OUTPUT T3.3

Title Developing and harmonising digital infrastructure solutions

Final version
06/2022

Part 1: Mobile-based digital infrastructure – the Living Danube Limes App

Part 2: Web-based digital infrastructure – the Living Danube Limes Database

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Project ID DTP3-359-2.2

A stream of cooperation

Contents

1. Introduction

The paper summarises the activities to develop common digital infrastructure of the Living Danube Limes project to increase visibility and dissemination of the information to the broad public. During the third and fourth period of the project the digital infrastructure, meaning the application for mobile phones and web-based version were developed. These were harmonised by using common database with all stored information.

2. Mobile-based digital infrastructure – the Living Danube Limes App

2.1. Definition of the app and its basic features of the app

The aim of the app is to present archaeological sites of Roman fortifications and settlements in the Danube region, with its relations to the museal clusters. The app is publishing remnants and found artefacts of Roman civilisation on the territory of 10 countries by the form of texts, images, interactive 3D models and virtual reality reconstructions. By this virtual presentation the touristic attractivity of these significant and fascinating places will be increased together with public cultural and historical knowledge about the Roman empire in the Danube region.

The data from 8 pilot archaeological sites and around 371 secondary sites were gathered by the online form till the publication of the application. These data are still possible to update and widen with additional sites as the application is connected to the structured database with its online interface with forms – content management system.

Application presents these locations on the interactive map, which is a basic motive of its user interface.

Main functionalities of the application

Interactive map	Shows the location and basic information of archaeological sites and museums.
Language localisation	The primary language of the app is English. The sites' texts and historical texts and terms explanations are also in the local languages of each project's country.
Presented data	The information are presented by various data formats as texts, images, videos, 3D models and VR reconstructions stored in one database.
VR reconstructions	The app contains VR reconstructions of 8 pilot sites.
Device compatibility	The app is compatible with Android and iOS smartphones, and it is downloadable through app stores of those platforms.
Communication and website implementation	The app accessibility is communicated by the related one-paged website on livingdanubelimes.eu with links to the app stores and interactive map with basic information to each archaeological site.
App sustainability	The app is sustained 5 years after the project. The domain livingdanubelimes.eu is ensured for 10 years.

	Its sustainability is enabled by the easy-to-use content management system, stable hosting solution and continual updates.

2.2. Interactive map and user interface

The user interface is based on the interactive map built on OpenStreetMap with Mapbox API. On the graphically customed map, the locations of archaeological sites and ship are displayed by the specific icons.
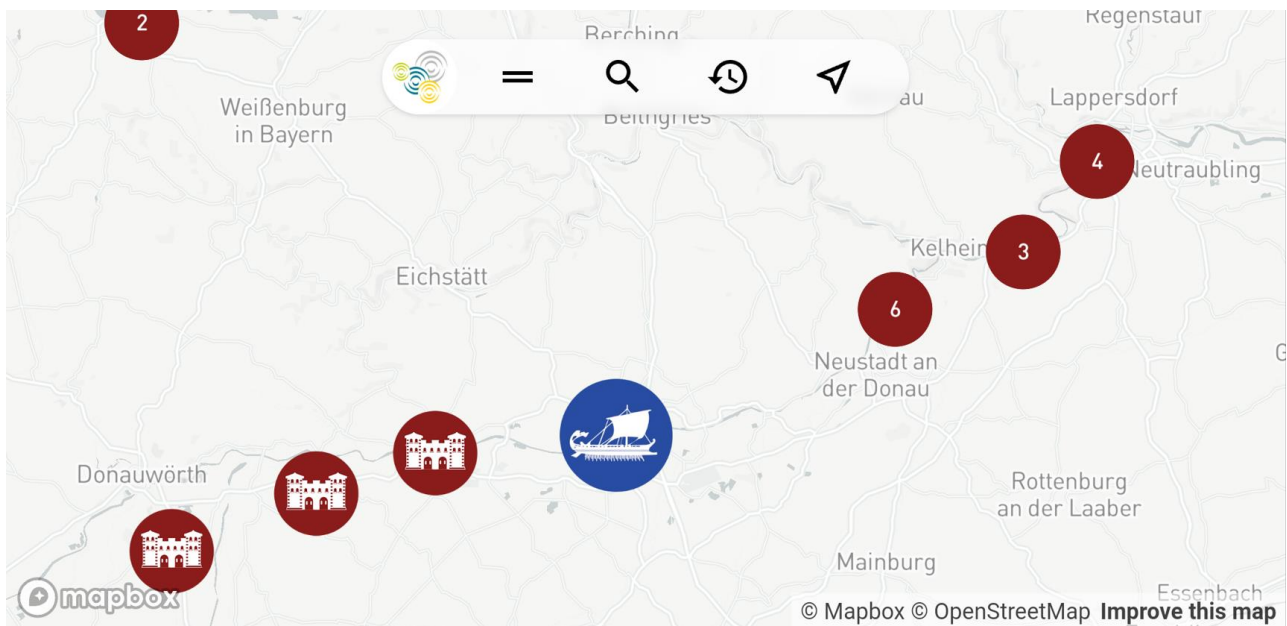
Interface of the app with interactive map and top bar. Source: Authors

The map is zoomable to show different details. The points with numbers are grouped sites, the number indicates the number of sites hiding in the group. As the user is zooming the map the clusters of sites are exploded showing the individual sites. The app is displaying different type of each site by 9 different icons for castell, city, legionary fortress, road, vicus, watchtower, wooden fort, or question mark for not identified type of the site. The ship is displayed by the icon of the ship.

Zooming of the map - the clusters of sites are exploded showing the individual sites by different icons. Source: Authors

In the top of the interface the bar with few icons is displayed. The icon with two lines represents the so-called hamburger menu for mobile phones with Information about the project, Historical Information, Project Websites, ability for Scanning the QR codes on sites for VR reconstructions and downloading the offline data for visiting sites without the connection.


The hamburger menu in the top interface bar and Historical information texts

Source: Authors, PLUS

The second icon in the top interface bar is a magnifier, which is for searching for specific site by its name.

The third icon in the bar - the clock is the icon for choosing the time period. The archaeological sites are displayed in layers according to the Roman Limes historical periods in years. It is possible to change the currently displayed year period to show the Roman Limes development and changes by appearing and disappearing of the icons according to the chosen period.
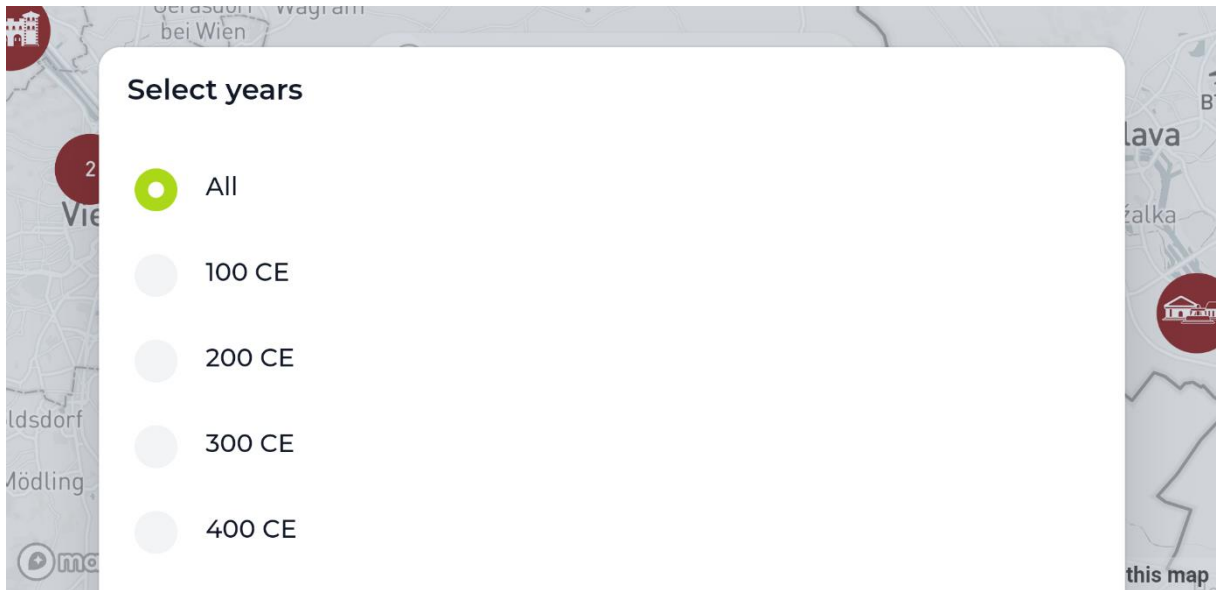
By tapping the icon of the clock, the window for choosing of the year period is opened.
Source: Authors

The last icon of Arrow in the top interface bar is the button for locating the user on the map by GPS localisation.

By touching the icon of the object on the map, the basic information with the title image is displayed with another optional data available as Basic information, media Gallery, Archaeological remains, Remarks and Virtual reconstructions. Each item is possible to open, containing its related media.
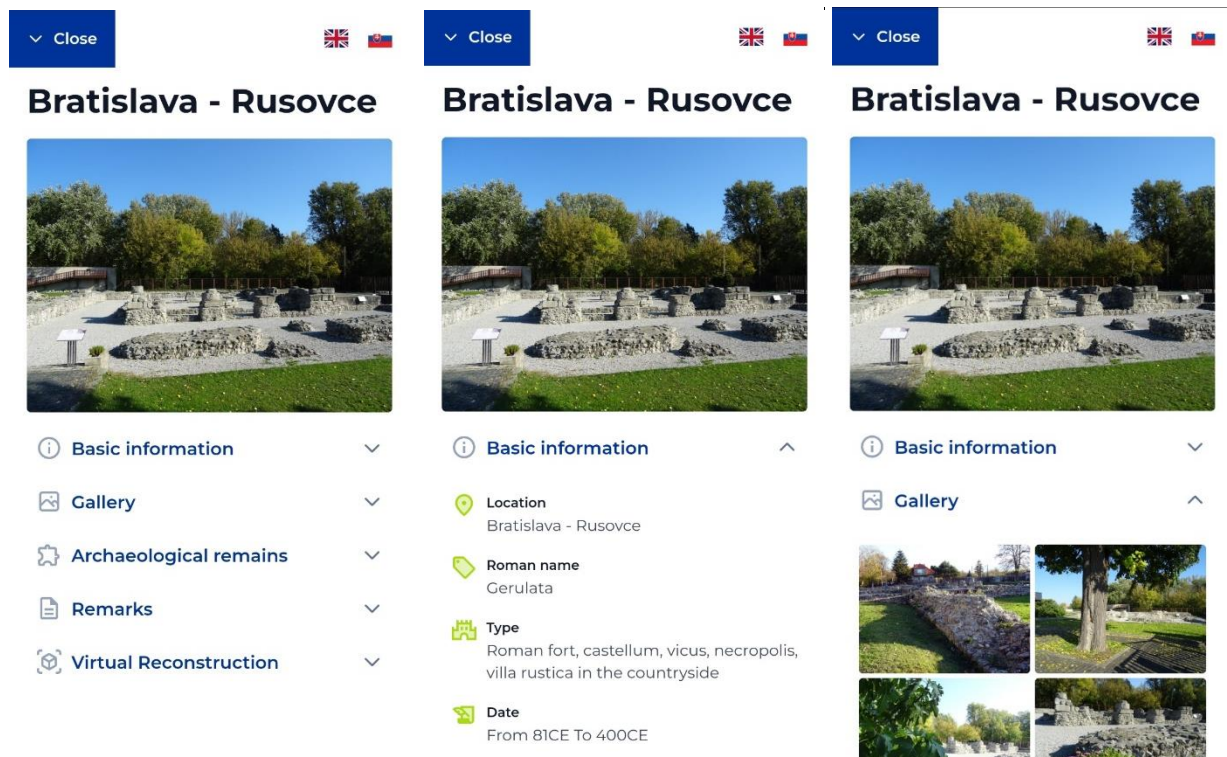
Tapping on the icon of the object on the map will display menu with additional information and media. Source: Authors

The map is using GPS localisation to show the current location of the user and will display also the location of the ship Danuvina Alacris on her cruise across the Danube.

Main functions of the map:

Customed interface	Customed interface built on OpenStreetMap and Mapbox API, displaying objects by specific icons.
Zooming	Shows different details of the archaeological sites according to the current zoom.
Historical periods	Present development and changes by appearing and disappearing of the icons according to the chosen period.
Display basic info	Touching the icon will display basic info and another optional media to examine.
GPS localisation	Shows the current location of the user and the ship

2.3. Language localisation

The primary language for the app is English. Selected information (Information of archaeological sites, Historical information & important terms) are in local national languages of the countries participating in the project. The media and virtual reconstructions are in English. Each partner provided the data of the sites in English and his national language. The language is possible to change by tapping on the icon of specific flag in upper right corner of the screen.
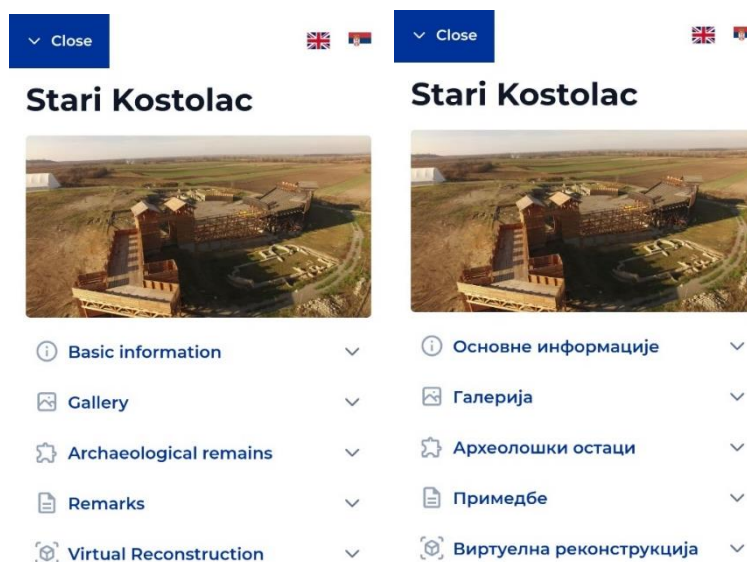
Menu with basic information about the site in English and local – Serbian language. Source: Authors

English	Primary language for the app
Partners' national languages	Archaeological site information, Historical information & important terms

2.4. Presented data

As the app presents various data in various media, the data are stored in the structured database, collected by all the partners of the project. The app is loading the data from this database online, which ensures that data can be updated or added later by the partners with content management system.

The app is displaying the information about the project, historical information and terms, and important links to the project websites. However, the main part of the presentation are data related to the archaeological sites and their museums.

These data are structured to basic information of archaeological sites, remains of the Roman objects on the sites, the image gallery, remarks and VR reconstructions.

The Basic Information represent structured textual data gathered about the site and information relevant to tourists as Location, Roman name, Type of the site, Dating, List of remains, Today's coverage, Museum with its link, Connection to the modern infrastructure.

Structured basic information about the site. Source: Authors, DUK
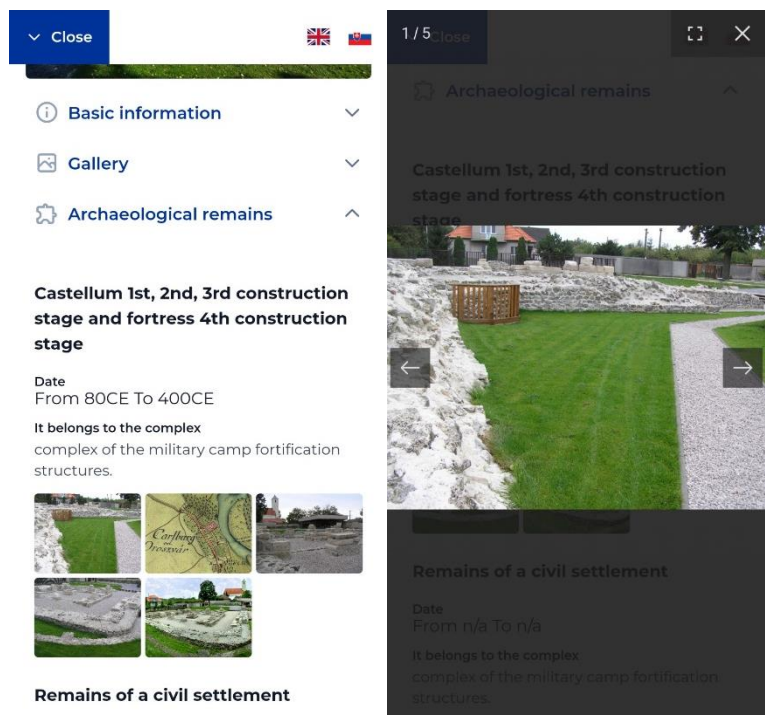
Gallery of media is displaying the images of the site in the intuitive image viewer with abilities to browse the images or zooming them.

Image gallery and browsing the images. Source: Authors

Under the menu item Gallery the item Archaeological remains is placed. This item provides information about the individual objects found on the site with its dating and images.


Left: Information to the specific remains on the site with objects' images. Right: Browsing the specific object's images. Source: Authors

Next item in the Site's menu are Remarks, which is a short textual description of the site provided by partners.

The last item in the list are Virtual reconstructions, which is currently available only for the pilot sites, but it can be enabled to other sites, when their models or virtual tours will be provided.

There are two types of VR reconstructions available through the app. When the site has a large-scale virtual reconstruction (e.g. whole fort), the virtual reconstruction is presented as a virtual tour with spots made of spherical panoramas. The visitor can teleport between those spots and examine the virtual site. The second type of presentation was dedicated rather for small-scale objects found on the site. These objects are presented as zoomable and rotatable 3D objects within the app. The specific VR reconstruction could be also opened by the scanning of the QR code located on the site by the menu item Scan QR code in the main hamburger menu of the app.
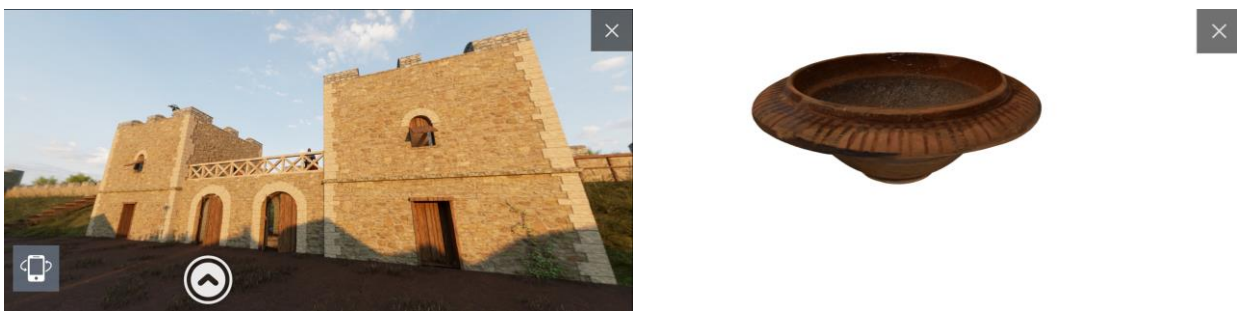
Left: Virtual reconstruction of Lederata site within the app. Right: Presentation of small finds from Zeiselmauer. Source: Authors

A different information is displayed after tapping the icon of the ship. This information contains name of the ship, title image, short description, type of boat, number of rowing crew members, length, height of mast, material the ship is from, construction methods, number of members in the leadership team, normal speed, maximum speed and relink to the site of the ship on the official project website. The ship has its own Gallery with images.

Except the currently presented data, relevant mainly to the visitors and tourists, the additional data, relevant rather for archaeology experts were gathered and stored in the database through the online forms and are still possible to gather by content management system. These data are explorable and editable by web-based solution. According to the needs, these data can be also loaded to the app by the further updates.

Another currently hidden field in the site´s menu are events happening on the site. This field contain name of the event, date of the event and title image of the event. These sites´ events will be displayed when the required data will be updated in the database.

Updates of data and the sites´ events are base for the push notification system which will be available in the planned update of the app.

Presented data briefly

About the project	Basic information about the project
Historical information	Historical modules provided by the partners, available also in 7 national languages of participating countries

Project websites	Links to the official project website, social media websites and links to the app stores.
Archaeological site data	Available by tapping the site´s icon
Basic information about the site	Name of the site Location Roman name of the site Type of the site Dating List of remains Today's coverage Museum with its link Connection to the modern infrastructure
Gallery of each site	Media gallery containing images with image browser
Archaeological remains of each site	Name of the remain Dating of the remain Belonging to complex Images of the remain with image browser
Remarks of each site	Textual description about the site
Virtual reconstructions of pilot sites	Virtual reconstruction of the site as virtual tour of the site or 3D models of the found objects
Events happening on the site	Name of the event Title image of the event Dating of the event
Data about the ship	Name of the ship Title image Short description Type of boat Number of rowing crew members Length Height of mast Material of the ship Construction methods Number of members in the leadership team Normal speed Maximum speed Link to the site of the ship on the official project website
Gallery of ship´s images	Media gallery containing images with image browser

2.5. Data collecting and data hosting

Data were formerly collected by Google form and were stored in the structured Google Drive and by Excel sheets. These data were imported to the structured database, editable by online forms. The purpose of this content management system is to add and edit existing content easier by project partners. Nevertheless, the app is downloading these data online, it has also

the ability to download the partial data for the offline use on the locations without the connection.

2.6. Device compatibility

The app is compatible with Android and iOS smartphones, and it is downloadable through the app stores of those platforms.

2.7. Communication and website implementation

The app accessibility is communicated by the web-based solution with interface similar to the app's interface with its map interface and links to the app stores.

2.8. App sustainability

The app will be sustained at least 5 years after the project. Its sustainability is ensured by the easy-to-use web-based content management system for updating the content, stable hosting solution and push-notification system informing users about updates of the content and new events on the sites.

2.9. Links

IOS App Store:

https://apps.apple.com/sk/app/living-danube-limes/id1630798794

Google Play:

https://play.google.com/store/apps/details?id=io.ldl.symbios&gl=SK

3. Web-based digital infrastructure – the Living Danube Limes Database

3.1. Definition of the web-based digital infrastructure

The aim of the web-based digital infrastructure is to connect partners of all 10 participating countries by the common online system for gathering, sharing, editing, and publishing the database of archaeological sites of Roman fortifications and settlements in the Danube region, with their relations to the museal clusters.

The second but also very significant aim is to present these data and Living Danube Limes app through the website for the wide public in the form of map, texts, and images. By this online presentation the touristic attractivity of these significant and fascinating places will be increased together with public cultural and historical knowledge about the Roman empire in the Danube region.

The data from 8 pilot archaeological sites and around 371 secondary sites were gathered to the database. This database is still possible to update and widen with its online interface with easy-to-use forms – content management system. The database is directly connected to the Living Danube Limes app and publicly visible website.

The web-based digital infrastructure therefore consists of two parts:

The interface for wide public, which is very similar to the interface of the app for smartphones, based on the interactive map with all gathered locations.

The second interface is accessible through the login screen and it is dedicated for participating institutions in the project for adding, sharing and editing the content of the database.

Main functionalities of the web-based infrastructure

Interface for wide public	
Interactive map	Shows the location and basic information of archaeological sites and museums.
Language localisation	The primary language of the website for public is English. The archaeological sites' texts and historical texts and terms explanations are also in the local languages of each project's country.
Presented data	The information are presented as texts, images and links to other websites and app stores.
Device compatibility	The website is compatible with wide range of devices and is openable in the standard widely used browsers.
Interface for institutions participating in the project	
Login screen	Access is possible with e-mail account and password
Adding and modifying the content of the database	By online forms
Viewing and sharing content between the participating institutions	Online forms with filled data are viewable or editable by all participants according to the policy of editing rights
Web-based infrastructure sustainability	The website is sustained 5 years after the project. The domain livingdanubelimes.eu is ensured for 10 years. Its sustainability is enabled by the easy-to-use content management system and stable hosting solution.

3.2. Interface for wide public

The publicly accessible interface is running on the domain livingdanubelimes.eu and it is based on the interactive map built on OpenStreetMap with Mapbox API. On the graphically customed map, the locations of archaeological sites and ship are displayed by the specific icons.
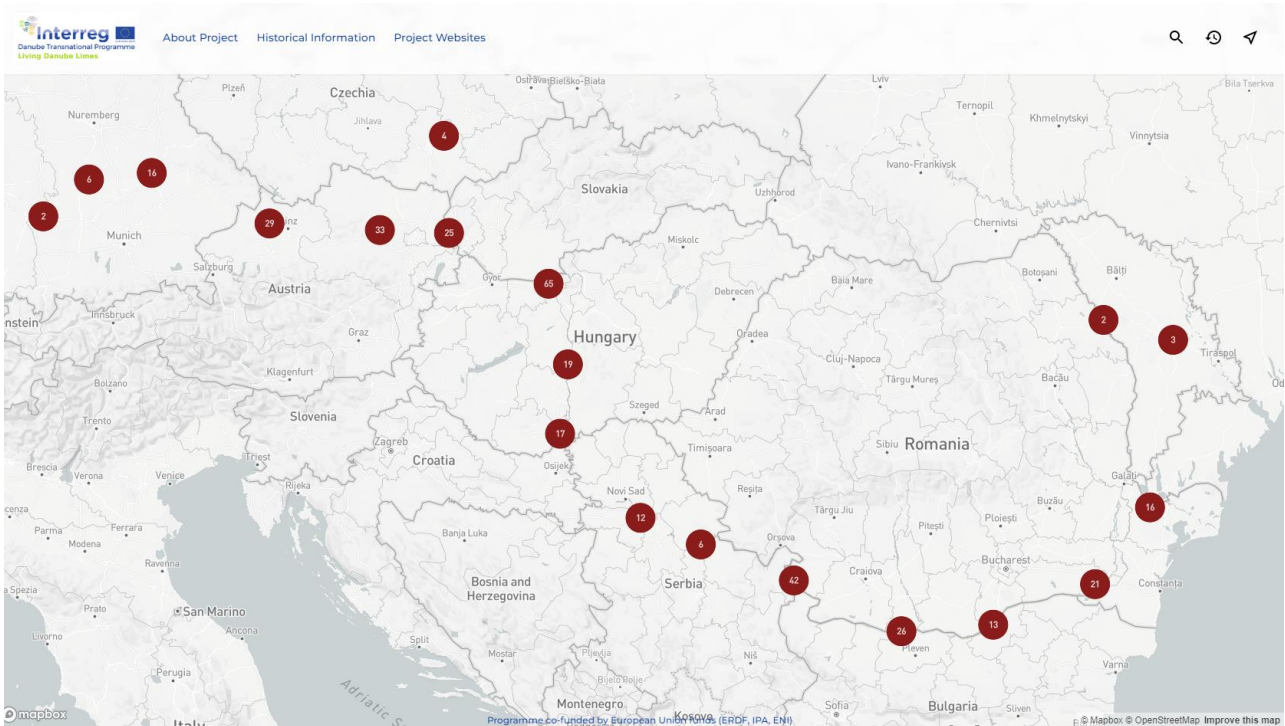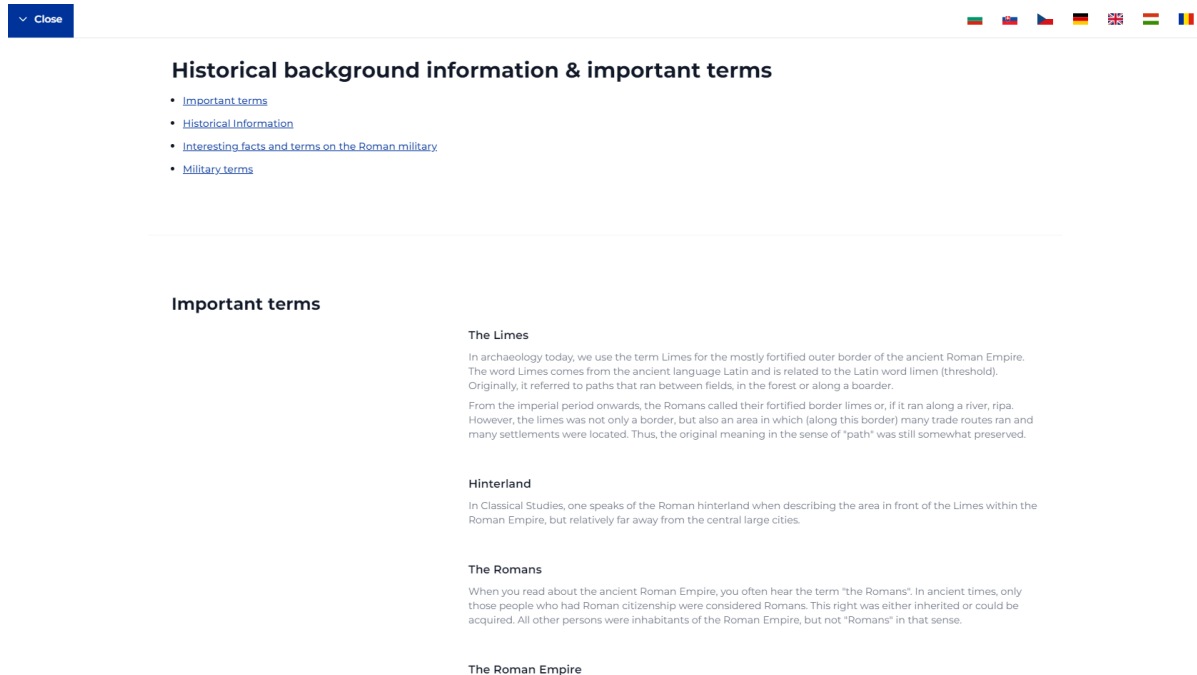
Interface of the website accessible by wide public. Interface is made of interactive map and bar placed at top of the screen. Source: Authors

The map is zoomable to show different details. The points with numbers are grouped sites, the number indicates the number of sites hiding in the group. As the user is zooming the map the clusters of sites are exploded showing the individual sites. The website is displaying different type of each site by 9 different icons for castell, city, legionary fortress, road, vicus, watchtower, wooden fort, or question mark for not identified type of the site. The ship is displayed by the blue icon of the ship.
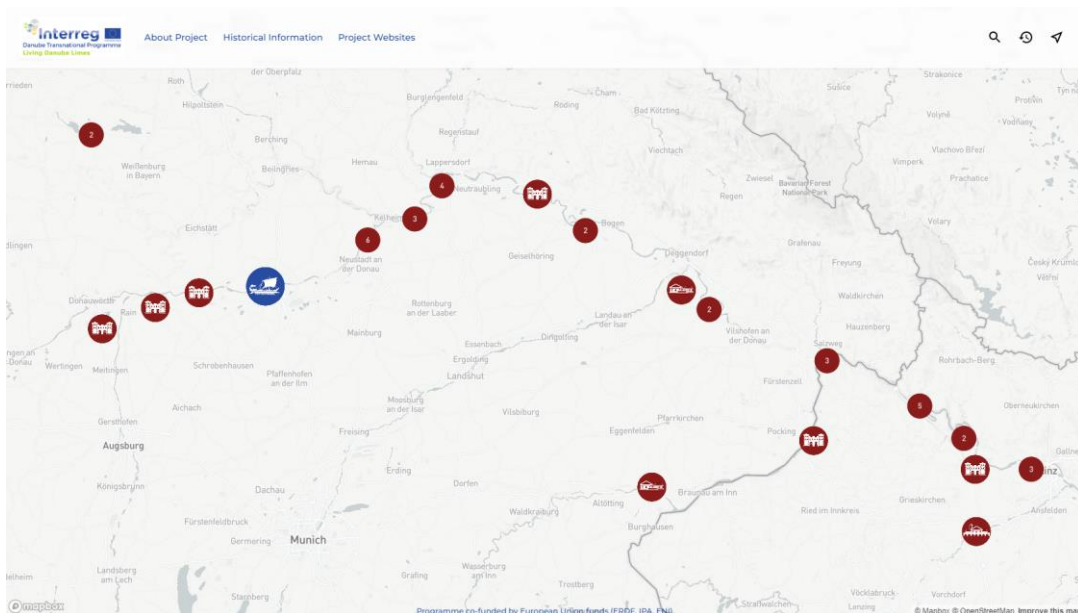
Zooming of the map - the clusters of sites are exploded showing the individual sites by different icons. Source: Authors

In the top of the interface the bar with menu and few icons in the right is displayed. The menu contains Information about the project, Historical Information and Project Websites including the links to the app stores for downloading and installing the Living Danube Limes app.

Historical information texts with bar interface on the top with flags for switching the language and close button. Source: Authors, PLUS

The first from the right icons in the top interface bar is a magnifier, which is for searching for specific site by its name.

The second icon in the bar - the clock is the icon for choosing the time period. The archaeological sites are displayed in layers according to the Roman Limes historical periods in years. It is possible to change the currently displayed year period to show the Roman Limes development and changes by appearing and disappearing of the icons according to the chosen period.
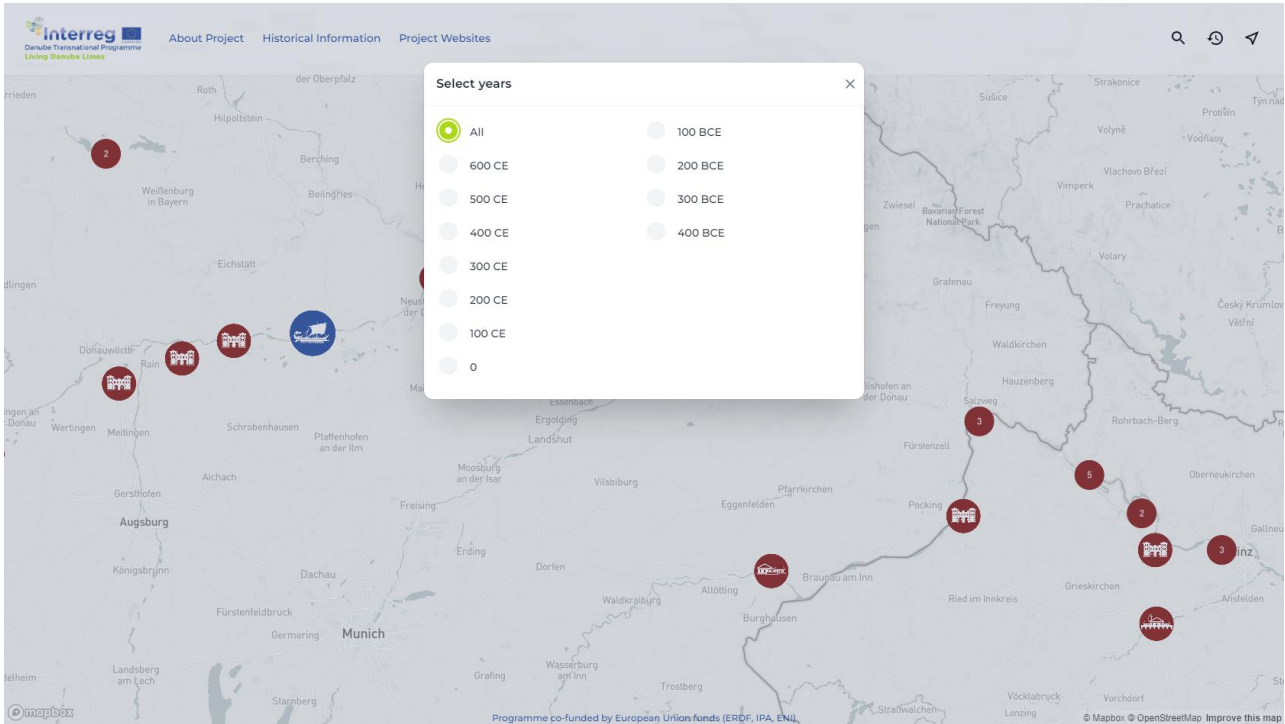
By clicking the icon of the clock, the window for choosing of the year period is opened.
Source: Authors

By clicking the icon of the object on the map, the basic information with the title image is displayed with another optional data available as Basic information, media Gallery, Archaeological remains, Remarks and Virtual reconstructions. Each item is possible to open, containing its related media.
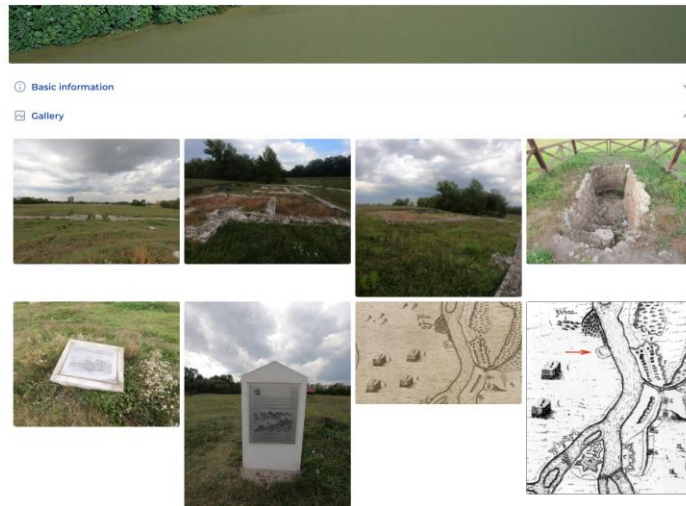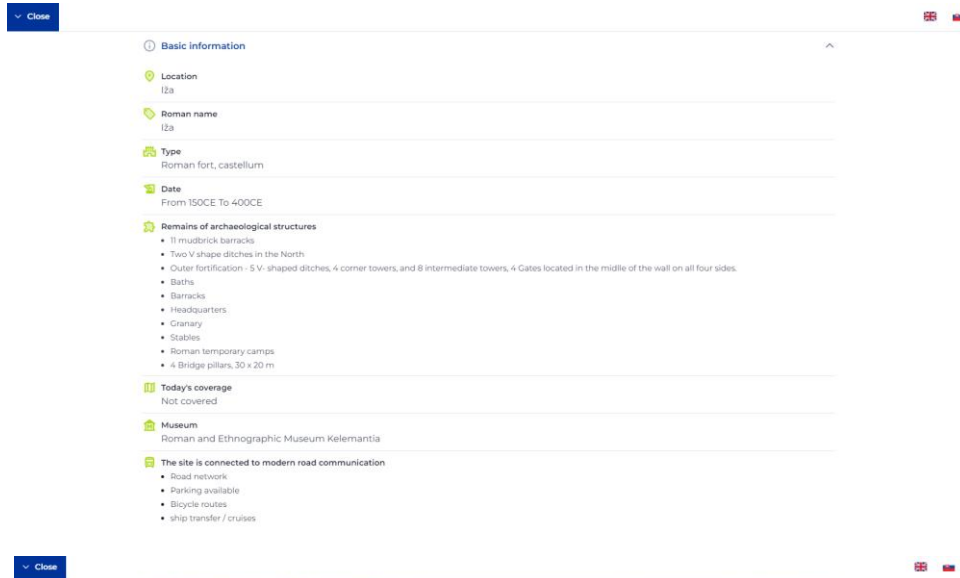
Clicking on the icon of the object on the map will display menu with additional information and media. Source: Authors

Main functions of the map:

Customed interface	Customed interface built on OpenStreetMap and Mapbox API, displaying objects by specific icons.
Zooming	Shows different details of the archaeological sites according to the current zoom.
Historical periods	Present development and changes by appearing and disappearing of the icons according to the chosen period.
Display basic info	Clicking the icon will display basic info and another optional media to examine.

Language localisation of the publicly accessible website

The primary language for the website is English. Selected information (Information of archaeological sites, Historical information & important terms) are in local national languages

of the countries participating in the project. The media and virtual reconstructions are in English. Each partner provided the data of the sites in English and his national language. The language is possible to change by clicking on the icon of specific flag in upper right corner of the screen.
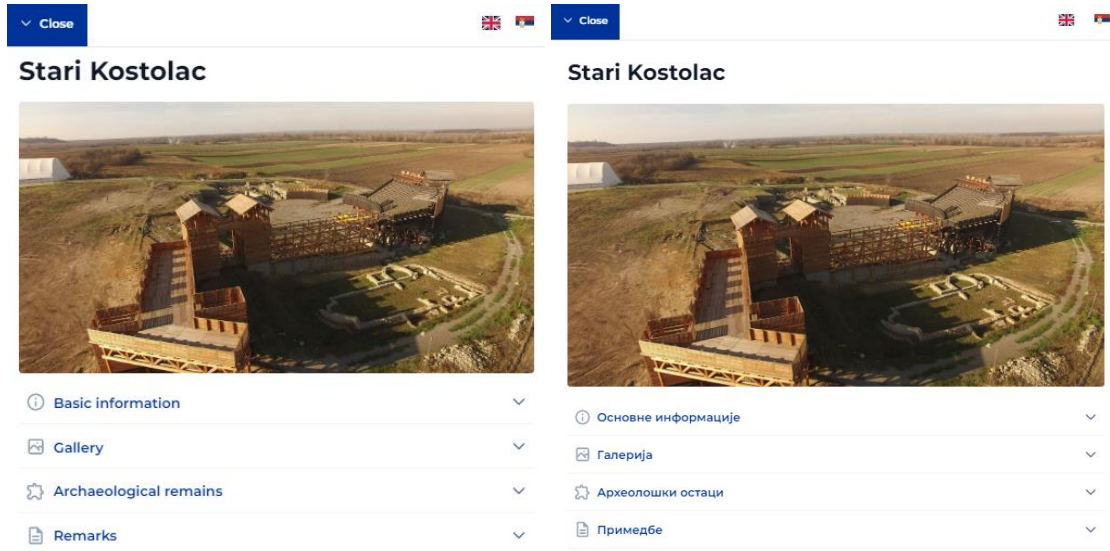
Menu with basic information about the site in English and local – Serbian language. Source: Authors

English	Primary language for the app
Partners' national languages	Archaeological site information, Historical information & important terms

Presented data to the public

As the website presents various data in various media, the data are stored in the structured database, collected by all the partners of the project. The website is loading the specific data from this database online.

The website is displaying the information about the project, historical information and terms, and important links to the project websites, social networks and mainly the links to application stores to download the Living Danube Limes App. However, the main part of the presentation are data related to the archaeological sites and their museums.

These data are structured to basic information of archaeological sites, remains of the Roman objects on the sites, the image gallery, remarks and VR reconstructions.

The Basic Information represent structured textual data gathered about the site and information relevant to tourists as Location, Roman name, Type of the site, Dating, List of remains, Today's coverage, Museum with its link, Connection to the modern infrastructure.
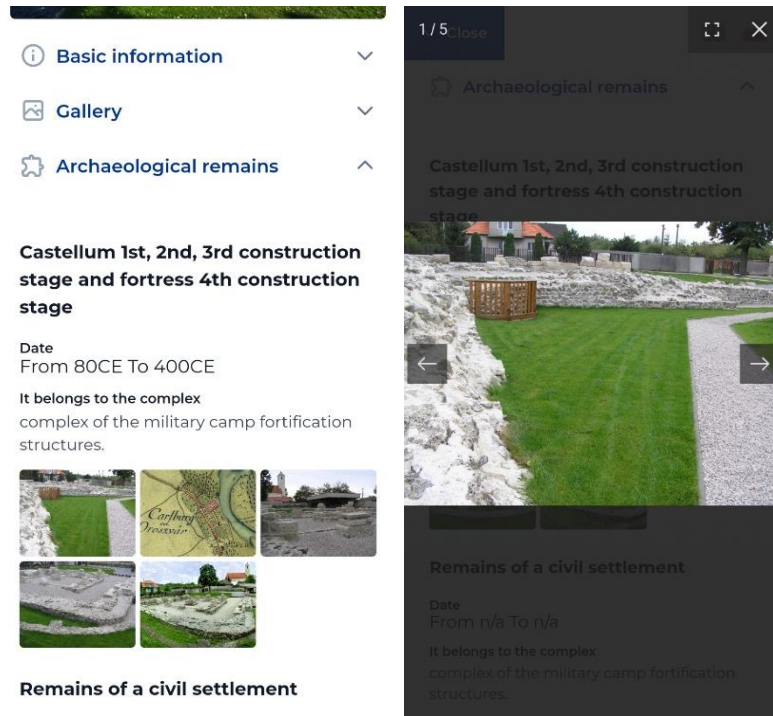
Structured basic information about the site. Source: Authors, DUK

Gallery of media is displaying the images of the site in the intuitive image viewer with abilities to browse the images or zooming them.

*Image gallery and browsing the images. Source: Authors*

Under the menu item Gallery, the item Archaeological remains is placed. This item provides information about the individual objects found on the site with its dating and images.

Left: Information to the specific remains on the site with objects' images. Right: Browsing the specific object's images. Source: Authors

The last item in the Site's menu are Remarks, which is a short textual description of the site provided by partners.

A different information is displayed after clicking the icon of the ship. This information contains name of the ship, title image, short description, type of boat, number of rowing crew members, length, height of mast, material the ship is from, construction methods, number of members in the leadership team, normal speed, maximum speed and relink to the site of the ship on the official project website. The ship has its own Gallery with images.
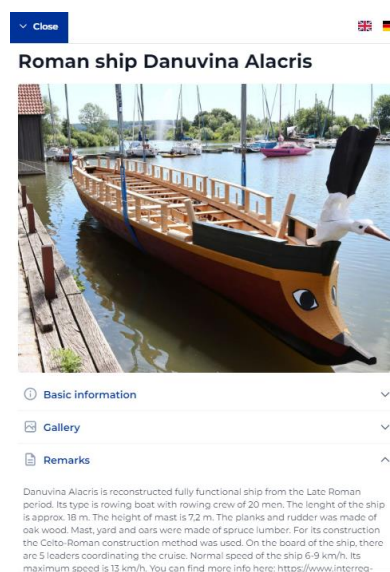
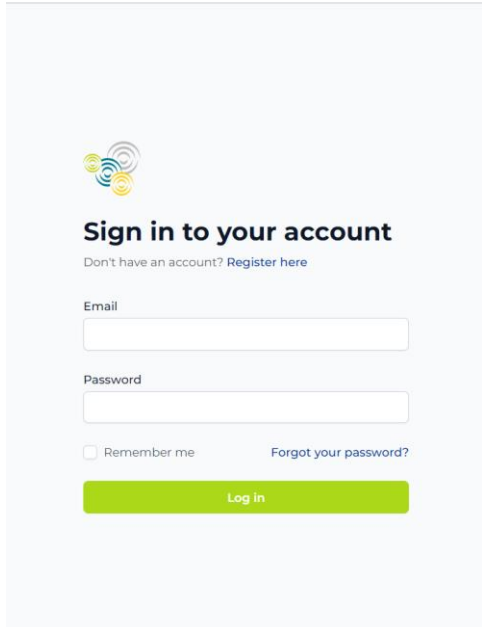*Ship's information and image gallery. Source: Authors*

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Another currently hidden field in the site´s menu are events happening on the site. This field contains name of the event, date of the event and title image of the event. These sites´ events will be displayed when the required data will be updated in the database by the partners.

Presented data to public briefly:

About the project	Basic information about the project
Historical information	Historical modules provided by the partners, available also in 7 national languages of participating countries
Project websites	Links to the official project website, social media websites and links to the app stores.
Archaeological site data	Available by tapping the site´s icon
Basic information about the site	Name of the site Location Roman name of the site Type of the site Dating List of remains Today's coverage Museum with its link Connection to the modern infrastructure
Gallery of each site	Media gallery containing images with image browser
Archaeological remains of each site	Name of the remain Dating of the remain Belonging to complex Images of the remain with image browser
Remarks of each site	Textual description about the site
Virtual reconstructions of pilot sites	Virtual reconstruction of the site as virtual tour of the site or 3D models of the found objects
Events happening on the site	Name of the event Title image of the event Dating of the event
Data about the ship	Name of the ship Title image Short description Type of boat Number of rowing crew members Length Height of mast Material of the ship Construction methods Number of members in the leadership team Normal speed Maximum speed Link to the site of the ship on the official project website
Gallery of ship´s images	Media gallery containing images with image browser

3.3. Interface for participating institutions

This interface is hidden from the wide public and it is accessible only through the login screen, running on the address livingdanubelimes.eu/login. The editors could log-in with their registered emails and password, which were sent to them. It is possible also to remember the password and request the new password, if it was forgotten.


Login screen to the content management interface. Source: Authors

After logging in, the Dashboard with brief information about recent updates and project stats is displayed. Project stats is showing how many sites are currently created in the system, how many countries are participating, how many editors are involved in total and how much content from the filled sites' information was already covered.

Under the stats, the recent updates could be found with name of the updated site and name of the editor.

On the left side of the window, the blue bar with three icons is displayed. The icon with house means back to home – to the introductory Dashboard. The second icon the Fort is for editing and viewing the added sites' data. The last icon is for editing the user's account as changing name, email, password and deleting account. In the bottom of this blue bar, the button for Log Out is located.
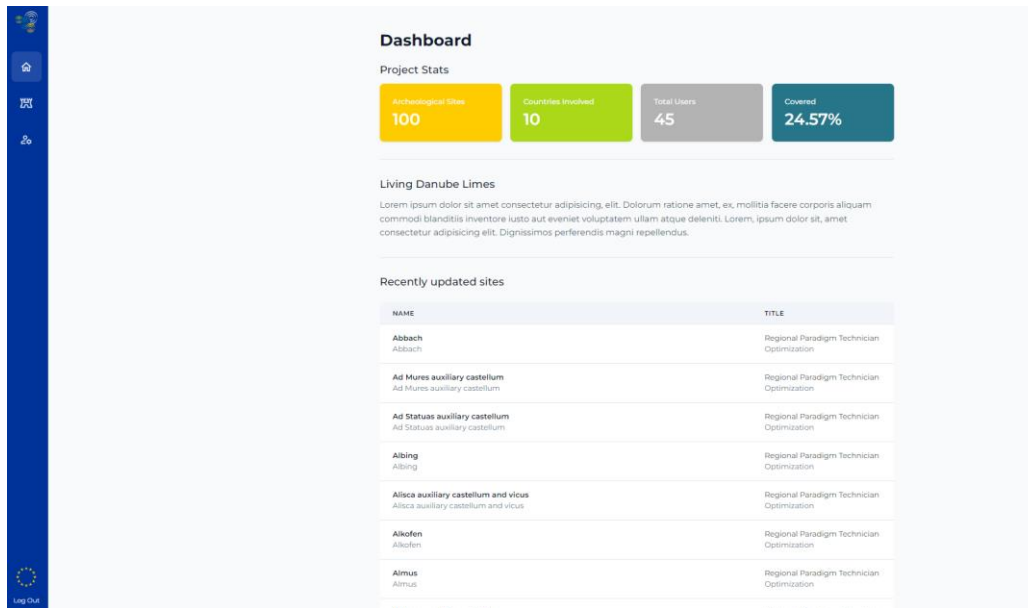
Introductory Dashboard screen with right control bar. Source: Authors

After clicking on the icon of the Fort the screen with added archaeology sites is displayed. This view provides the user with basic information about the added sites as name of the site, status of the site, user's role in the editing of the site and button to show the details of the site.

The role of the user in the editing of the site can be Admin to have all rights of editing the site's content, then the Member of the editing team, which can also edit the site. User can be then only Viewer of the site and he is unable to edit it. This role enables participating members to also view sites' data of all participating partners, the sites which he did not added.

The view can also search for a specific site by the name of the site and to add new sites.
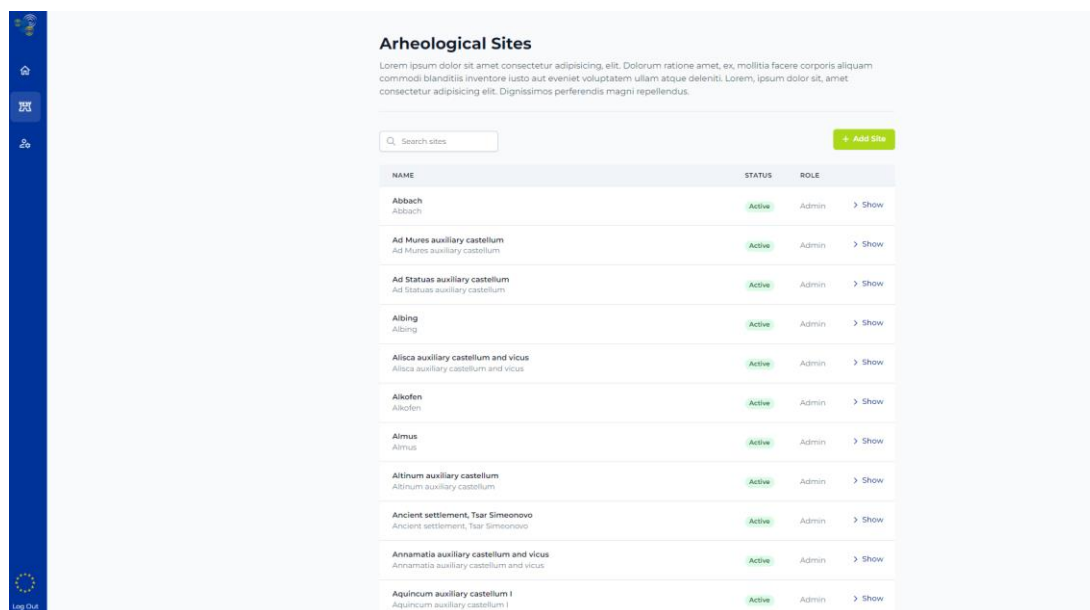
Screen with the list of Archaeological Sites. Source: Authors

After clicking on the button of adding the new site or showing the details of a site in the list, the screen for site's editing is opened. The forms with fields are visible for all participating

members, thus they see and share all data in the database. If the role of the user is Admin or Member, he can also edit or fill these forms.

On the left side of the view, the bar with summary of all forms is displayed. The forms for gathering and editing content are Site Settings, Events, Basic Information, Media, Considerations for touristic exploitation, Remarks, Archaeological Remains, Construction Phases, Military Forces and Research History. This bar also shows which forms are already filled and which are still missing some data.

Languages

Some of the gathered data are bilingual. Primary language is English for all sites, the secondary language is based on the site's Country in the Site Settings. The example on the images shows Country of the site Slovak and then Slovak flags next to the field for Slovak translations.
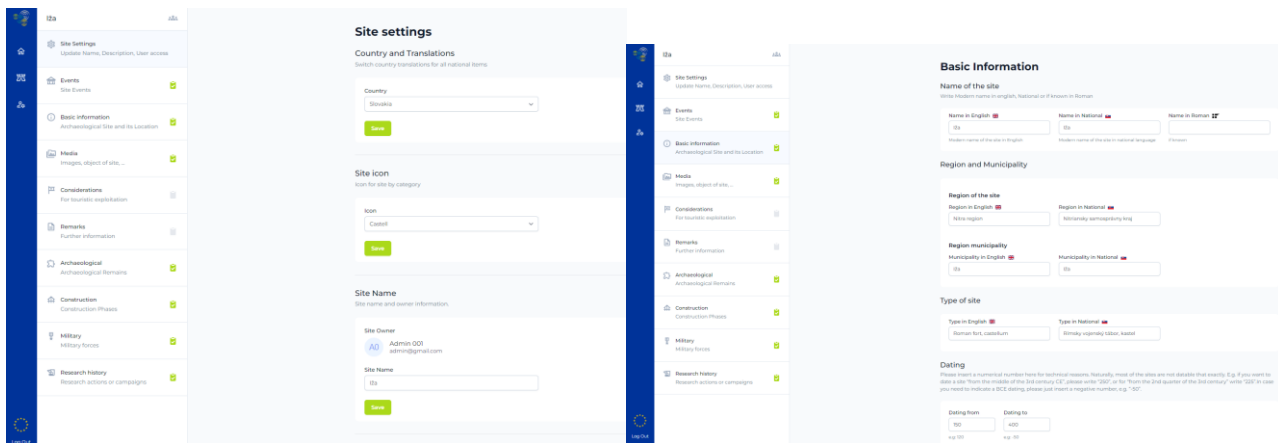
Screens of archaeological site editing or addition. Left: Site Settings, Right Basic Information
Source: Authors

Gathered and editable content
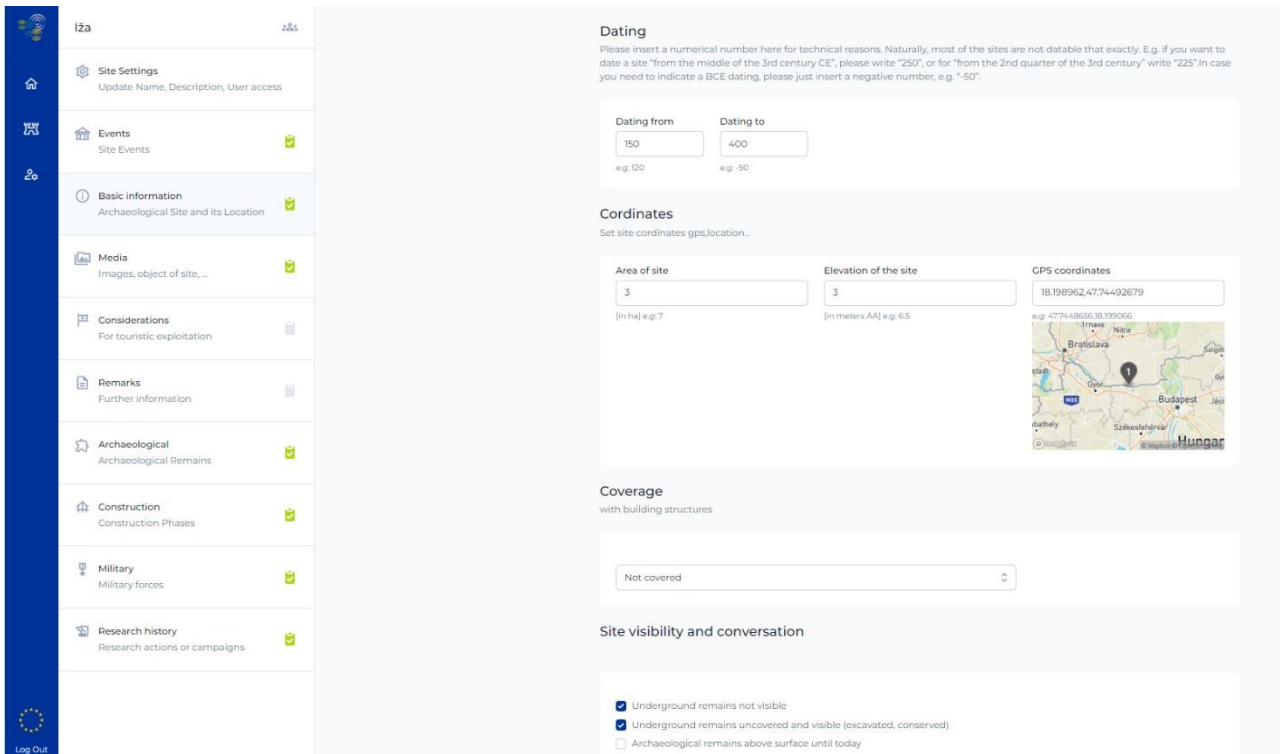
The first form in the left-side bar are the Site settings, user can change here the Country of the site, but also the Icon of the site, which is displayed on the public map, Site's name and to add new or existing members to the team for editing the site.

The second form in the list are Basic Information. This form is opened by default for viewing or editing the existing site. The Basic Information contains Name of the site, Region and Municipality, Type of site, Dating, Physical coordinates – including Area, Elevation and GPS with preview of the map to show where GPS coordinates are placing the site. The GPS coordinates are also placing the site on the publicly visible map.

According to Dating of the site in this form, the site is displayed or hidden in the public map with the Historical period set.

The further gathered data are current Coverage of the site with buildings, Site visibility and conversation, State of research, UNESCO status and Legal protection of the site.
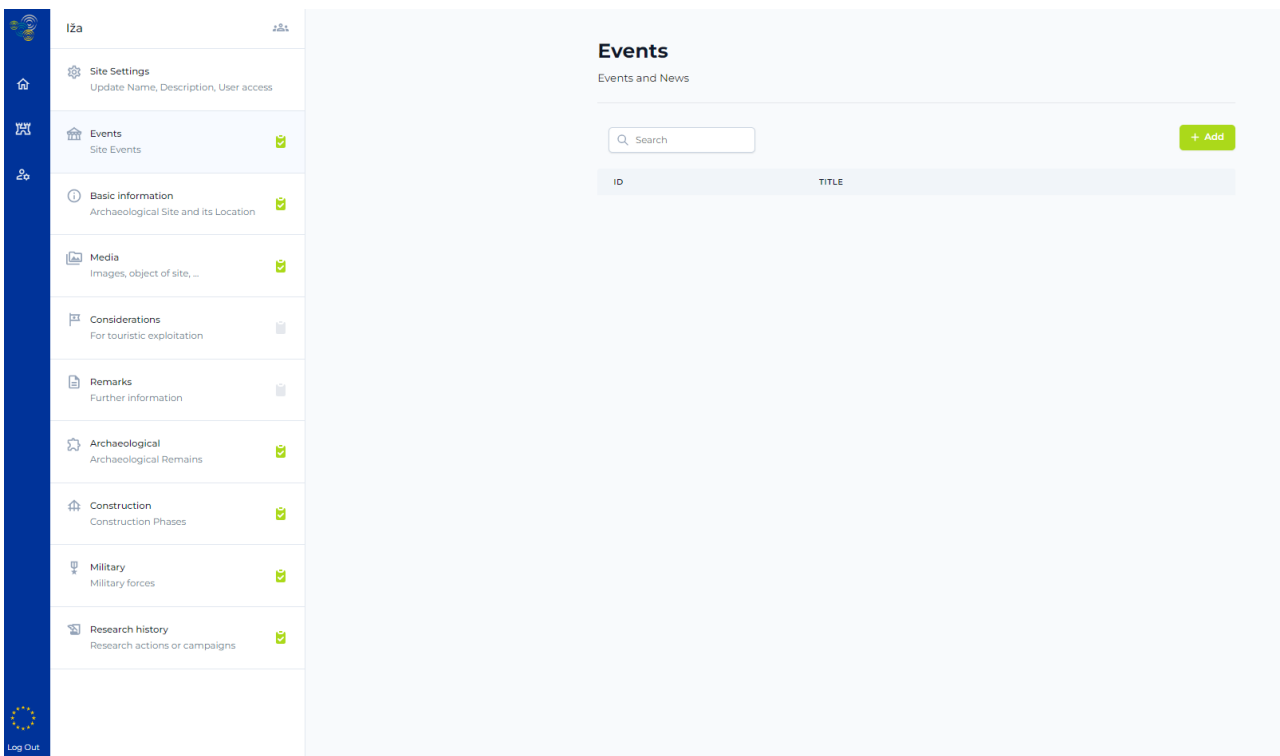
Basic Information form with Dating and Coordinates. Source: Authors

The third form in the list are Events. On this form, user can create or edit events, which are happening on the site by defining Event title, Date of the event and Short description.
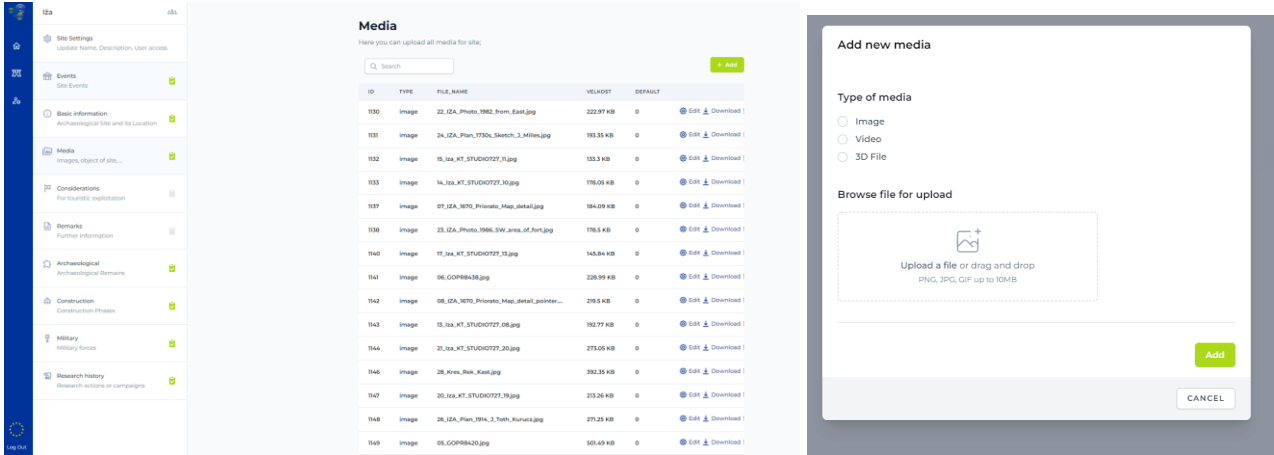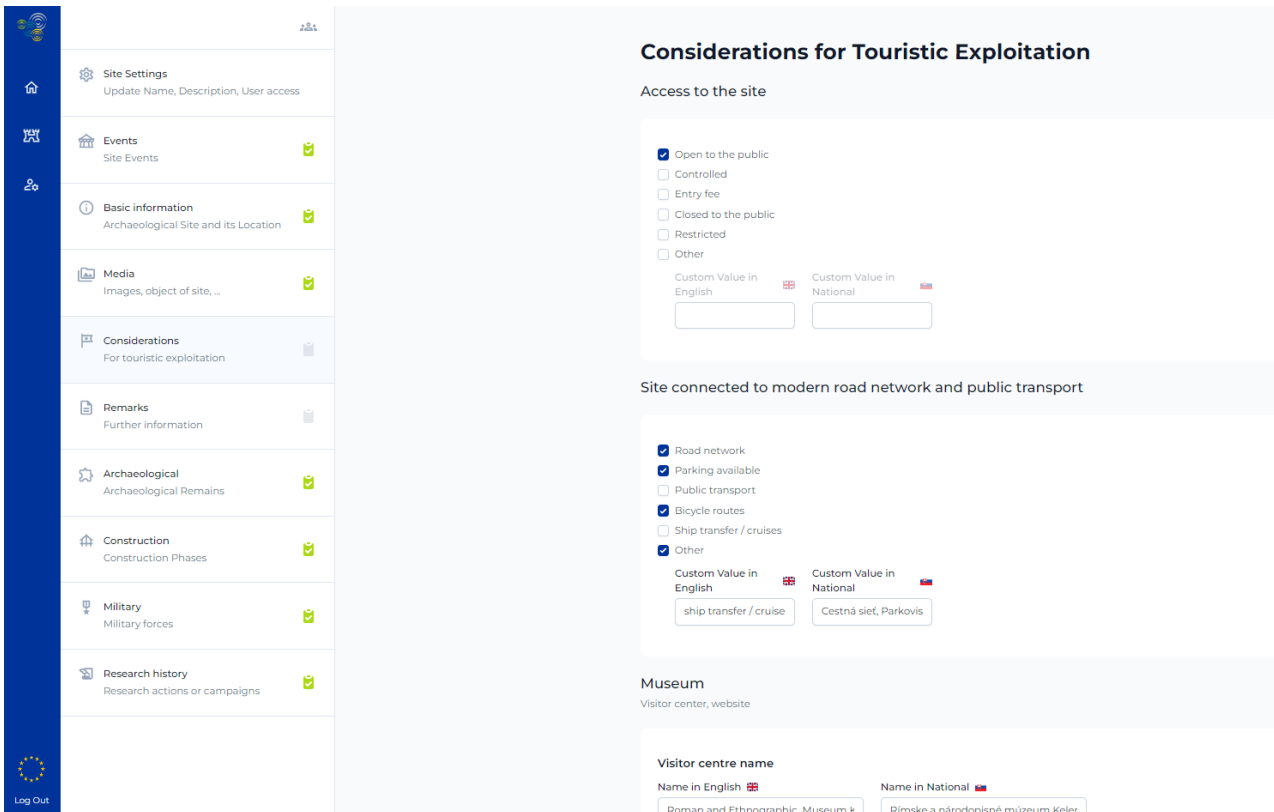

Events screen of the site. Source: Authors

The next form in the list is Media. This form is gathering Images, Videos, 3D data or any other documents related to the site. The user is able to view these Media, Edit their properties and Download them. Media should be named as title of media and then author of the media to record and display also copyright information.


Media form to Add, Edit and Download documents related to the site. Source: Authors

The subsequent form is Consideration for touristic exploitation. This form is collecting data relevant to tourists as Access to the site, Connection to the modern road network, related Museum's information, On-site presentation and Service. Museum's GPS coordinates here are placing the museum with its icon on the publicly visible map.


Consideration for Touristic Exploitation screen. Source: Authors

Sixth form in the left-side list is Remarks. This is a short textual description of the site displayed on the public website and in the app.
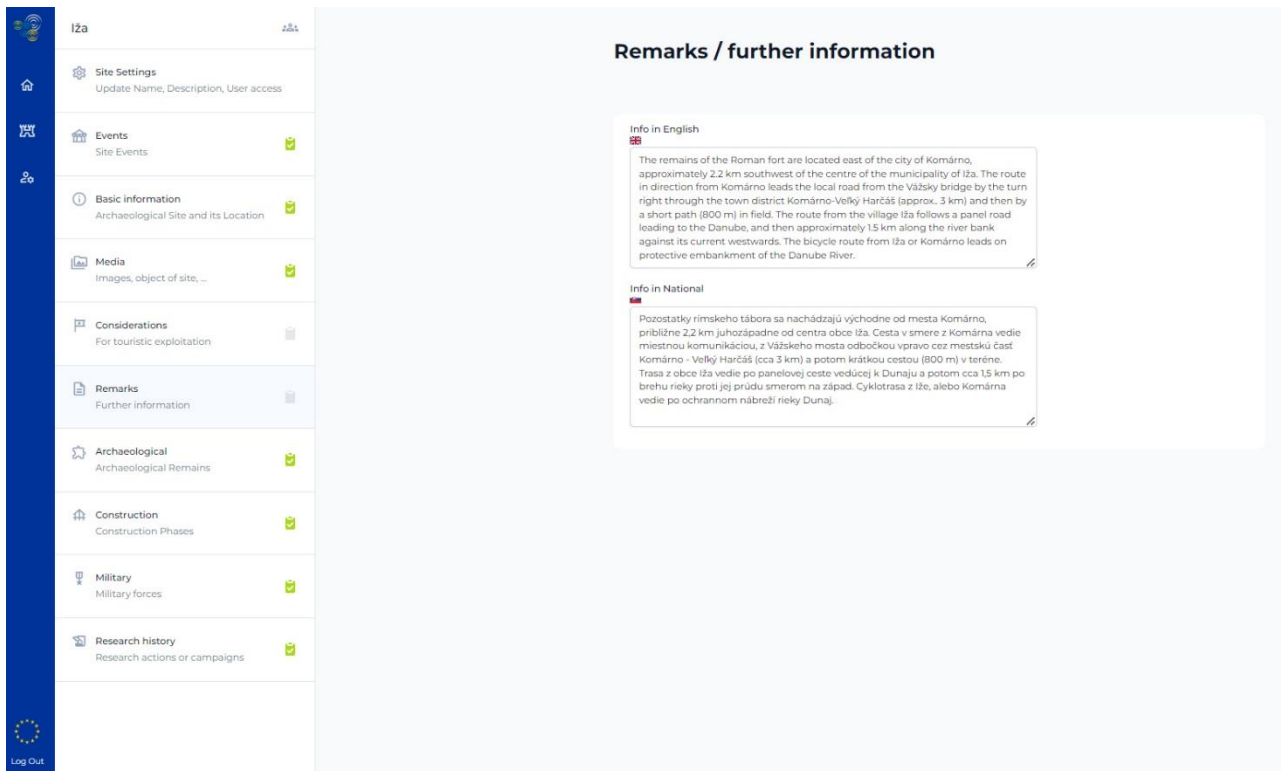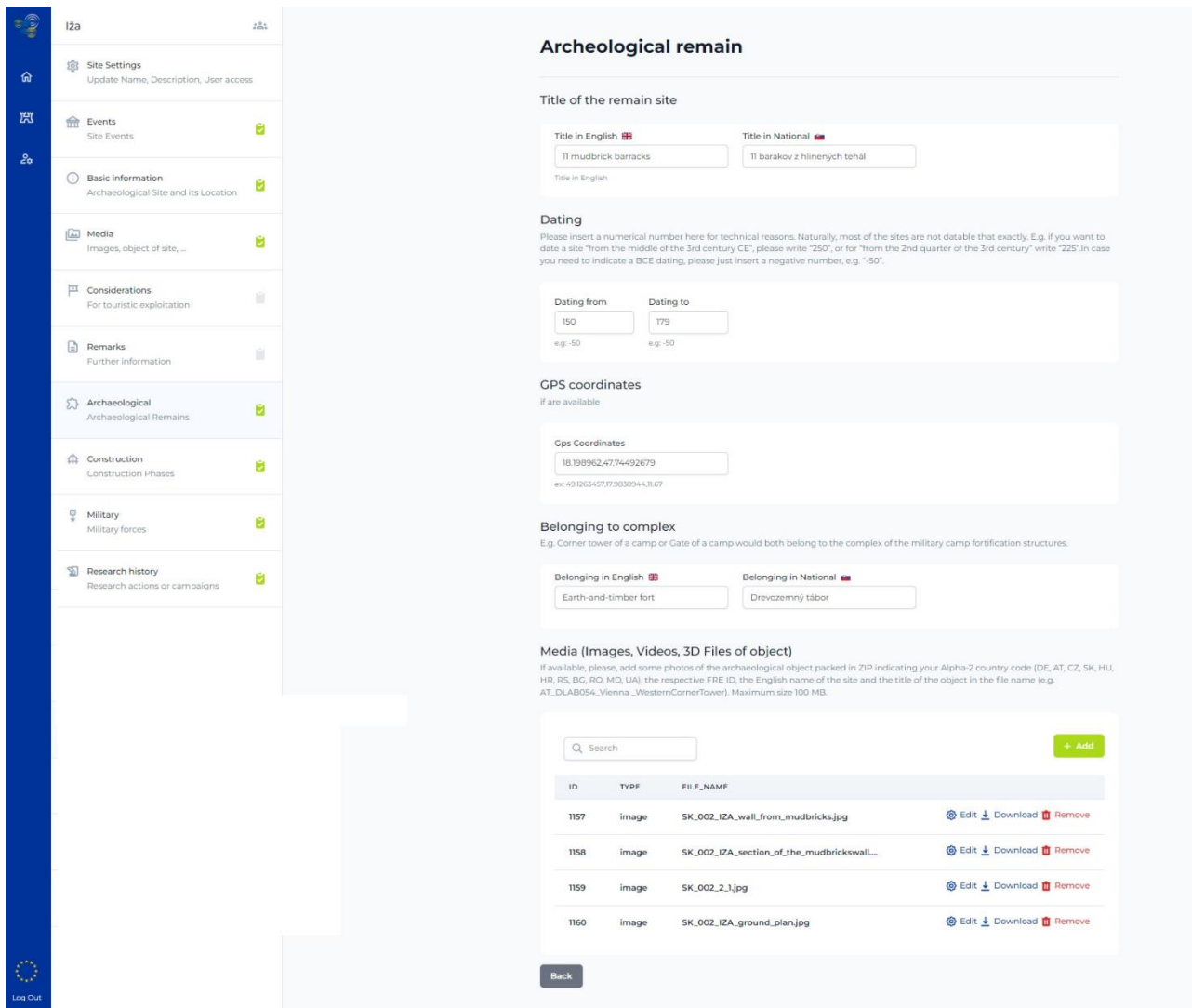

Remarks – further information form. Source: Authors

The next form Archaeological Remains contains editable list of objects found on the site. User can add new or view the existing archaeological remains.
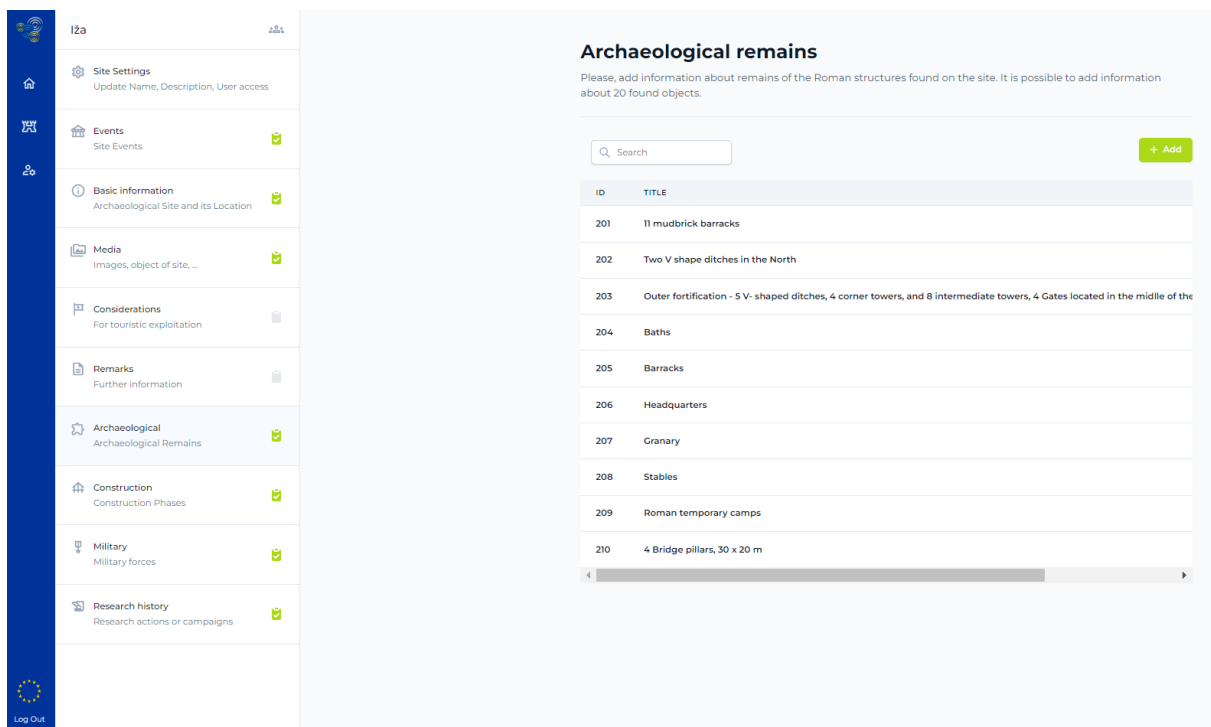
Screen for viewing and editing the list of remains. Source: Authors

By clicking the View of the remain, user will open the details of this remain, where it is possible to add or edit the Title of the remain, Dating, GPS coordinates, Belonging to complex and list of Media of the remain.

Screen of Remain details. Source: Authors

The eighth form is dedicated to the Construction phases of the site. User can add or edit the list of the phases. After clicking the button for Adding the new phase or the button for viewing the existing one, the form with details is opened. Here the data as Phase title, Short description and Dating of the phase are collected.
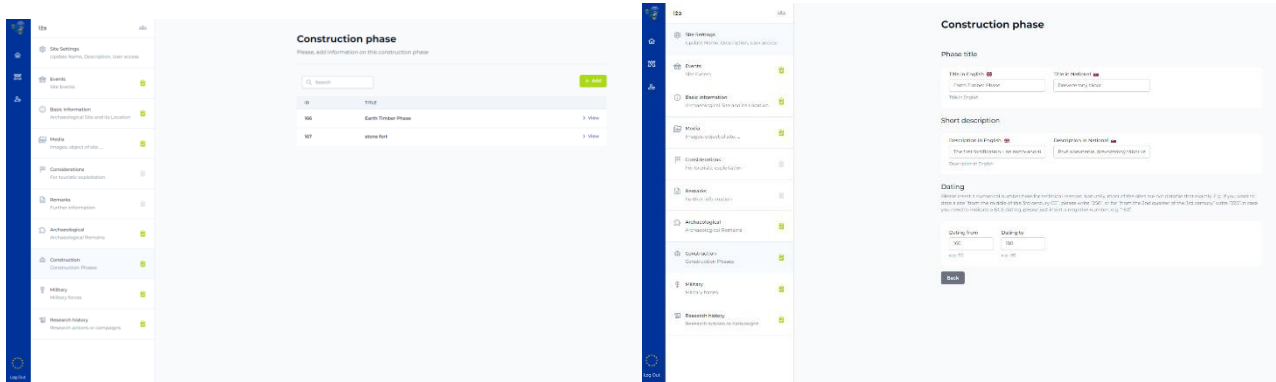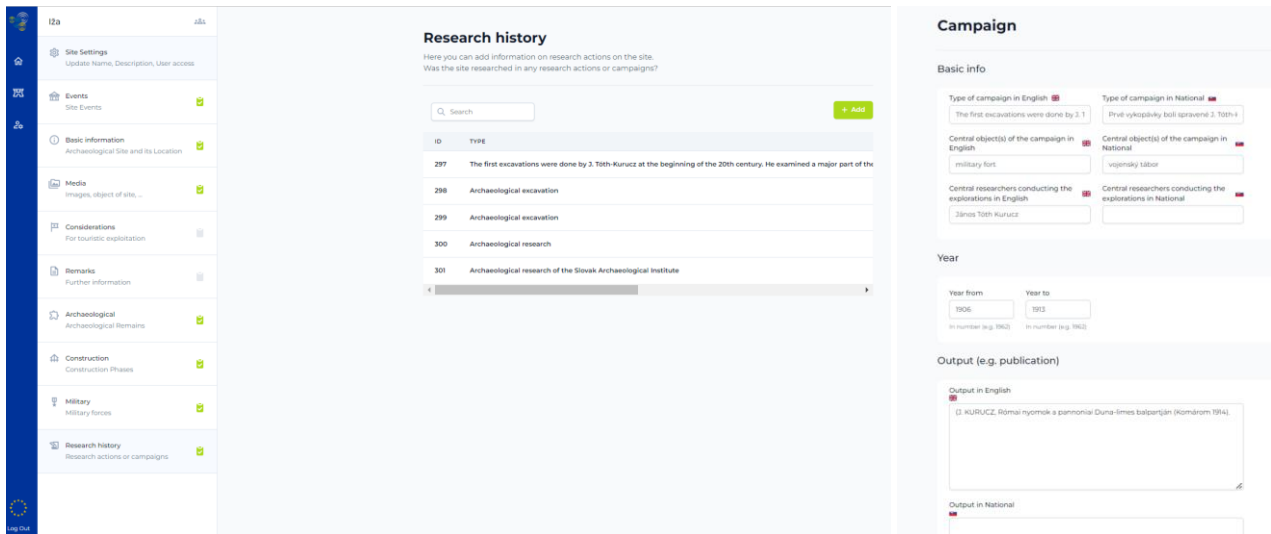
List of construction phases and screen with details of construction phase. Source: Authors

Similar structure has also the form of Military forces. The first screen is list of Military forces for adding and editing. After clicking Add or View, the screen with details appears. The collected details are Name of the military force, Dating of stationing and Evidence of stationing.
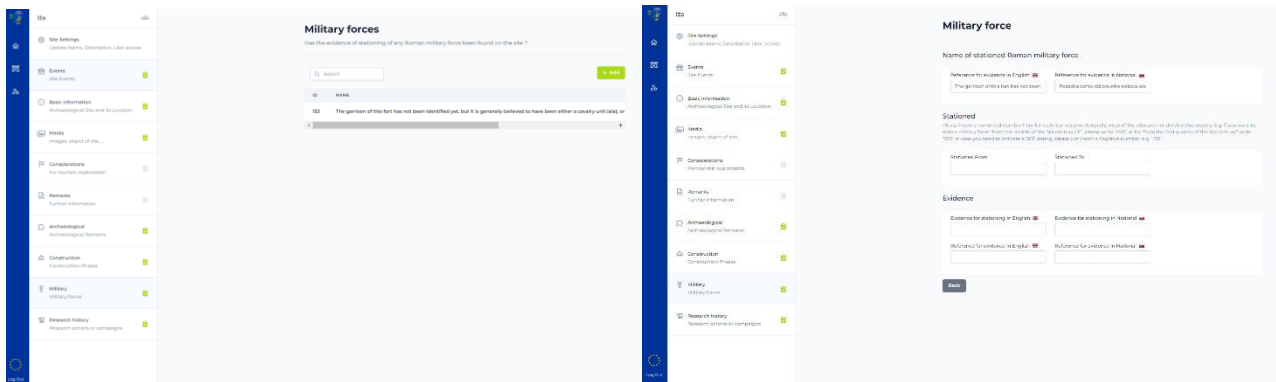
Left: List of Military forces. Right: Form collecting details of Military forces, which stationed on the site. Source: Authors

The last form collects information about Research history of the site. The form again consists of list of Research campaigns with ability for Adding new items and Viewing/editing the existing ones. The collected details here are Type of the campaign, Central objects of the campaign, Dating of the campaign and Outputs.

Form for editing the Research history with details of each campaign. Source: Authors

Gathered data briefly:

Site Settings	Country
	Site icon
	Site name
	Add existing members of editing team
	Register new member of editing team
	List of editing members
Basic information	Name in English and national language
	Name in Roman language
	Region of the site in English and national language
	Municipality in English and national language
	Type of the site in English and national language
	Dating from
	Dating to
	Area of the site
	Elevation of the site
	GPS coordinates
	Coverage with buildings in English and national language
	Site visibility and conversation in English and national language
	State of research in English and national language
	UNESCO status in English and national language
	Legal protection in English and national language
Events	Add event
	View event
	Event title
	Event dating
	Short description in English and national language
Media	List of media
	Type of media
	Add media
	Edit media

	Delete media
Consideration for touristic expoitation	Access to the site in English and national language
	Connection to modern road network in English and national language
	Museum name in English and national language
	Museum website
	Museum GPS coordinates
	On-site presentations in English and national language
	Service in English and national language
Remarks	Remarks in English and national language
Archaeological remains	List of remains
	Add remain
	View remain
	Title of remain in English and national language
	Dating
	GPS coordinates
	Belonging to complex in English and national language
	List of Media to Edit, Download, Remove
Construction phase	List of construction phases
	Add phase
	View phase
	Phase title in English and national language
	Short description in English and national language
	Dating
Military forces	List of forces
	Adding forces
	Viewing forces
	Name of the force in English and national language
	Dating of stationing
	Evidence for stationing in English and national language
	Reference of stationing in English and national language
Research history	List of research campaign
	Add campaign
	View campaign
	Type of campaign in English and national language
	Central objects of the campaign in English and national language
	Researchers conducting the explorations in English and national language
	Dating of the campaign
	Outputs of the campaign in English and national language

3.4. Updates and correctness of the gathered data

As the gathered data are extensively large and they are collected and editable by all partners, it is planned that they will be updated continually. The updates of the data are automatically presented also on the public website and within the Living Danube Limes app by their regular updates. The responsibility for the correctness of these data, copyright information and

authorship information are therefore on all participating partners. STUBA is not responsible for any incorrections, missing information or copyright issues, which are not related to the technical processing of the data. It is planned that incorrections or additions will be managed by a specific partner of the project.

3.5. Web-based infrastructure sustainability

The web-based infrastructure will be sustained at least 5 years after the project. The domain of the website livingdanubelimes.eu is subscribed for 10 years. Sustainability of the web-based solution is ensured by direct link between the database, publicly visible website and Living Danube Limes app, very compatible easy-to-use web-based content management system for updating the content and stable hosting solution.

3.6. Link

www.livingdanubelimes.eu