
Description	Olio su tela						
Artefact	Dipinto	Disciplinary Sector	Historical-Artistic	Category	Movibile		
Width (cm)		Depth (cm)		Height (cm)		Diameter (cm)	
Storage Area	Chiesa di S. Filippo Neri	Current Storage Sector	Esposizione - Chiesa del Seminario				
Temporary Storage Area	Chiesa del Seminario	Historic Storage Sector	Esposizione - Chiesa del Seminario				
Transfer							
Date	02/11/2016	Officer	Mariconi P.				
Note	Esposizione - Chiesa del Seminario						

EXTERNAL REFERENCE

https://it.wikipedia.org/wiki/Apparizione_della_Vergine_a_san_Filippo_Neri

ATTACHED

Event + Intervention +

Back Edit New

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(a)

ARCH SAVING CULTURAL HERITAGE Home GIS dashboard Construction | Object Sheet Geocatalog Hello antonio.costanzo@ingv.it Logout

Construction Object

NEW OBJECT

Title	Apparizione della Vergine col Bambino a S. Filippo Neri			Author	Tiepolo	Quantity	1
Description	Olio su tela						
Artefact	Dipinto	Disciplinary Sector	Historical-Artistic	Category	Movibile		
Width (cm)		Depth (cm)		Height (cm)		Diameter (cm)	
Storage Area	Chiesa di S. Filippo Neri	Current Storage Sector	Esposizione - Chiesa del Seminario				
Temporary Storage Area	Chiesa del Seminario	Historic Storage Sector	Esposizione - Chiesa del Seminario				
Transfer							
Date	02/11/2016	Officer	Mariconi P.				
Note	Esposizione - Chiesa del Seminario						

EXTERNAL REFERENCE +

https://it.wikipedia.org/wiki/Apparizione_della_Vergine_a_san_Filippo_Neri

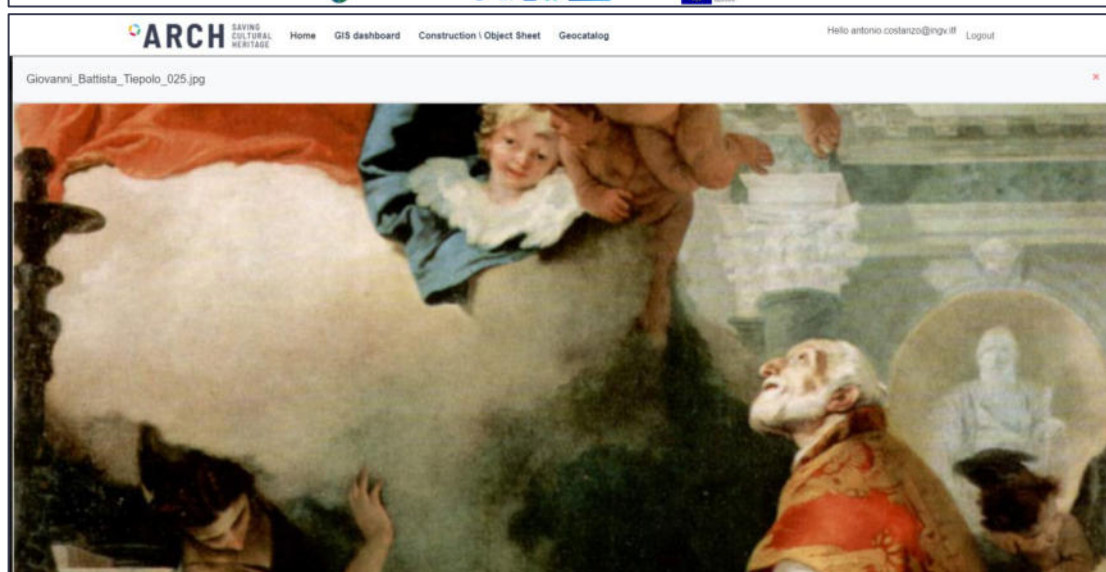
ATTACHED

Upload new file [Scegli file] Giovanni_Bat_tiepolo_025.jpg

Cancel Save

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(b)



(c)

Figure 34: Object Electronic Sheet: view (a) and edit mode (b), and visualization of an attachment (c).

NEW EVENT

Purpose:

Description:

Date Start: Date End:

External Responsible: Internal Responsible:

ATTACHED

Upload new File:

NEW INTERVENTION

Description:

Rating: Urgency:

Evaluation Date: Responsible:

Date Start: Date End:

Upload new File:

(a)
(b)

Figure 35: Object Electronic Sheet: windows to include a new event (a) and a necessary intervention (b).

Using links, which are shown at the bottom of the object list (Figure 33), the user can also:

- insert a new object filling the table in Figure 34
- consult the list of the storage areas (Figure 36a)
- Insert a new storage area (Figure 36b) to be linked as container or shelter to the objects

ARCH SAVING CULTURAL HERITAGE

Home GIS dashboard Construction \ Object Sheet Geocatalog

Hello antonio.costanzo@ingv.it Logout

Construction
Object

STORAGE AREA LIST

Name	City	Construction	Shelter	No	Action
Chiesa dei SS. Gregorio e Valentino	Caldarola	Construction	No		✎ 👁
Chiesa di S. Cristoforo	Camerino	Construction	No		✎ 👁
Chiesa di S. Andrea	Camerino	Construction	No		✎ 👁
Chiesa della S.ma Annunziata	Camerino	Construction	No		✎ 👁
Chiesa di S. Filippo Neri	Camerino	Construction	No		✎ 👁

Previous Page 1 of 6 Next

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Home GIS dashboard Construction \ Object Sheet Geocatalog

Hello antonio.costanzo@ingv.it Logout

Construction
Object

STORAGE AREA

Name: Shelter:

Latitude: Longitude:

City: Construction:

EXTERNAL REFERENCE:

ATTACHED

Upload new File:

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(a)
(b)

Figure 36: List of the storage areas (a) and table to insert a new one (b).

4.4. 3D viewer

The 3D viewer is a specific web application to visualise point clouds and meshes related to the cultural heritage object, in order to have a realistic view in three-dimensional space. In addition this tool can be used as support to extract specific information or to make measurements directly on the constructions and objects, which can be queried in 3D mode. This viewer will allow managing models also supporting any further analyses in the next tasks of the project.

In the electronic sheet, the icon  appears if a 3D model is available for the element (cf. Figure 37). Once the user clicks on the icon, the viewer opens the model in a new window depending on whether it is a point cloud or a mesh.

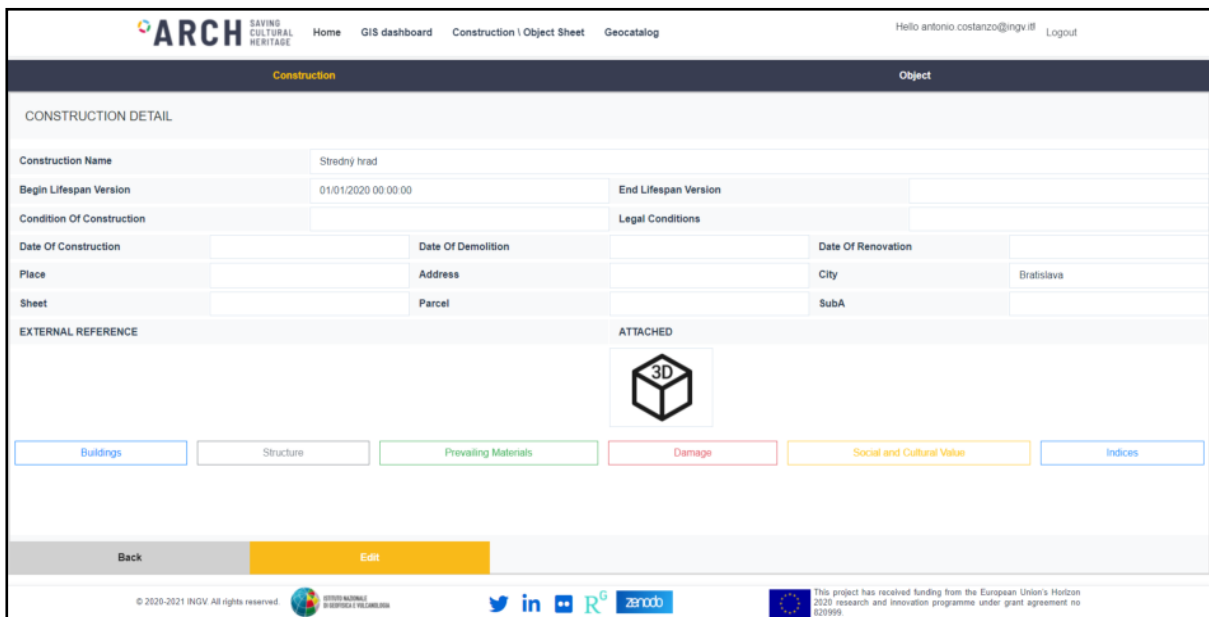


Figure 37: Electronic Sheet of a construction with a related point cloud

The point clouds allow obtaining very dense information – although discontinuous - so a high resolution can be obtained and details can be identified (e.g. crack in the masonry façade or imperfections in the plaster of the paintings); in this case the view is based on the Potree open-source Web-based Graphics Library¹². The user is enabled to manage the model, navigate and make measures (Figure 38) through the menu in the upper left part of the window. Moreover, another viewer already developed in the PON MASSIMO project¹³ (Figure 39), based on the Babylon.js¹⁴ library, has been improved and integrated into this tool of the information system, in order to manage also the representation of objects by means of meshes. It allows to navigate continuous models with the possibility to turn on/off the different parts and to include markers to which specific information can be linked.

¹² <https://github.com/potree/potree>

¹³ <https://ponmassimo.rm.ingv.it/portal/>

¹⁴ <https://www.babylonjs.com/>

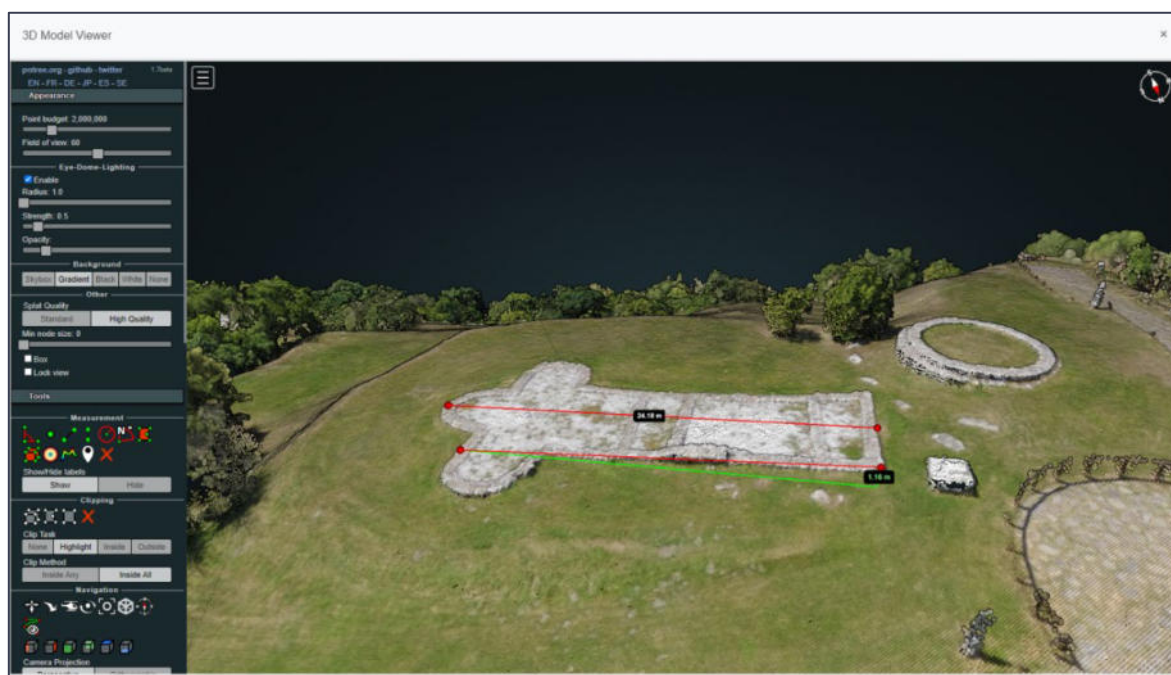


Figure 38: 3Dviewer for point clouds.

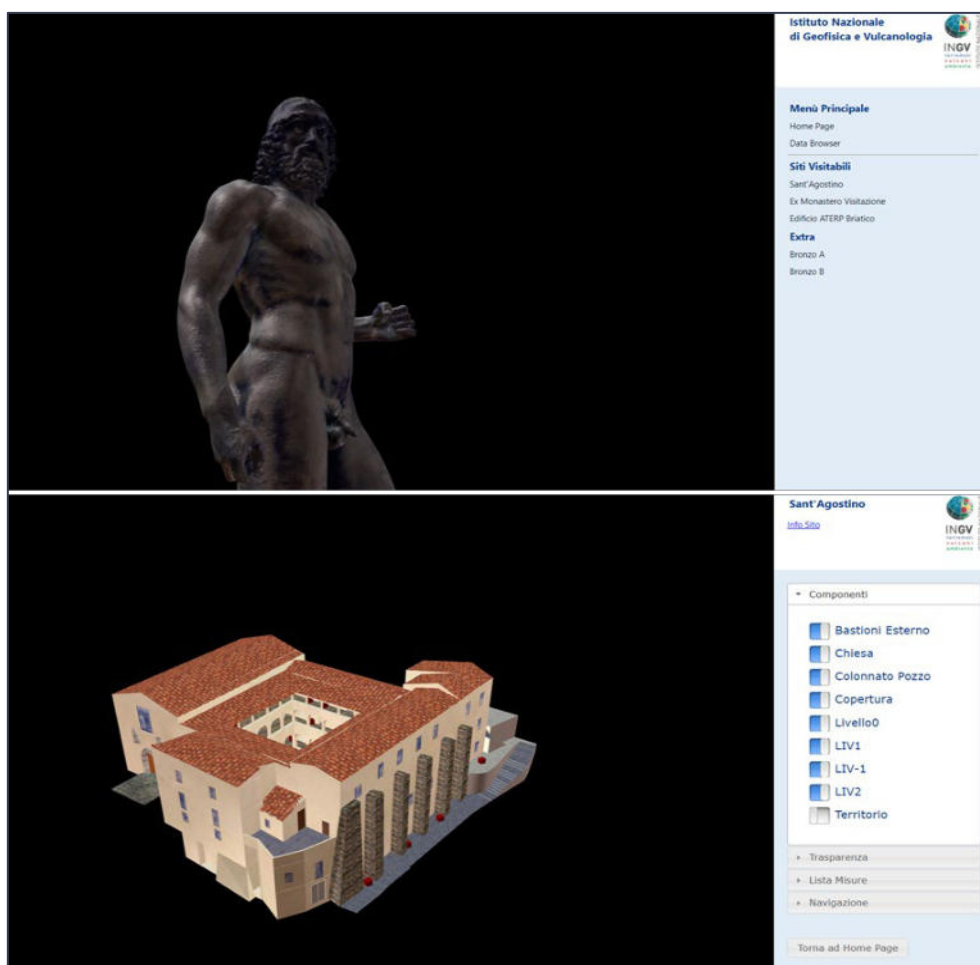


Figure 39: 3Dviewer for meshes developed in PON MASSIMO (after [25]) and included in the ARCH platform.