D13.4 – VREs Operation Final Activity Report JRA2

Version 1 *(final)*

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1 Executive Summary

Virtual Research Environments (VREs) are “systems” specifically conceived to provide their users with a web-based set of facilities (including services, data and computational facilities) to accomplish a set of tasks by dynamically relying on the underlying infrastructure. VREs are among the key products developed and delivered by the ARIADNEplus project to support the target communities and application scenarios in archaeology.

The development of VREs is based on three main activities: (i) the development of software artifacts that realise a set of functions (including those needed for accessing certain datasets), (ii) the deployment of these artifacts in an operational infrastructure following the release procedures and tools presented in the deliverable D13.1 “Software Release Procedures and Tools JRA2”, and (iii) the final deployment and operation of well-defined Virtual Research Environments by exploiting the facilities offered by the underlying D4Science infrastructure and its services [1].

This deliverable D13.4 - “VREs Operation Final Activity Report'' is the updated version of D13.2 - “VREs Operation Mid-term Activity Report ''. D13.4 documents the last of the above-mentioned three activities – i.e. the exploitation of the services and technologies offered by the underlying infrastructure to serve the needs of defined scenarios – as implemented in the second period, from January 2021 to November 2022 - of the ARIADNEplus project. Specifically, it focuses on how the components have been exploited and operated to support the development of the ARIADNEplus VRE gateway https://ariadne.d4science.org, its underlying infrastructure, and the VREs from M25 (January 2021) to M47 (November 2022). These activities have been carried out within Work Package 13. Specifically in Task 13.1 Infrastructure Operation (JRA2.1) and Task 13.3 VREs Operation (JRA2.3).

In addition to the 5 VREs created and operated in the first period, 3 more VREs were created and operated in the second reporting period, for a total of 8 VREs. One VRE of the second reporting period, namely ARIADNEplus Lab (cf. Section 4.6), was created in July 2021 as the virtual laboratory to support developers, researchers, data managers, and data analysts belonging to the archaeological community worldwide. The “Geoportale Nazionale per l’Archeologia (GNA)” VRE (cf. Section 4.7) was created in January 2022, as the evolution of the existing Geoportal Prototype VRE (cf. Section 4.4), which was developed for the integration, validation, harmonization, visualization, and access of archaeological georeferenced datasets collected in Italy. Finally, the Esquiline VRE (cf. Section 4.8) was created in October 2022 for the integration and display of data originating from 19th century excavations and historical cartography in a spatio-temporal database, allowing the reconstruction of the transformation of an urban landscape through the centuries.

As of November 2022, the VREs are serving the needs of more than 400 users in total spread across 21 countries and more than 10.000 user sessions. This required to deal with approximately 100 tickets (59 requests for support, 9 requests for incidents and bugs, 9 requests for Virtual Machine or Container creations).

2 Introduction and Objectives

Virtual Research Environments (VREs) are “systems” aiming to provide their users with web-based working environments that offer the entire spectrum of facilities (including services, data, and computational facilities) needed to accomplish a given task by dynamically relying on the underlying infrastructure. VREs are key products delivered by the ARIADNEplus project to meet the needs of its target community and scenarios; they are dedicated to discussing and developing various approaches and solutions to be applied to concrete cases and scenarios, and also devised to serve specific communities and practitioners confronting a given research question.

The end-user accesses the VREs by exploiting a web component providing access to the ARIADNEplus infrastructure, namely the ARIADNEplus Infrastructure Gateway. This gateway is accessible via the URL https://ariadne.d4science.org/ and it is indeed expected to be the end-user access point to the ARIADNEplus Virtual Research Environments.

This deliverable – D13.4 ‘VREs Operation Final Activity Report’ – details the activity leading to the deployment and operation of a series of Virtual Research Environments addressing the needs during the final 2 years of the ARIADNEplus Project, from M25 (January 2021) to M47 (November 2022).

A total of 8 Virtual Research Environments were created and/or operated to serve the needs arising in the context of the ARIADNEplus project (the complete list is in Table 1). Specifically, a total of 5 Virtual Research Environments during the first period until M25, and 3 Virtual Research Environments during the second period until M47. Overall, these VREs are serving the needs of more than 400 users in total spread across 21 countries and more than 10.000 user sessions.

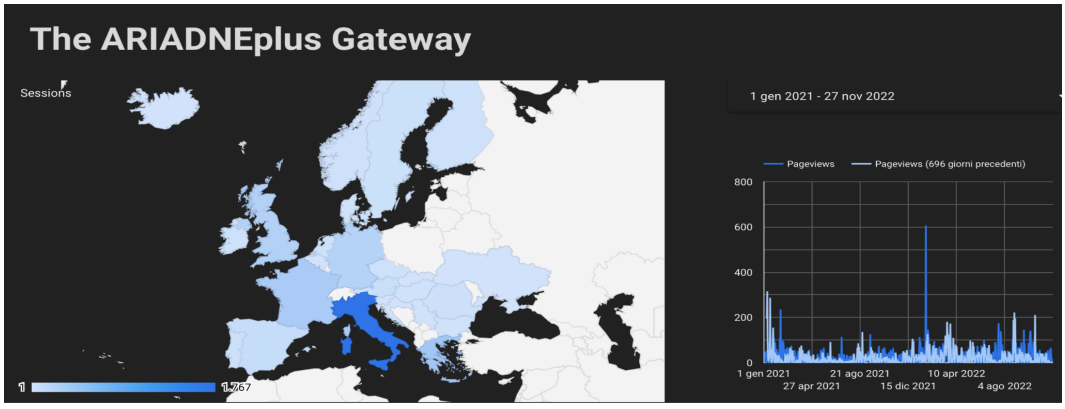


Figure 1. The European geo-distribution of user sessions on the ARIADNEplus Infrastructure Gateway in the second period of the project.

The deliverable maintains the previous document (D13.2 - “VREs Operation Mid-term Activity Report”) structure. Section 3 describes the policies and procedures governing the planning and deployment of Virtual Research Environments. Section 4 describes the Virtual Research Environments that have been deployed and operated during the period and reports on their usage statistics. For each Virtual Research Environments, the deliverable describes the goal and the main facilities offered to their users. Section 5 ends the report by describing some conclusions.

3 VREs Procedures

Deployment and operation of VREs is a collaborative effort involving the WP13 team called to deploy and configure the technology to create VREs expected by the work packages working to develop the enabling technology, i.e. WP12, WP15 and WP16.

The procedure leading to VRE deployment is a consolidated one, *i.e.* it is the procedure inherited from the D4Science infrastructure and described in the D4Science Wiki[1].

For the needs of ARIADNEplus, it was decided to support this activity by the project activity tracker. A specific VRE tracker has been created with the goal of capturing the entire process from specification to operation. The specification of the VRE is produced by the VRE designer/requester. This specification must contain:

- VRE name and abstract;
- Membership policy, i.e. whether the VRE is open or restricted, who is allowed to invite members, VRE expected datasets;
- VRE expected functionalities;
- VRE due date.

The following statuses are supported:

- ***Planned***: the WP4 team is fine with the specification, i.e. the specification contains enough details to proceed with the creation, and acknowledges that the creation of the VRE is feasible by the due date initially requested (or liaise with the designer/requester to find a mutually suitable date);
- ***Available***: the VRE is up and running and ready to be validated by the VRE designer/requester;
- ***Released***: the VRE has been validated and the target community can start using it;
- ***Removed***: the VRE has been disposed of, at the request of its manager;
- ***Rejected***: the requested VRE cannot be created as the requirements outlined for it cannot be satisfied.

[1] https://wiki.d4science.org/index.php?title=Virtual_Research_Environments_Deployment_and_Operation

3.1 VREs Creation, Deployment and Operation

This section briefly describes the facilities used by VRE creators for the actual deployment of VREs, reports the complete list of deployed and operated VREs, and offers a characterisation of each available VRE.

The act of definition and deployment of a new VRE is supported by a wizard (cf. Figure 2) that enables authorised users to transform the opened requests according to the procedure described in Section 3 into an actual specification and then, automatically, into a working VRE made available by the ARIADNEplus gateway.

Through the wizard, the user is requested to specify: (i) the descriptive information characterising the expected VRE (i.e. name, description, duration, etc.), and (ii) the functionalities and datasets to be made available in the specific VRE by selecting among the available ones. The resulting list of functionalities is derived from the feasible functionalities created thanks to the software version and services hosted by the underlying D4Science infrastructure.

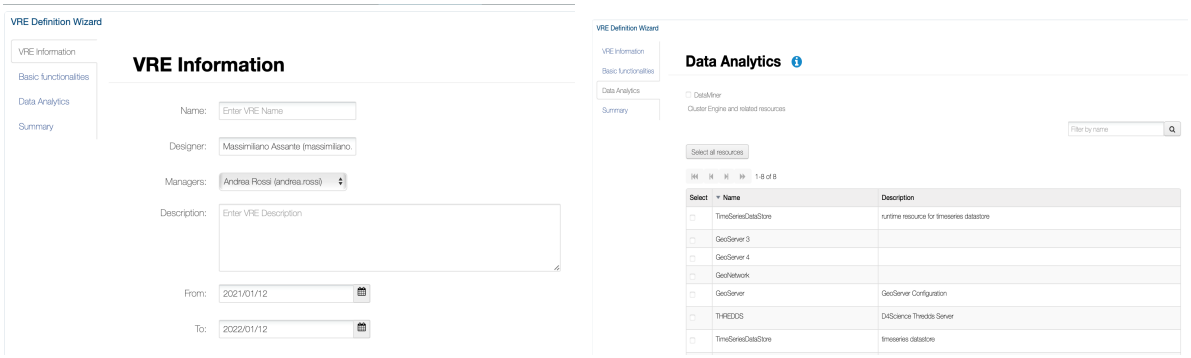


Figure 2. VRE Creation Wizard Screenshots

A total of 8 Virtual Research Environments were created and/or operated to serve the needs arising in the context of the ARIADNEplus project. Specifically, a total of 5 Virtual Research Environments during the first period until M25, and 3 Virtual Research Environments during the second period until M47.

The following Virtual Research Environments were existing prior to M25:

1. The ARIADNEplus Project VRE (cf. Section 4.1) which was created first and prior to the project kick-off and dedicated to the Project management and file exchange;

2. The ARIADNEplus Mappings VRE, which was created after a few months to support the metadata mappings in the project. (cf. Section 4.2);

3. The ARIADNEplus Aggregation Management VRE, to have a place where only some of the project partners could discuss in a controlled environment about data integration issues and possible procedures to activate or propose to the whole consortium (cf. Section 4.3);

4. The Geoportal Prototype VRE (cf. Section 4.4), developed for the integration, validation, harmonisation, visualisation, and access of archaeological georeferenced datasets collected in Italy;

5. The Archeomar VRE, developed for the visualisation and controlled access of archaeological georeferenced datasets (cf. Section 4.5);

In addition to the above 5 VREs created and operated in the first period, 3 VREs were created and operated in the second reporting period:

6. The ARIADNEplus Lab, was created in July 2021 as the virtual laboratory supporting developers, researchers, data managers, and data analysts belonging to the archaeological community worldwide (cf. Section 4.6);

7. The “Geoportale Nazionale per l’Archeologia (GNA)” VRE was created, in January 2022, as the evolution of the existing Geoportal Prototype VRE (cf. Section 4.4), developed for the integration, validation, harmonization, visualization, and access of archaeological georeferenced datasets collected in Italy (cf. Section 4.7);

8. The Esquiline VRE was finalized in October 2022 for the integration and display of data coming from 19th century excavations and historical cartography in a spatio-temporal database, allowing the reconstruction of the transformation of an urban landscape through the centuries (cf. Section 4.8).

4 Statistics related to the VREs usage

In Figure 3, the number of VREs operated per month from January 2021 to November 2022 is reported. Prior to January 2021 a total of 5 VREs were already existing as documented in D13.2 "VREs Operation Mid-term Activity Report". During the second and third reporting period 3 VREs have been created.

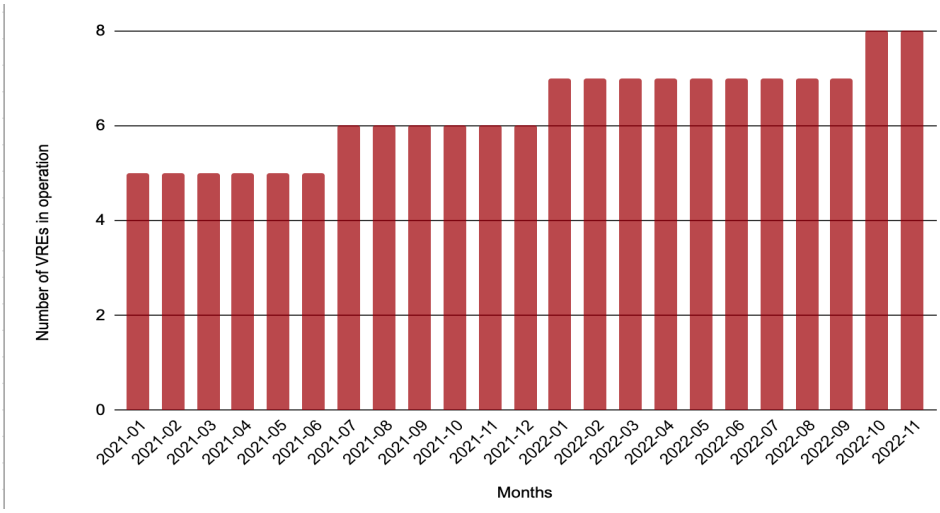


Figure 3. Number of VREs operated per month (January 2021 – November 2022)

Figure 4 complements Figure 3 by reporting on the user distribution among the VREs operated per month in the second period of the project.

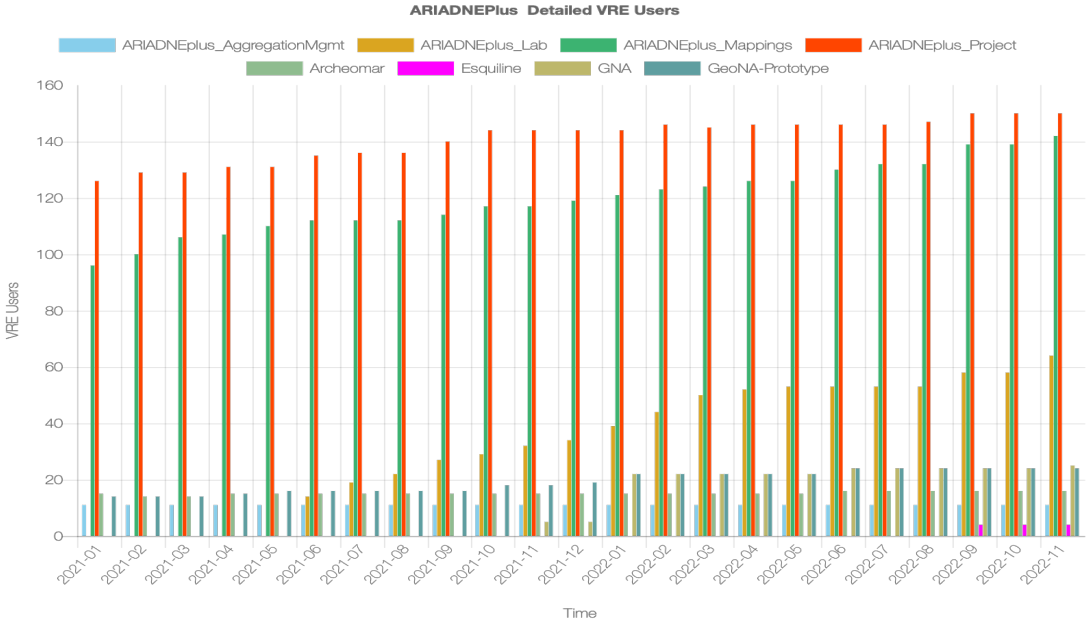


Figure 4 Number of VREs operated per month and their users' number (January 2021 – November 2022)

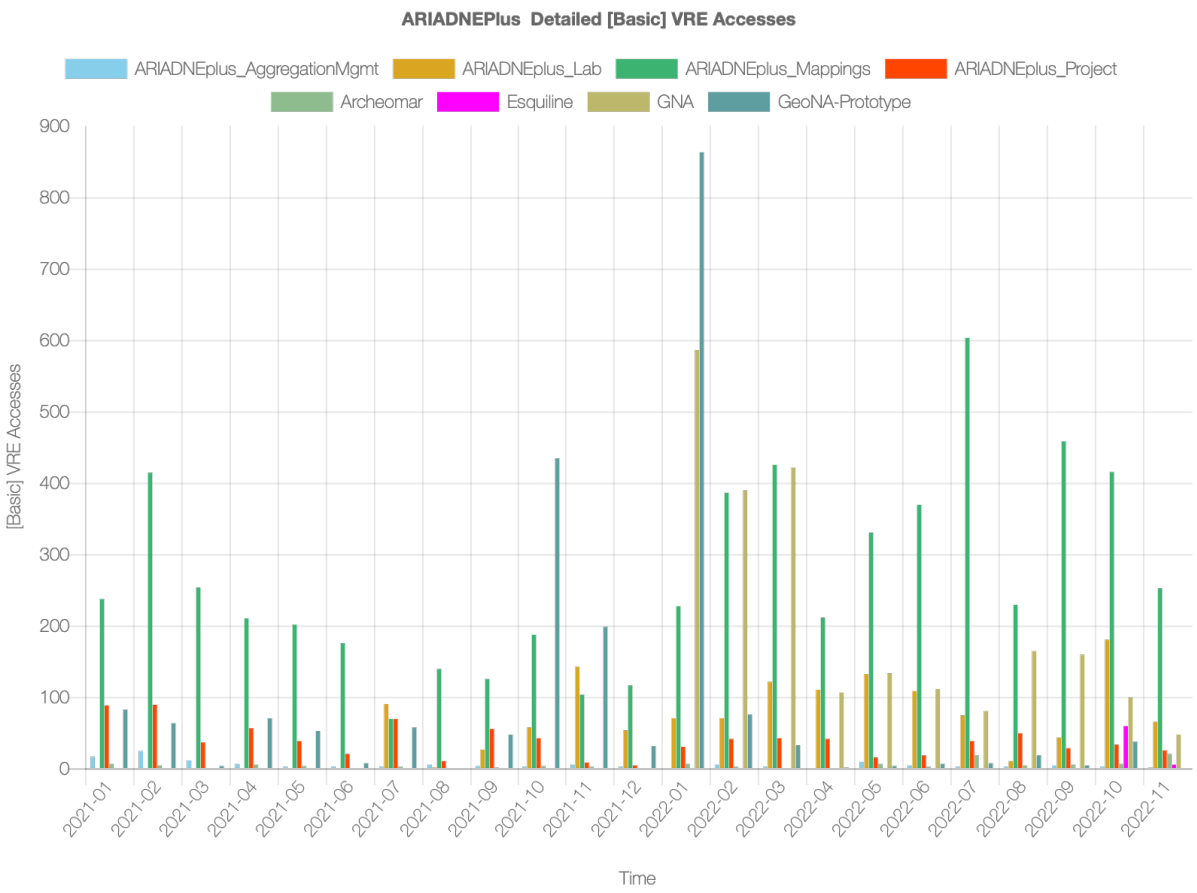


Figure 5 Number of VRE User Accesses per month (January 2021 – November 2022)

Figure 5 reports on the number of VRE user accesses per month in the second period of the project, showing how often the ARIADNEplus Project members have accessed and exploited these VREs. This chart shows peaks of up to 600 accesses per month on more than one VRE, and one peak of 900 accesses. As in the first period, the most accessed VRE in the second period has been the ARIADNEplus Mappings; its average number of accesses per month for the second period has grown up to 266 access per month, reflecting the frequent mapping activity that VRE members have been doing in the period.

The operation of VREs requires the management of requests for support, of issues and malfunctions, but also the creation of new Virtual Machines and Containers (e.g. Docker). Figure 6 shows a screenshot of the issue tracker reporting the tickets for these types of tickets. During the current reporting period, a total of 24 such tickets have been resolved. An additional ARIADNEplus issue tracker has been created in the second period, namely ARIADNEplus Support[2] open not only to the project members but also to the ARIADNE community at large, i.e. students and any practitioner interested in the ARIADNE

[2] https://support.d4science.org/projects/ariadne-support/issues

infrastructure technology. On this ARIADNEplus Support issue tracker, 21 support requests and 5 bugs were reported during the current period.

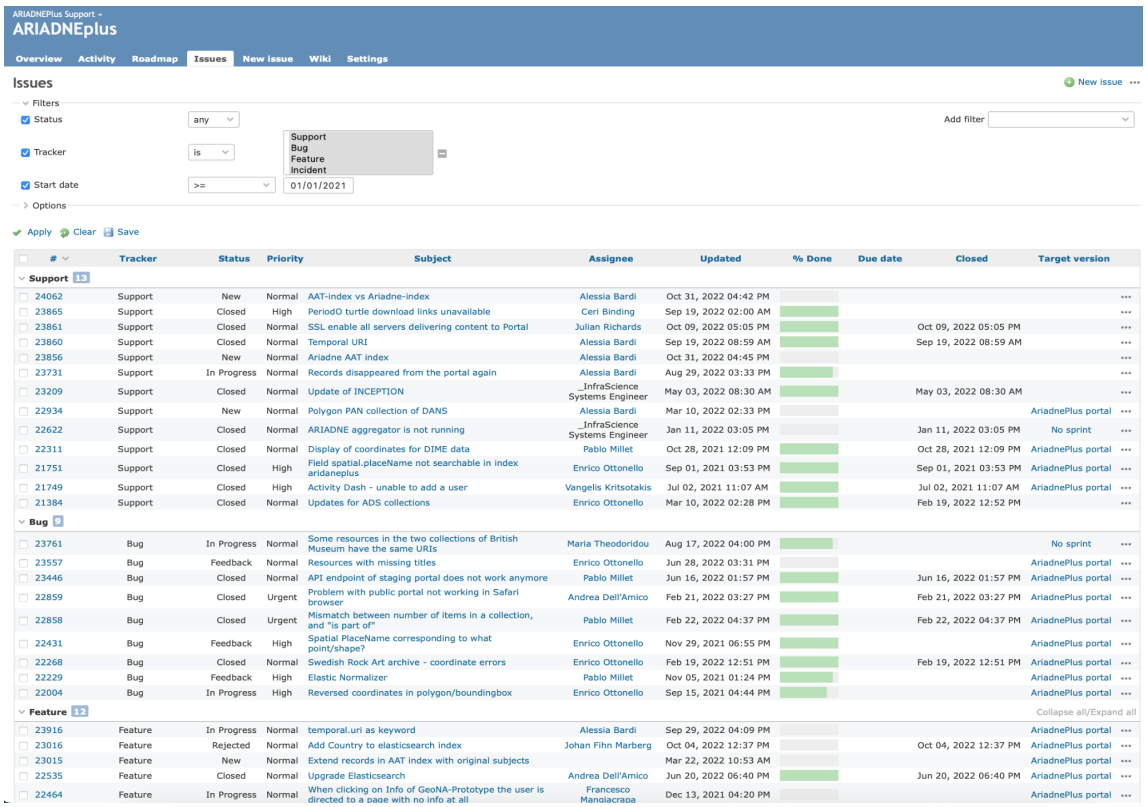


Figure 6 A Screenshot of the ARIADNEplus issue tracker used for the management of requests for support and malfunctions.

A brief description of each available VRE is reported in the following sections. All the VREs are provided with:

- A ***shared workspace*** to enable every user to store and organise the information objects interested in working with. In addition to that, the user is allowed to collaborate with other users by sharing objects and messages;
- A ***VRE Management facility*** to enable authorized users (i.e. VRE Managers) to manage other users using or wanting to access the VRE. VRE Managers can (i) authorize users for access to the VRE, (ii) assign or withdraw roles to users, (iii) remove users, and (iv) send communications to the current users;
- A ***social networking facility*** to enable users to use the common facilities typical of social networks – e.g., posting news, commenting on posted news – yet adapted to the settings of working environments like those characterising ARIADNEplus. Users can post news as well as applications;
- A ***notification facility*** to alert users on relevant activities as they happen. These notifications offer a sense of anticipation and create a productivity boost. Users

receive an alert (through *a priori* selected channels, e.g., email, web portal, twitter) notifying them when something of interest has happened in their VRE(s);

- A ***members facility*** to provide users with a list of VRE co-workers, i.e. the list of members partaking in the VRE and contributing to it;
- A ***messaging facility*** to provide users with a common email environment As-a-Service. The distinguishing feature is represented by its integration with the rest, e.g., it is possible to send any information object residing in the workspace (regardless of how "big" and "complex" it may be) as an attachment without consuming bandwidth.

Table 1 reports the complete list of VREs created and/or operated during the 2 reporting periods: 5 VREs from January 2019 to December 2020 in shaded background, 3 VREs from January 2021 to November 2022) in regular background.

VRE name	Start date	Membership	#Users[3]
ARIADNEplus Project	Jan. 2019	Private	150
ARIADNEplus Mapping	Feb. 2019	Restricted	142
ARIADNEplus Aggregation Mgmt.	Mar. 2020	Restricted	11
Geoportal Prototype	Apr. 2020	Restricted	24
Archeomar	Apr. 2020	Private	16
ARIADNEplus Lab	Jul. 2021	Open	64
GNA	Jan. 2022	Private	25
Esquiline	Oct. 2022	Private	4

Table 1. List of ARIADNEplus VREs

4.1 ARIADNEplus Project VRE

This VRE was devised to support ARIADNEplus project activities and discussions. Only members of the ARIADNEplus consortium have access to this VRE.

The ARIADNEplus Project VRE is available at
https://ariadne.d4science.org/group/ariadneplus-gateway/explore?siteId=164842781

This VRE has been in operational status since January '19 and it is serving 150 users as of end of November 2022, namely the ARIADNEplus Consortium members. A screenshot of the VRE

[3] Number of members of the VREs in November 2022.

is provided in Figure 7. It shows the home page and the menu items for accessing the VRE facilities.

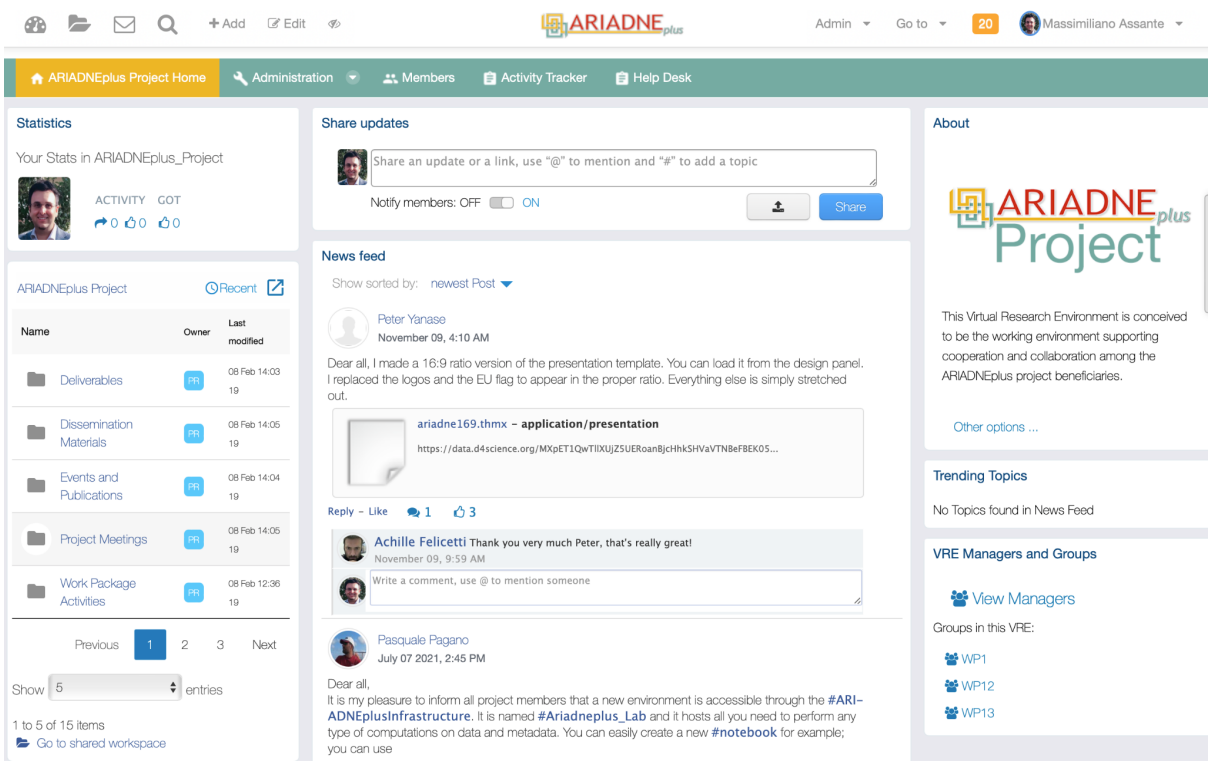


Figure 7 A Screenshot of the ARIADNEplus Project VRE home page and the menu items for accessing the VRE facilities.

In addition to the basic functionality, as social networking area for supporting the discussions among members and a user management facility for managing membership, this VRE is specifically equipped with the following capabilities:

- ARIADNEplus Activity Tracker System: a facility enabling project members to access the project issue tracking system;
- ARIADNEplus help desk: a facility enabling project members to access the help desk, useful for reporting queries or any features to request/bugs to report;
- A shared area in the workspace that makes available objects of interests, e.g. project deliverables, presentations, working notes. More than 3.100 files (40.81 GB on disk) were shared by the consortium by using it;
- A user management area that enables authorised users (i.e. VRE Managers) to manage other users using or willing to access the VRE. VRE Managers can (i) authorise users in accessing the VRE and its services, (ii) assign or withdraw roles to users, (iii) remove users, and (iv) send a communication to the current users;
- A Members area, enabling each VRE member to be informed on the rest of VRE members and acquire details for contacting them.

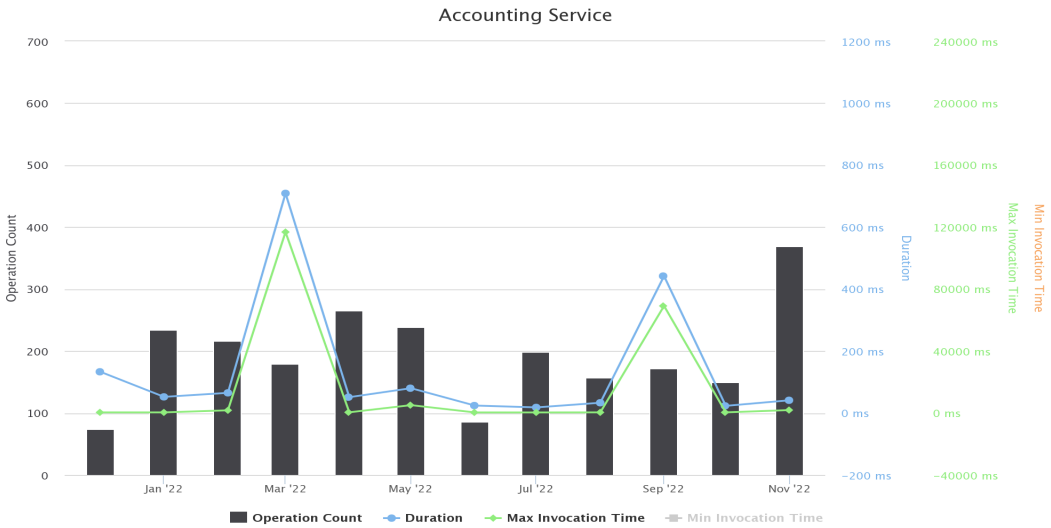


Figure 8 ARIADNEplus Project VRE Operations per Month

Figure 8 reports the total number of operations performed in the context of this VRE during the last 12 months (Dec. 21 to Nov 22). Operations include service tasks needed to maintain the VRE operational as well as human tasks.

4.2 ARIADNEplus Mappings VRE

This VRE was conceived to be the working environment supporting the metadata mappings in the ARIADNEplus project. Only members of the ARIADNEplus consortium that deal with metadata mappings have access to this VRE.

The ARIADNEplus Mappings VRE is available at
https://ariadne.d4science.org/group/ariadneplus-gateway/explore?siteId=164895341

This VRE has been in operational status since February ’19 and it is currently serving 142 users as of end of November 2022. A screenshot of the VRE is provided in Figure 9. It shows the home page and the menu items for accessing the VRE tools, among which we find those tools needed by the members to perform their metadata mapping activities. Specifically, the **XML3 Mapping Tool**, the **Vocabulary Matching Tool**, and the **Activity Dash Tool** aiming at tracking the several processes (activities) of a workflow that might or not be executed in a certain order.

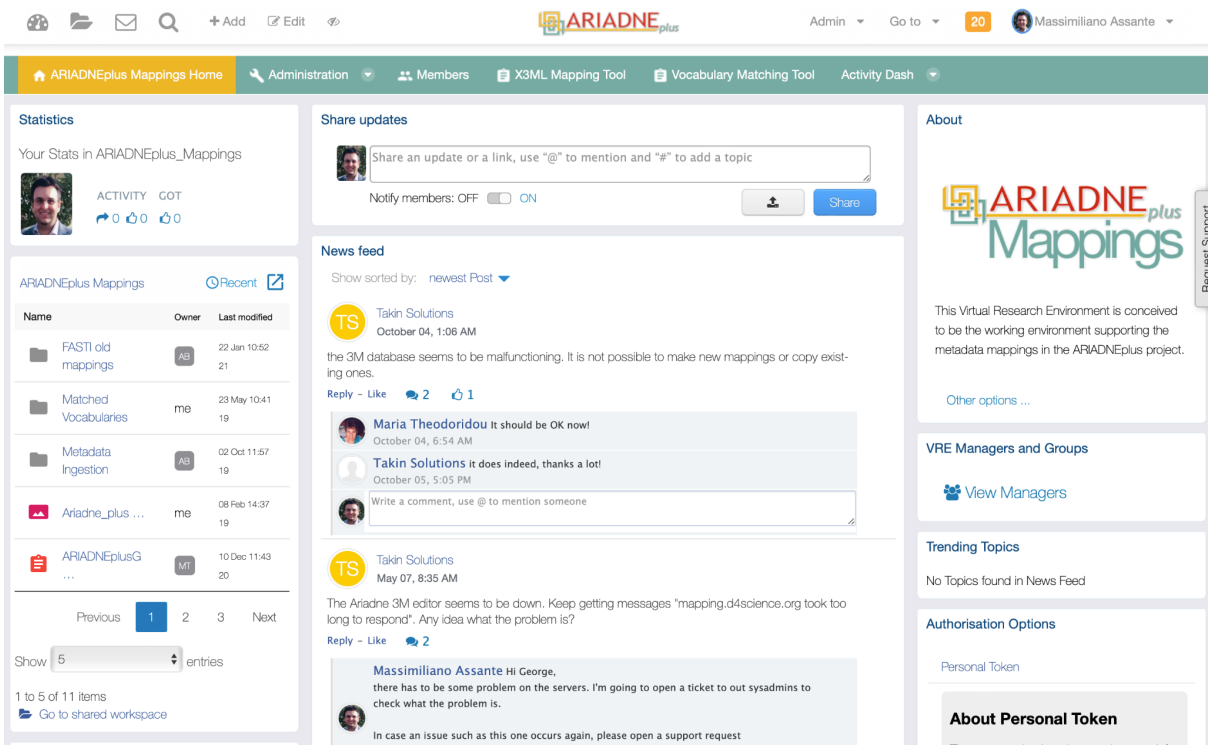


Figure 9 A Screenshot of the ARIADNEplus Mappings VRE home page and the menu items for the VRE tools.

In addition to the aforementioned VRE tools for metadata mappings and to the basic social communication functionality, this VRE is equipped with the following capabilities:

- A shared area in the workspace to make available objects of interests, e.g. mappings, vocabularies and working notes;
- A user management area that enables authorised users (i.e. VRE Managers) to manage other users using or willing to access the VRE. VRE Managers can (i) authorise users in accessing the VRE and its services, (ii) assign or withdraw roles to users, (iii) remove users, and (iv) send a communication to the current users;
- A Members area, for enabling each VRE member to be informed on the rest of VRE members and acquire details for contacting them.

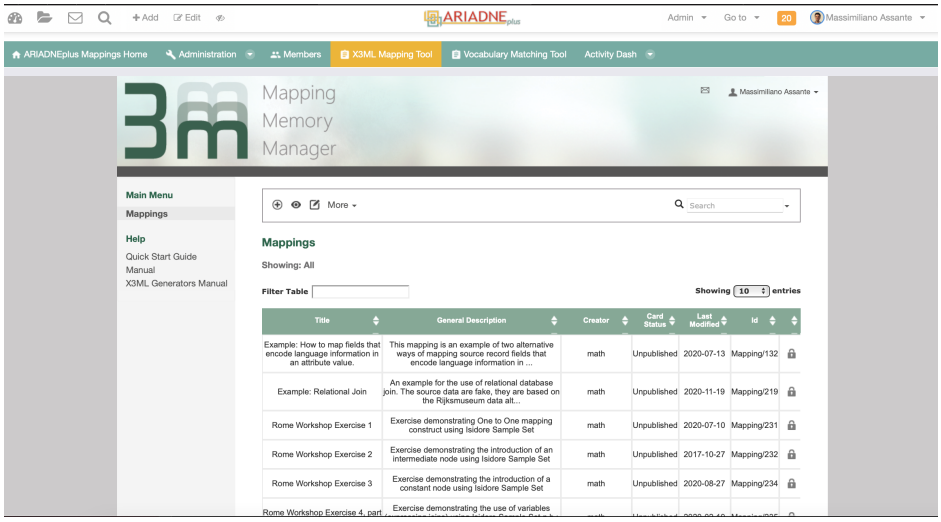


Figure 10 A Screenshot of one of the ARIADNEplus Mappings VRE tool: the 3M Mapping tool

Figure 10 shows the 3M Mapping tool available in the VRE. The 3M Mapping tool is provided by FORTH-ICS partner and integrated into the infrastructure. This tool assists users during the mapping definition process, using a human-friendly user interface and a set of sub-components that either suggests or validates the user input.

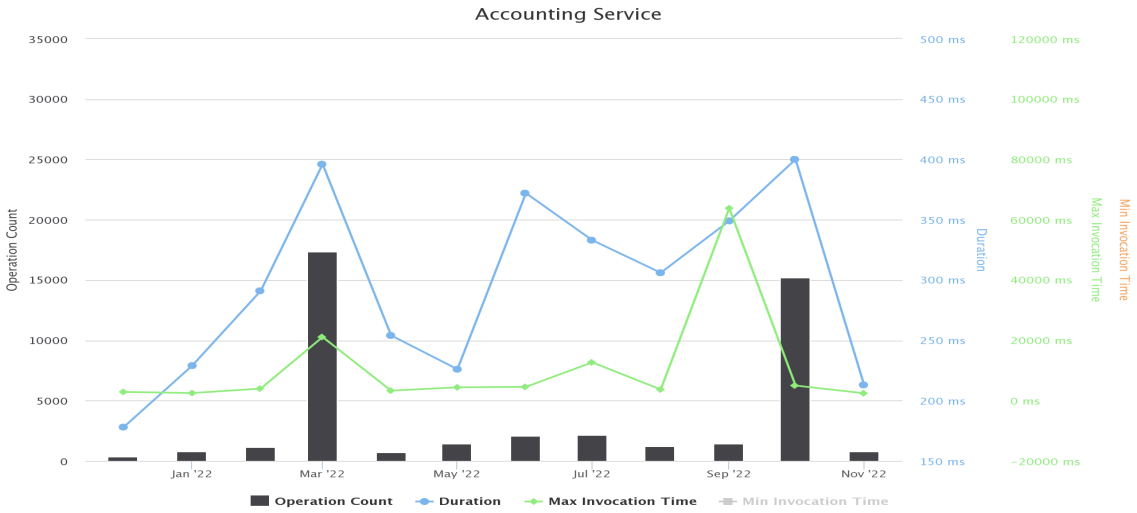


Figure 11 The ARIADNEplus Mappings VRE Operations per Month

Figure 11 reports the total amount of operations performed in the context of this VRE during the last 12 months (Dec. 21 to Nov 22). Operations include service tasks needed to maintain the VRE operational as well as human tasks.

4.3 ARIADNEplus Aggregation Management VRE

The goal of the VRE is to have a place where only some of the project partners can discuss in a controlled environment about data integration issues and possible procedures to activate

or propose to the whole consortium. The VRE access is therefore private, access only via managers' invitation.

The ARIADNEplus Aggregation Management VRE is available at
https://ariadne.d4science.org/group/ariadneplus-gateway/explore?siteId=233677541

This VRE has been in operational status since March 2020 and it is currently serving 11 users, as of end of November 2022, the ones needing to discuss data integration issues and procedures. A screenshot of the VRE is provided in Figure 12.

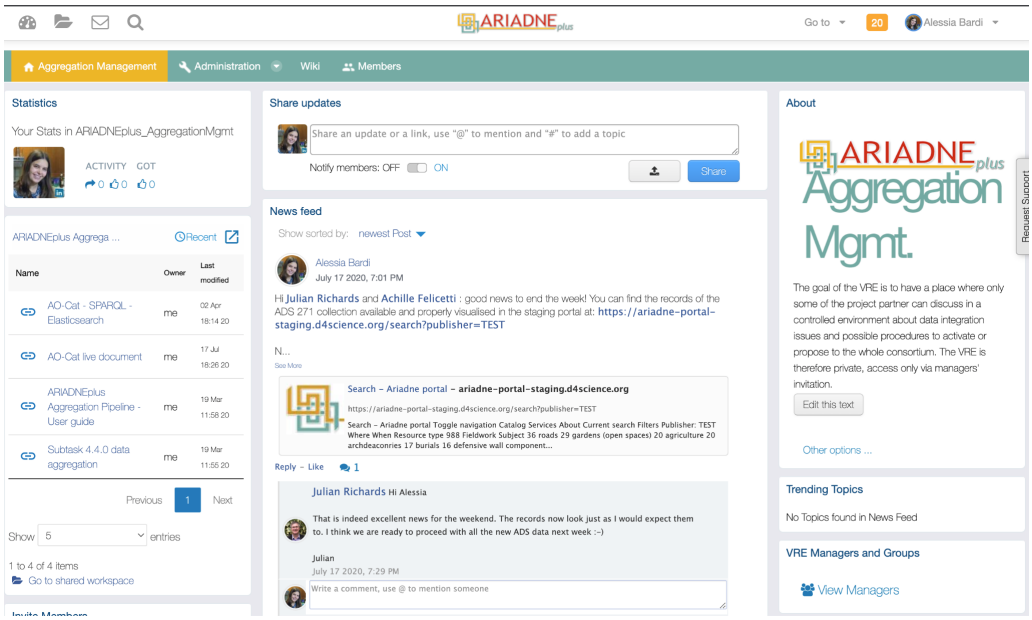


Figure 12 A Screenshot of the ARIADNEplus Aggregation Management VRE home page.

This VRE features basic functionality only. Specifically, a social networking area for supporting the discussions among members - which is especially used in this VRE - and a user management facility for managing membership.

4.4 Geoportal Prototype VRE

The Geoportal Prototype VRE (also named Geo-NA Prototype) was conceived to be a working environment developed for the integration, validation, harmonisation, visualisation, and access of archaeological georeferenced datasets collected in Italy. This prototype is intended to be a pilot for other national archaeological geoportals.

As it is still a prototype, the VRE contains data in Italian only to facilitate the participation of Italian archaeologists who are contributing to its development.

The Geoportal Prototype (Geo-NA Prototype) VRE is available at https://ariadne.d4science.org/group/ariadneplus-gateway/explore?siteId=229043941

This VRE has been in operational status since April 2020 and it is currently serving 24 users, those who are contributing to its development. A screenshot of the VRE is provided in Figure 13.

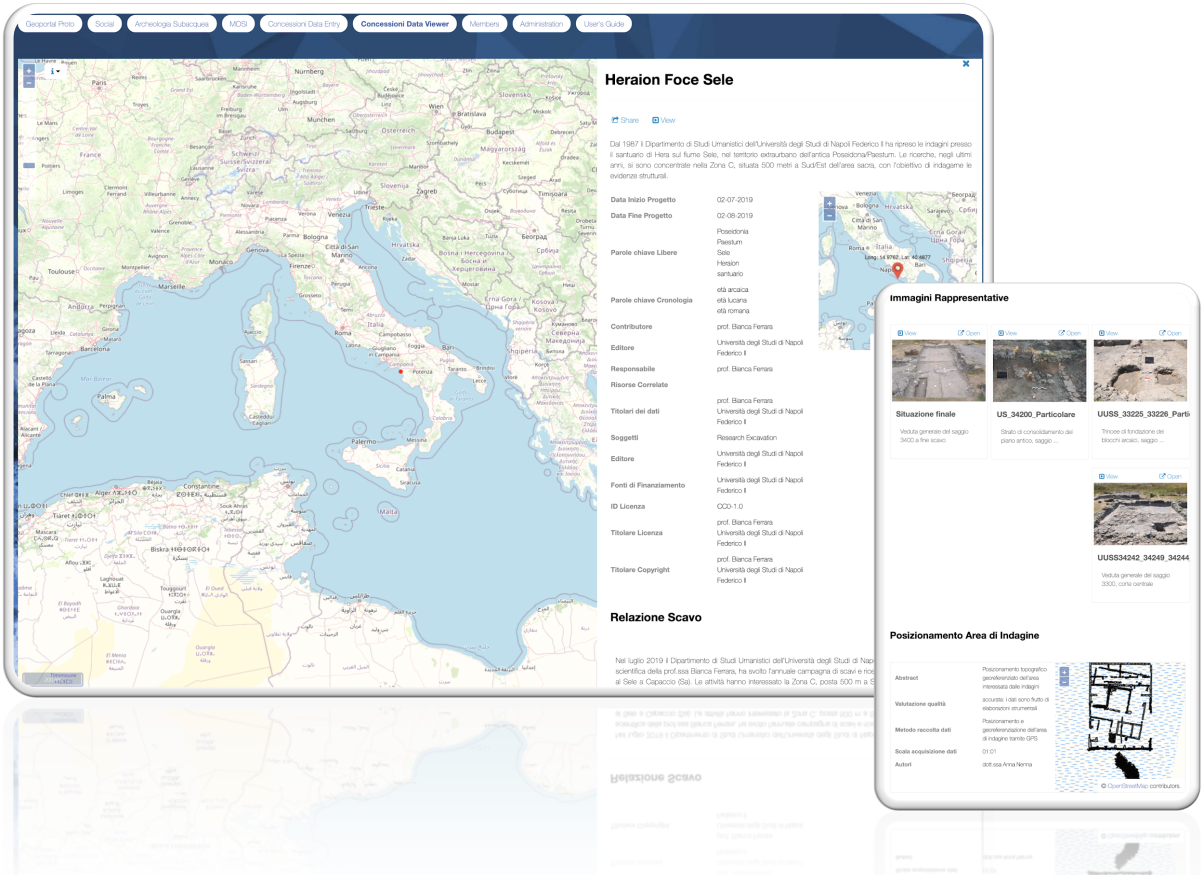


Figure 13 A Screenshot of the Geoportal Prototype VRE GIS Data Viewer page.

This VRE provides the following Dynamic GUIs:

- ***Data Collection Form*** assisting users to publish GIS projects;
- ***GIS Viewer*** allowing any user to visualise projects on a map;
- ***Project Viewer*** assisting users in accessing information, documents, images and datasets associated with the GIS project.

These dynamic GUIs exploit the (i) GeoPortal service, managing validation and management of GIS projects, described in D15.1 “Mid-term interim report on ARIADNEplus services”; the (ii) D4Science Workspace to store and access attached documents; and the (iii) D4Science SDI (Spatial Data Infrastructure) to offer OGC Compliant Services (e.g. WMS, WFS, WCS, etc.).

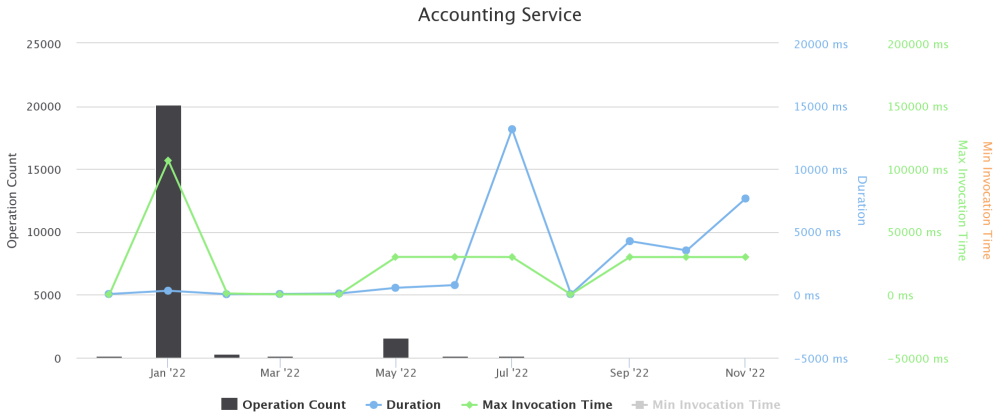


Figure 14 The Geoportal Prototype VRE Operations per Month

Figure 14 reports the total amount of operations performed in the context of this VRE during the last 12 months (December 2021 to November 2022). Operations include service tasks needed to maintain the VRE operational as well as human tasks. As one can see, the number of operations have a peak in January 2022 and are limited after that. The reason is that this VRE was used as a prototype for the Geoportale Nazionale per l'Archeologia (GNA) VRE (cf. Sec. 4.7) that was indeed released in January - February 2022, as the evolution of this Geoportal Prototype VRE.

4.5 Archeomar VRE

The Archeomar VRE was conceived as a working environment developed for the visualisation and controlled access of archaeological georeferenced datasets. These datasets contribute also to the Geoportal Prototype VRE.

This prototype is intended to be a pilot for other possible national archaeological geoportals.

At the moment the VRE contains data in Italian only, to facilitate the participation of Italian archaeologists who are contributing to its development.

The Archeomar VRE is available at https://archeomar.d4science.org

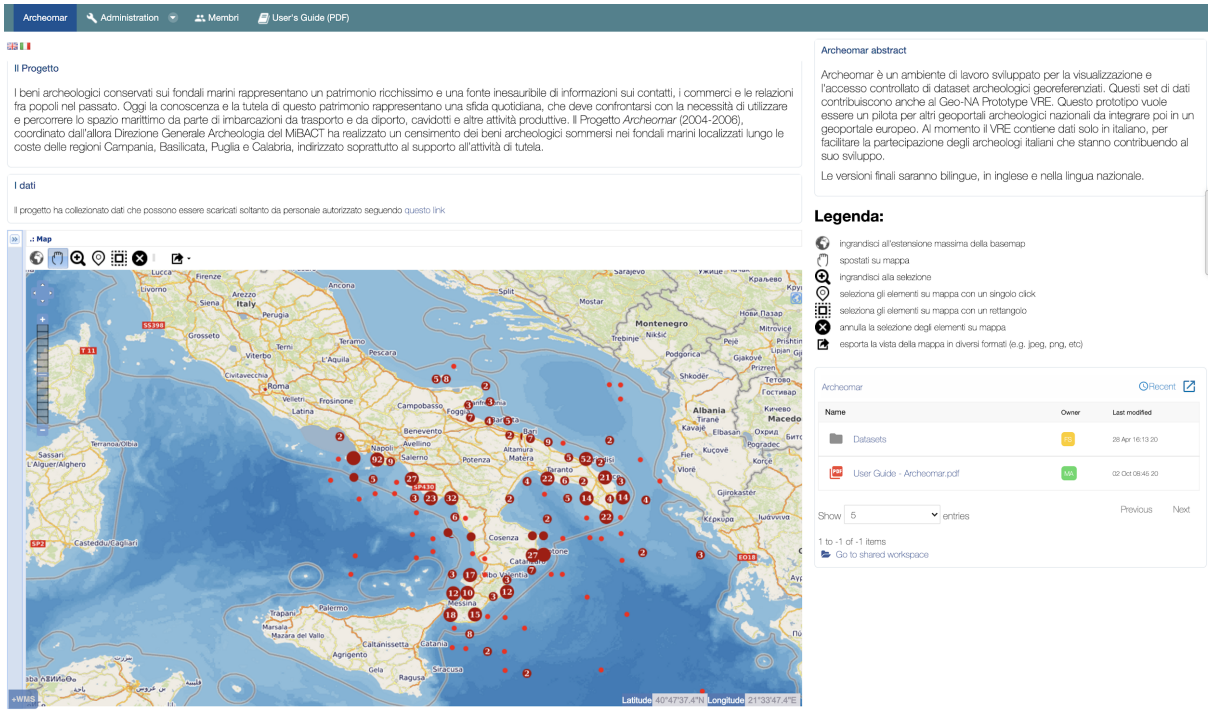


Figure 15 A Screenshot of the Archeomar VRE home page.

The Archeomar offers an interactive map which contains data that can be visualised through the application GIS viewer. The map displays part of the datasets created by the Archeomar Project (2004-2006). The project, coordinated by the Directorate General of Archeology of the MiBACT[4] Italy, carried out a census of the archaeological assets submerged in the seabed along the coasts of Campania, Basilicata, Puglia and Calabria regions, mainly aimed at supporting the activity of protection.

This VRE has been in operational status since April 2020 and it is currently serving 16 users, the ones needing to discuss data integration issues and contributing to its development. A screenshot of the VRE is provided in Figure 15.

4.6 ARIADNEplus Lab VRE

The ARIADNEplus Lab VRE has been developed to provide the ARIADNEplus community with a working environment to experiment with ARIADNEplus VRE facilities. This VRE provides archaeologists and scholars with a virtual research lab and a set of tools to aggregate the data of the ARIADNE infrastructure, make this data interoperable with personal external data, and to analyse and manipulate the data to answer specific research questions of archaeology or related disciplines.

[4] https://www.beniculturali.it

This VRE is available at https://ariadne.d4science.org/web/ariadneplus_lab

This VRE has been in operational status since July 2021 and it is currently serving 64 users. A screenshot of the VRE is available in Figure 16. It shows the home page and the menu items for accessing the VRE facilities.

The ARIADNEplus Lab VRE provides the following services:

- **JupyterHub**. It enables the exploitation of computational environments and resources without burdening users with installation and maintenance tasks. This JupyterHub environment is (i) preconfigured with libraries and packages to ease the execution of common data analytics tasks, and (ii) provides access to the Workspace enabling sharing of resources with other members much easier.
- **Analytics Engine**. The Analytics Engine (DataMiner) permits the execution of an array of analytics methods by transparently relying on distributed computing infrastructure. Executions can run either on multi-core machines or on different computational platforms, such as D4Science and other different private and commercial Cloud providers. New software can be integrated by using the dedicated Software Importer (SAI).
- **GraphDB**. It provides users with access to the ARIADNEplus Knowledge Base, an archaeological Linked Open Data set modelled according to the ARIADNE ontology and provided by an international network of organisations. With GraphDB, any user can explore the knowledge base with the available web GUI or programmatically with SPARQL queries. For details, the user guide is accessible as an executable Jupyter Notebook within the same laboratory.
- **RStudio**. It provides an integrated development environment for R. It includes a console and a syntax-highlighting editor, and it enables code execution. Tools for plotting are also included. This RStudio environment is (i) preconfigured with libraries and packages to ease the execution of common data analytics tasks, and (ii) provides seamless access to the Workspace enabling sharing of resources with other members much easier.

In addition to the aforementioned VRE tools for data aggregation and analysis, and to the basic social communication functionality, this VRE is equipped with the following capabilities:

- A shared area in the workspace, that makes available objects of interests, e.g. datasets, maps, SPARQL queries, and working notes;
- A user management area, enabling authorised users (i.e. VRE Managers) to manage other users using or willing to access the VRE. VRE Managers can (i) authorise users in accessing the VRE and its services, (ii) assign or withdraw roles to users, (iii) remove users, and (iv) send a communication to the current users;

- A Members area, providing each VRE member information about the other VRE members and also allowing them to acquire details for contacting each other.

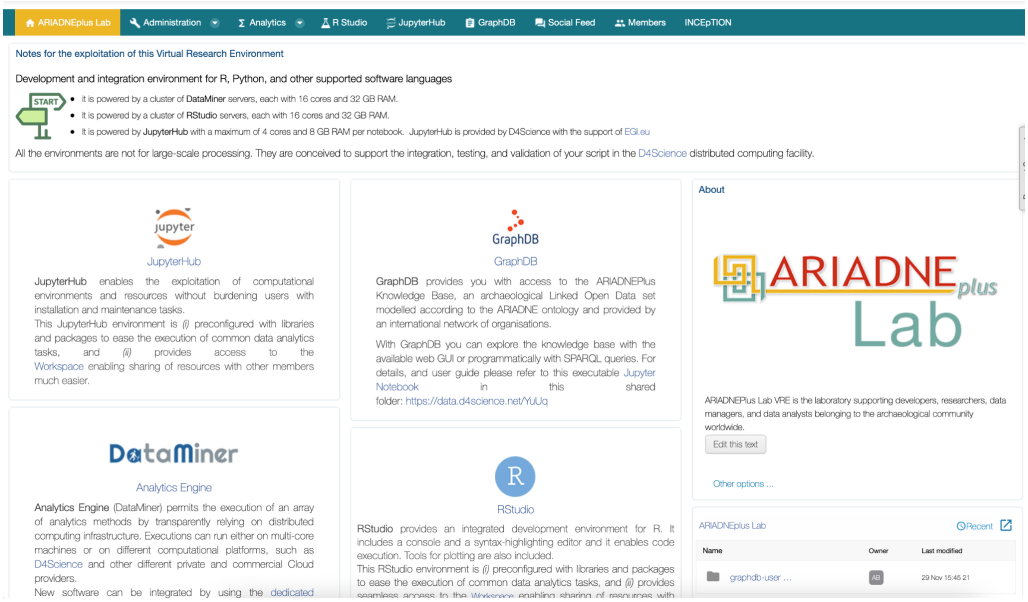


Figure 16 A Screenshot of the ARIADNEplus Lab VRE home page

4.7 Geoportale Nazionale per l'Archeologia (GNA) VRE

The "Geoportale Nazionale per l'Archeologia (GNA)" VRE has been in operational status since January 2022 as the evolution of the existing Geoportal Prototype VRE (cf. Sec. 4.4). This VRE is currently serving 64 users and it was created for the integration, validation, harmonization, visualization, and access of archaeological georeferenced datasets collected in Italy.

The GNA VRE consists of *(i)* an application, namely "Concessioni Data Entry", that allows publishing an excavation concession in the GNA service and, once published, update its content (metadata and files) and *(ii)* a data viewer application, namely "Concessioni Data Viewer" which is configured as an open format access and exchange point for archiving, researching and knowledge of data relating to Italian archaeology. The GNA offers a system that includes not only data relating to the protection interventions by the Ministry (preventive archaeology, emergency excavations) but also the results of field investigations conducted by universities and other research institutions, with a view to data-sharing and collaboration between the Ministry, the academic world and other subjects who work in the field for various reasons, contributing to the knowledge and protection of the national archaeological heritage.

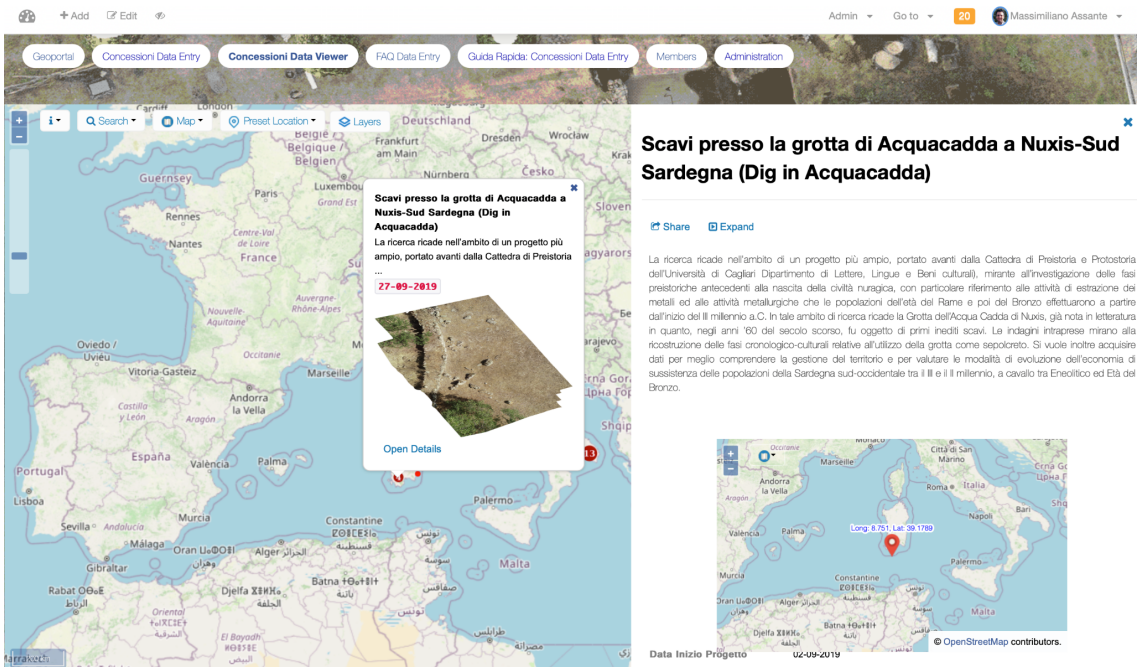


Figure 17 A Screenshot of the GNA VRE Data Viewer

Figure 17 shows the Data Viewer in action, while Figure 18 reports the total amount of operations performed in the context of this VRE during the last 12 months (December 2021 to November 2022). Operations include service tasks needed to maintain the VRE operational as well as human tasks.

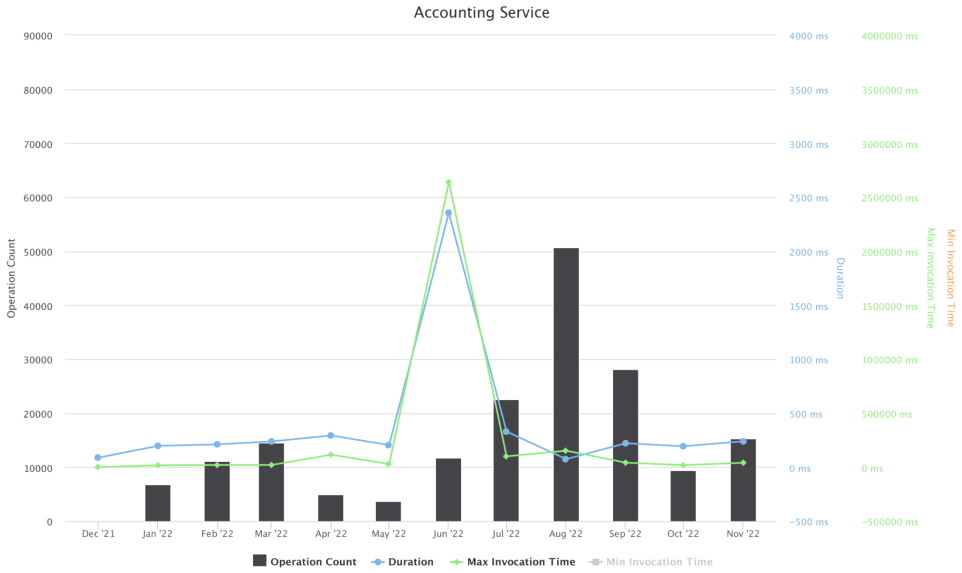


Figure 18 The GNA VRE Operations per Month

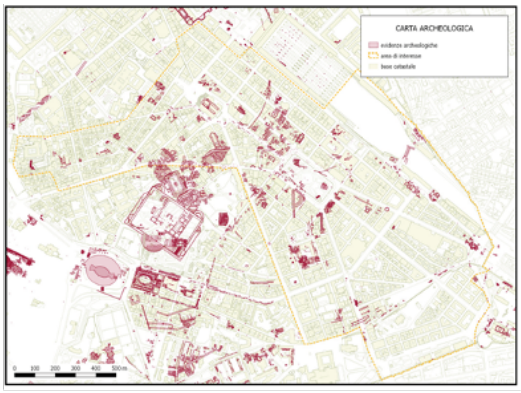
4.8 Esquiline VRE

The Esquiline was a boundary zone between the urban and extra-urban areas of ancient Rome, providing archaeological data about both funerary and settlement contexts.

The Esquiline VRE offers services for the exploitation of temporal GIS technology to offer new methods of investigation and data presentation, paving the way to innovative site analyses aimed at integrating excavation data from different archives, allowing the re-creation of the archaeological context where layers of findings overlap over the time.

It integrates the data and tools operated by SITAR WebGIS. The SITAR WebGIS was designed and implemented by the Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma (formerly the Soprintendenza Speciale per il Colosseo, the Roman National Museum and the Archaeological Area of Rome), with its own financial resources and thanks to the commitment of an internal working group and a technical-scientific service specially set up for the implementation of its SITAR Project - Archaeological Territorial Information System of Rome.

The case study area in the contemporary city



Archaeological map of the case study area

Figure 19 A Screenshot of the Esquiline area

Figure 20 A Screenshot of the Esquiline VRE

5 Concluding Remarks

Virtual Research Environments are among the key products to be delivered by the ARIADNEplus project to meet the needs of its target community and application scenarios. They are "systems" aiming at providing their users with web-based working environments that offer the entire spectrum of facilities (including services, data and computational facilities) needed to accomplish a given task by dynamically relying on the underlying infrastructure.

This deliverable D13.4 focuses on how the components have been exploited and operated to support the development of the ARIADNEplus VRE gateway[5], its underlying infrastructure, and the VREs developed from M25 (January 2021) to M47 (November 2022). Overall, D13.4 detailed the Virtual Research Environments deployed and operated during the 4 years of the ARIADNEplus Project (from January 2019 to December 2022): 8 VREs in total, five of them in the first 2 years of the project, and the remaining 3 in 2021 and 2022. These activities have been carried out within Work Package 13, specifically Task 13.1 Infrastructure Operation (JRA2.1) and Task 13.3 VREs Operation (JRA2.3).

These VREs are serving the needs of more than 400 total users spread across 21 countries and more than 10.000 user sessions. This required to deal with approximately 100 tickets (59 requests for support, 9 requests for incidents and bugs, 9 requests for Virtual Machine or Container creations).

[5] https://ariadne.d4science.org

6 References

1. *M. Assante, L. Candela, D. Castelli, R. Cirillo, G. Coro, L. Frosini, L. Lelii, F. Mangiacrapa, P. Pagano, G. Panichi, F. Sinibaldi*. (2019). **Enacting open science by D4Science**, Future Generation Computer System

2. *Assante, M., Candela, L., Castelli, D., Cirillo, R., Coro, G., Frosini, L., Lelii, L., Mangiacrapa, F., Marioli, V., Pagano, P., Panichi, G., Perciante, C., Sinibaldi, F.* (2019). **The gCube System: Delivering Virtual Research Environments as-a-Service**. Future Generation Computer Systems, Vol. 95