# D6.2 Initial Report on the Project Impact

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## About this document

This document is a contractual deliverable of the ARIADNE - Advanced Research Infrastructure for Archaeological Dataset Networking in Europe – Plus project. It presents the Initial Report on the Project Impact (D6.2) that has been produced under WP6 "Fostering Innovation and Impact". The research leading to these results has received funding from the European Community's Horizon 2020 Programme (H2020-INFRAIA-2018-1) under grant agreement n° 823914. But the content of this document cannot be considered to reflect the views of the European Commission.

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# Table of contents

## Acronyms of ARIADNE partners

ADS — Archaeology Data Service, University of York, United Kingdom

AIAC — Associazione Internazionale di Archeologia Classica, Italy

AMZ — Arheoloski muzej u Zagrebu / Archaeological Museum of Zagreb, Croatia

ARUP-CAS — Archeologicky ustav AV CR, Praha, v.v.i. / Institute of Archaeology of the Academy of Science, Czech Republic

ASU — Arizona State University, Center for Digital Antiquity, United States

ATHENA-RC — Athena Research and Innovation Center, Institute for the Management of Information Systems, Greece

AU — Aarhus University, School of Culture and Society - Department of Archeology and Heritage Studies, Denmark

BUP — Bruxelles Urbanisme & Patrimoine, Direction des Monuments et Sites, Belgium

CARARE — Connecting Archaeology and Architecture in Europe, Ireland

CENIEH — National Research Centre on Human Evolution, Spain

CNR-ISTI — Consiglio Nazionale delle Ricerche, Istituto di Scienza e Tecnologie della Informazione, Italy

CNRS — Centre National de la Recherche Scientifique (CNRS), TGIR Huma-Num, France

CONICET — Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Instituto de Antropología de Córdoba - IDACOR, Argentina

CYI-STARC — The Cyprus Institute, Science & Technology in Archaeology Research Center, Cyprus

DANS — Data Archiving and Networked Services, Netherlands Academy of Arts and Sciences, Netherlands

DGPC — Directorate-General for Cultural Heritage, Portugal

FI — Fornleifastofnun Islands, Institute of Archaeology, Iceland

FORTH-ICS — Foundation for Research and Technology Hellas, Institute of Computer Science, Greece

HNM — Hungarian National Museum, Hungary

IAA — Israel Antiquities Authority, Archaeological Division, Israel

IAVP — Institutul de Arheologie Vasile Parvan, Romania

ICA — Istituto Centrale per l'Archeologia (Institute under the Ministry of Culture), Italy

ICCU — Istituto Centrale per il Catalogo Unico (Institute under the Ministry of Culture), Italy

INFN — Istituto Nazionale di Fisica Nucleare, INFN-Sezione di Firenze, INFN-Cultural Heritage NETwork, Italy

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| INP | Institutul Național al Patrimoniului / National Heritage Institute of Romania, Museum and Archaeological Documentation Department, Romania |
| INRAP | Institut National des Recherches Archéologiques Préventives, France |
| KHM-UO | Museum of Cultural History, University of Oslo, Norway |
| LNEC | Laboratorio Nacional de Engenharia Civil, Portugal |
| NARA | NARA National Research Institute for Cultural Properties, Japan |
| NIAM-BAS | National Institute of Archaeology with Museum, Bulgarian Academy of Sciences, Bulgaria |
| ÖAW ACDH-CH | Österreichische Akademie der Wissenschaften, Austrian Centre for Digital Humanities and Cultural Heritage, Austria |
| PIN | PIN Soc.Cons.A.R.L. - Servizi Didattici e Scientifici per l'Università di Firenze s.c.r.l., Italy |
| PP | University of Patras, Department of Cultural Heritage Management and New Technologies, Greece |
| RGK | Römisch-Germanische Kommission des Deutschen Archäologischen Instituts, Germany |
| RUG | University of Groningen, Groningen Institute of Archaeology, Netherlands |
| SRFG | Salzburg Research Forschungsgesellschaft, Austria |
| SND | Swedish National Data Service, University of Gothenburg, Sweden |
| UB | Universitat de Barcelona, Departamento de Historia y Arqueología, Spain |
| UH | University of Helsinki, Department of Cultures, Finland |
| USW | University of South Wales, School of Computing and Mathematics, Hypermedia Research Group, United Kingdom |
| UniRoma1 | Sapienza Università di Roma, Dipartimento di Biologia Ambientale, Italy |
| ZRC-SAZU | Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Institut of Archaeology, Slovenia |

# 1    Executive Summary

## 1.1    ARIADNEplus in brief

The overall objective of the ARIADNE initiative is to help the archaeological research and data management communities in Europe (and beyond) to more effectively share and reuse data which are dispersed and often difficult to discover and access. For this purpose the initiative has developed a digital infrastructure and services that enable registration, aggregation, integration, and search and retrieval of data records which describe and link to available data.

The initial ARIADNE project has implemented the first e-Infrastructure services for this. ARIADNEplus enhances these services and provides several new or enhanced e-research services. The initial ARIADNE project had 23 partners while ARIADNEplus has a consortium of 41 partners, now comprising 37 formal partners from 23 European countries and one each from the United States, Argentina, Israel and Japan. Still growing, ARIADNEplus already has 10 associated partners.

ARIADNEplus will integrate data resources from many more archaeological domains and methods than the initial ARIADNE project. For example, this includes paleo-anthropology, bioarchaeology and environmental archaeology, studies of inorganic materials such as metals or ceramics, satellite and aerial imagery from remote sensing, and more.

The whole e-Infrastructure has now been moved to a Cloud-based platform. Furthermore, the aggregated data records are transformed into Linked Data, which enables novel ways to search and browse data based on the relations detected between them.

Thus ARIADNEplus takes the next steps in enabling data sharing, integration and (re)use for archaeological research across institutional and national, as well as disciplinary boundaries. Fostering a culture of data sharing and reuse, alongside joint capacity building will be crucial for the take-up of the ARIADNEplus FAIR data resources, common e-infrastructure and services.

## 1.2    Framework of the impact evaluation

This ARIADNEplus deliverable presents the Initial Report on the Project Impact in month 30 of the 48 months lifecycle of the project. The evaluation of the project results covers all activities of the project.

ARIADNEplus is an Integrating Activity funded under the Horizon 2020 Work Programme 2018-2020 for European Research Infrastructures, including e-Infrastructures, henceforth short: RI Programme. An Integrating Activity has to implement three lines of activities, Networking, Transnational access and virtual access, and Joint research activities.

A common evaluation scheme for Integrating Activities does not exist, but ARIADNEplus developed a monitoring and reporting framework, taking full account of the statements of expected impacts of the RI Programme and/or its section "Specific features for Research Infrastructures", Part D.

*Chapter 2* comprises the summarised results of 11 areas of project activities, stated or implied by the expressed expectations of the RI Programme:

- Extension of the stakeholder community

- Supporting the FAIR data agenda in archaeology

- Standardisation of archaeological datasets

- Access to integrated knowledge-based resources

- New services and virtual research environments (VREs)

- Research infrastructures coordination

- Cross-disciplinary fertilisation and sharing of resources

- Innovation and partnership with industry

- Use of services beyond research

- TNA, training activities and materials

- Dissemination and communication

These activities have different weights, for example, *Access to integrated knowledge-based* resources comprises the whole ARIADNEplus Data Portal and integrated datasets, while *Use of services beyond research* is not a project priority, but is nevertheless one of its ambitions.

The initial evaluation report shows that the project achieved essential results in the core areas of activities in the reporting period, specifically the definition and implementation of the new data models, development and launch of the new Data Portal, and ingest of an already large volume of data records. Also in other areas significant results have been achieved, while in others the work started and will be progressed in the next phase of the project, particularly development of ARIADNEplus VREs and demonstration Pilots.

*Chapter 3* outlines the framework. It describes in greater detail the Integrating Activity scheme, gives important background for the expected impact statements, briefly discusses the 10 statements, and references the sections which present the related activities and results achieved.

# 2      Summary report of results

This chapter presents the summarised results of the 11 areas of project activity.

## Extension of the stakeholder community

*> Refers to RI Programme expected impact statement [6].*

The leading role of the ARIADNE initiative as integrator of archaeological data resources and driving the FAIR data agenda in the domain is confirmed by its growth and recognition by the main bodies for archaeology in Europe.

The ARIADNEplus project started in January 2019 with a consortium of 41 partners, up from 23 of the initial ARIADNE project, now including partners from the United States, Argentina, Israel and Japan. Thus the ARIADNE initiative is now present more strongly across Europe but in other world regions as well.

Most of the archaeological partners of ARIADNEplus also participate in the COST Action SEADDA (Saving European Archaeology from a Digital Dark Age), a partnership with representation from nearly all European countries, not only those in the EU.

SEADDA and ARIADNEplus have complementary goals. SEADDA is focussed on ensuring a more sustainabile future for digital archaeological resources through the creation of new and better repositories, while ARIADNEplus supports finding and accessing data that is being shared through existing and new repositories.

ARIADNEplus increasingly receives requests by organisations to join the ARIADNE network as an associated partner or project. Meanwhile 10 European organisations have already joined the network as associated partners, including heritage authorities, archaeological institutes, as well as domain research and technology centres.

Through associated projects the ARIADNE network also expands regionally, e.g. through the North African Heritage Archive Network (NAHAN), and thematically, e.g. through the ROCEEH project in the field of Palaeanthropology in regions of Africa, the Levant, Eurasia and Europe.

The importance of the ARIADNE initiative is recognised by the European Archaeological Council (EAC) and the European Association of Archaeologists (EAA). The President of EAA and the former President of the EAC both sit on the ARIADNEplus Scientific Advisory Board, ensuring regular dialogue with both organisations.

The ARIADNE research infrastructure clearly supports community needs for services enabling data sharing, discovery and access. The results of the community needs survey in 2019, with responses of 484 researchers and data managers from all partner countries and others included in the analysis, confirmed high appreciation of the initial ARIADNE services and planned advancement of new services.

The extended stakeholder community also welcomes guidance from ARIADNEplus in the application of the FAIR data principles in archaeology.

## Supporting the FAIR data agenda in archaeology

*> Refers to RI Programme section "Specific features for Research Infrastructures", Part D, (i) Networking Activities.*

ARIADNEplus is committed to promoting the FAIR data agenda within the archaeological sector in Europe (and beyond), in line with the respective policies of the European Commission and EU member states on open access to research publications and data.

The Board of the European Association of Archaeologists (EAA) has endorsed the FAIR principles and proposed a collaboration with ARIADNEplus for their implementation in archaeology. The European Archaeological Council (EAC) works with SEADDA, the sister project of ARIADNEplus, on progressing the FAIR data agenda in the sector.

Furthermore, an international collaboration on the implementation of the FAIR data principles in archaeology has been initiated, currently involving American and European archaeological research centres, data repositories and initiatives, such as the Coalition for Archaeological Synthesis (CfAS). The overall goal is to advance comparative and synthetic research in archaeology for which FAIR datasets are required to enable aggregation and analysis.

The immediate promotion of FAIR data by ARIADNEplus takes different forms, including recommend-dations and dissemination of guidance, a FAIR data management plan (DMP) template for archaeologists, FAIR as part of training activities, and an online hub of training materials.

Researchers and data managers in archaeology look for practical guidance on what is meant by FAIR data and how to create and make it available. ARIADNEplus and SEADDA adopted the PARTHENOS FAIRify Guidelines and supported the dissemination of versions in different languages in the archaeological community.

Meanwhile there were nearly 2,500 unique downloads of the guidelines from the Zenodo repository, comprising downloads of the available versions in Czech, English, French, German, Greek, Hungarian, Italian, Portuguese and Turkish.

ARIADNEplus promotes the standardisation of Data Management Plans (DMPs) and appropriate practices of archaeological researchers and projects, taking account of the particular requirements of archaeological datasets. A domain-specific DMP protocol has been prepared, corresponding with the respective guidance for domain-specific DMPs of the Science Europe group of research funders and organisations.

An ARIADNEplus team has developed an online DMP tool that supports archaeological researchers in creating a DMP for their project, conforming to the standard criteria of the domain. Furthermore, in a collaboration with OpenAIRE, the requirements for making the DMP machine-actionable have been investigated.

### Standardisation of archaeological datasets

*> Refers to RI Programme expected impact statement [8].*

ARIADNEplus promotes standardisation and integration of archaeological datasets based on the ISO standard CIDOC CRM (Conceptual Reference Model) and domain-specific extensions, for example, CRMarcheo for excavations. Created in the first ARIADNE project, CRMarchaeo has been adopted by other archaeological research projects.

Importantly, the ARIADNE initiative not only provides CRM extensions but also  the 3M (Mapping Memory Manager) system developed by FORTH-ICS, the most advanced tool for mapping datasets to the CRM and extensions, or other application profiles. The system can be accessed and used within the ARIADNEplus D4Science space.

The data catalogue developed in the first ARIADNE project (ACDM) initiated the CRM-based standard-isation of data catalogues in archaeology, cultural heritage and related fields of the humanities. Based on jointly developed expertise, the new ARIADNE data catalogue model (AO-Cat) provides greater flexibility and detail to describe data collections as well as individual items.

Deeper integration of domain-specific datasets is now possible within ARIADNEplus, through the creation of CRM-based Application Profiles. These profiles extend the AO-Cat ontology by including

specific classes and properties to better describe datasets within archaeological sub-domains such as archaeometry (e.g. material studies and dating) and ancient DNA studies, but also studies of inscriptions (e.g. rock carvings, inscriptions on amphorae), for example.

A major part of the practical standardisation work of the ARIADNE initiative in the field of archaeology is demonstrating the power of using common vocabularies for data integration. The core examples here are the Getty Art and Architecture Thesaurus (AAT) and the PeriodO gazetteer for cultural period definitions.

For their resource subjects, partners create semantic mappings of terms using their "local" vocabularies (thesauri, term lists) to concepts/terms of the large multilingual Getty AAT. This enables subject-based searches within the ARIADNE Data Portal across the different data collections and records. Within the first phase of ARIADNE, 12 partners mapped over 6,400 terms (in different languages) from 27 national or local vocabularies (thesauri, term lists) to the AAT. For ARIADNEplus the total number of mappings thusfar has climbed to over 15,700, representing the mappings of 22 partners.

Again, as in the case of the FORTH 3M system (for CRM mapping), a state-of-the-art tool for vocabulary mappings is being provided with USW Vocabulary Matching Tool. This tools is also available via the D4Science platform.

The PeriodO gazetteer system provides unique identifiers (URIs) for cultural period definitions which allow clear and stable linking of archaeological and historical data resources which refer to the same period. Begun in the first ARIADNE project, ARIADENplus represents the largest contribution of cultural chronologies and periods within PeriodO, representing 24 European countries and regions. The collection is now being extended by ARIADNEplus partners and associated projects (e.g. ROCEEH provided 134 named periods used within Paleoanthropology, including a set of period labels in Africaans).

The semantic integration of datasets based on the AO-Cat, the Getty AAT and PeriodO allows users of the ARIADNE Portal to find, for example, relevant data for "Iron Age" research from different countries, although the "Iron Age" has a different time-span in France, England and Ireland, allowing the Data Portal to become an effective tool for researchers in archaeology and cultural heritage.

## Access to integrated knowledge-based resources

*> Refers to RI Programme expected impact statement [8].*

The new ARIADNE Data Portal exploits the enhanced integration of knowledge-based data resources, i.e. resources described with the CRM-based data catalogue model (AO-Cat) and common terminology used within the domain, such as AAT, PeriodO and other vocabularies. These complex enhancements, including definition, implementation, remapping of datasets, testing and revisions, represent nearly two years work, although the impact of the COVID-19 crisis has slowed the planned progress.

**The new Data Portal as an effective research tool**

Meanwhile the new ARIADNE Portal has now been released with enhanced search, visualisation and exploration capabilities. It includes many new features within the Map-based search (e.g. viewing of different layers, polygon-based search), various options for filtering data records, which can also be applied to both the Map and Timeline search, improved resource landing pages, and more.

Results of the community needs survey have been duly considered, as seen for example with the extra effort invested on the Map search facility to support high user interest in more refined location-based search of the resources.

The initial ARIADNE search and access portal has been turned into an effective tool for researchers in archaeology and cultural heritage. Use of different search filters allows new types of research, for example, exploration of settlement patterns in different regions and periods, patterns of artefacts found in different regions of a country or across different countries, etc.

Previously, these research outcomes were not as easily achieved. It reduces researcher effort in discovering, combining and using data for comparative research. The new ARIADNE Portal supports these tasks in an integrated way, and with the ingest of more datasets from different countries the potential to exploit this functionality will continue to increase.

**Ingestion of datasets**

At present the new ARIADNE Portal contains 1,782,988 data records (as of 16 June, 2021), which are based on the advanced semantic AO-CAT data model and domain vocabularies. These are records from 10 of the project data providers, while datasets from several others are currently in the ingestion ingestion process (which will bring to total to 1,938,470 records), and more being prepared for aggregation and transformation within the data catalogue. In the coming month the total number of cross-searchable records will climb over 2 million.

**Portal access and usage**

From January to May 2021, there were nearly 2,000 unique visits to the ARIADNE Portal, primarily from Europe (85%), followed by North America (7.6%) and Asia (3.7%), and minor use from other regions. Among European countries, the UK stands out with 44.8% of the visits, followed by Italy with 6.4%, Bulgaria with 6.2%, France and Netherlands each with 4.5%, Germany and Sweden with 2.7%.

Analysis of the portal usage showed that visitors looked up the "About" page and "Services" page, and conducted various searches. The most interest was attracted by the map-based search facility with 433 searches, followed by 397 keyword-based searches, and 92 uses of the timeline-based search.

The promotion of the Data Portal follows a "soft launch" approach with national announcements when new partner data from that country has been added. Thereby the number of visitors is expected to grow as potential portal users are invited to explore newly added datasets from their country, along with the existing data.

## New services and virtual research environments (VREs)

*> Refers to RI Programme expected impact statement [2].*

**New and advanced e-research services**

While the ARIADNE Portal already provides an effective research tool, new and advanced e-research services will continue to be added or provided within virtual research environments (VREs). These e-research services will be demonstated in some of the planned ARIADNEplus Pilots.

The VRE services will be hosted by the Cloud-based D4Science platform provided by CNR-ISTI, where the previously mentioned CIDOC CRM and vocabulary mapping tools are already in productive use.

Some services may also allow enhancement of the Portal, for example, the CNR-ISTI Cloud-based Geoserver, which provides geospatial/GIS functionality. Already planned is an ARIADNEplus Pilot by the Istituto Centrale per l'Archeologia (ICA) which will allow users explore the spatio-temporal development of a part of ancient Rome.

Among the advanced services are the Visual Media Services (VMS) of CNR-ISTI VCLab, which enable effective online publication and exploration of enhanced images (e.g. Reflectance Transformation Imaging - RTI) and 3D models of buildings and artefacts. Released in early 2015, the original VMS have so far been employed by 460 researchers and other users.

The advanced VMS will have new functionanlity, for example, users will be able to link documentation to selected parts of a 3D model of a monument or artefact. This will be used in one of the ARIADNEplus Pilots by CYI-STARC. A major ongoing development will make the VMS ready to effectively handle LiDAR data. When completed, this new service will be employed in an ARIADNEplus Pilot by ZRC-SAZU.

Advanced Natural Language Processing (NLP) has already been implemented, building on the expertise gained in the first ARIADNE project and subsequent developments, e.g. within an EOSCpilot demonstrator (Textcrowd). Thusfar, experiments have been conducted on archaeological documents in Dutch, English, Italian and Swedish. A large demonstration pilot is intended by INRAP using reports in French from their preventive archaeology work.

The planned portfolio of e-research services also includes annotation and linking of text and image items (e.g. fieldwork reports, artefact or laboratory images), to enable multidisciplinary, Linked Data-based referencing of items.

**Virtual Research Environments (VREs)**

VREs are one of the most ambitious innovation goals for ARIADNEplus in the field of archaeological research. VREs combine and tailor services for the specific research tasks and data types of a community of researchers. VREs must be co-designed by archaeologists and technical experts to ensure the research environment is relevant and fit for purpose.

To kick-start the development, a series of VRE use-case workshops are planned. Their purpose is to promote thinking by archaeological research communities represented within ARIADNEplus about which data-related research tasks can be supported by VRE services. This is expected to generate "wish lists" and general and domain-specific community requirements for services, which will provide a basis for functional descriptions of VREs seen as relevant.

Workshops have already been held involving two of the thematic domains represented in ARIADNEplus: Geospatial and Mortuary Data and Research (January 2021), and Ancient DNA and Environmental Data and Research (May 2021). Two further workshops will be held in the last quarter of 2021: Archaeological Science (involving domains in addition to aDNA research), and Spatial Applications, to accommodate the ARIADNEplus Pilots in which the spatial dimension plays a particularly important role.

## Research infrastructures coordination

*> Refers to RI Programme expected impact statement [3]*

Coordination with related e-Infrastructures in the field of humanities and heritage research started within the first ARIADNE project through networking with the major European projects already active at that time, CENDARI, CLARIN, DARIAH and Europeana.

A regular exchange with Europeana has continued, as the core focus of Europeana is making digital/digitised cultural heritage content accessible, including archaeology content. Among the common topics with Europeana research groups is the growing importance of 3D content, use of Cloud-based solutions, and adoption of the FAIR principles by cultural heritage institutions.

A major strand of joint development between the ARIADNE initiative and other research data infrastructures has been CIDOC CRM-based models for catalogues of humanities and heritage data resources. The initial model created by ARIADNE for archaeology has been taken up by the PARTHENOS humanities and social sciences e-Infrastructures cluster project (which included CLARIN and DARIAH, and leading national digital humanities centres). In turn, the PARTHENOS catalogue model provided the basis for the current ARIADNEplus model (AO-Cat).

While this has advanced considerably, the model still allows alignment of digital humanities, archaeology and heritage science data catalogues, enabling significant synergies between the different research infrastructures and domains of research they serve.

Close relations exist with the research infrastructure E-RIHS for heritage science as several partners were involved in the preparatory phase of E-RIHS. Particularly relevant for ARIADNEplus are scientific data from advanced methods of material analyses and conservation of artifacts. As some ARIADNEplus partners employ such methods, the CIDOC CRM extension CRMhs (heritage science) has been created, also as a contribution to the future E-RIHS DIGILAB component.

The first showcase implementation of the CRMhs is planned by the ARIADNEplus partner INFN, from which records will be included in the ARIADNE data portal.

Overall, the common point of coordination between research infrastructures, particularly their e-Infrastructure component, is the European Open Science Cloud (EOSC) initiative. ARIADNEplus aims for full integration into the EOSC. Therefore ARIADNEplus will register its portfolio of Cloud-based services in the EOSC "marketplace" (catalogue of resources).

Some Cloud-based services provided by CNR-ISTI for ARIADNEplus can already be found in the EOSC Portal Catalogue and Marketplace; for example, the Visual Media Service VRE and the more generic RPrototypingLab VRE. In addition, there is a platform-level integration of the D4Science platform with the EOSC which allows connecting the ARIADNEplus part of D4Science in a transparent way with the EOSC (e.g. through a federated identity service).

## Cross-disciplinary fertilisation and sharing of resources

*> Refers to RI Programme expected impact statement [6].*

In the ARIADNE research e-Infrastructure initiative cross-disciplinary fertilisation is being promoted by the participation of research groups and sharing of datasets from different fields of archaeological research, which has been greatly extended by ARIADNEplus.

Cross-fertilisation is particularly being fostered through the common objectives of research groups, to share and integrate data, enabling comparative research and synthesis, which ARIADNEplus supports through advancing the semantic interoperability of data resources.

CIDOC CRM application profiles, with a common CRM core and specifications for datasets of different archaeological domains, could play an important role in future cross-disciplinary research.

In ARIADNEplus, the work on such application profiles has significantly contributed to building common understandings and cross-fertilisation. Differences and common aspects of domain datasets became clearer in the process.

Strong cross-fertilisation is also being fostered between scholars and developers of e-research services in the ARIADNEplus VRE use cases workshops. VREs must be co-designed by scholars and technical experts. In the process, service developers learn about researcher requirements, and researchers learn how VREs can support their research tasks.

Collaboration with external developers is foreseen specifically for Linked Data applications, as they can can access and build on ARIADNEplus Linked Data through an openly available interface (SPARQL endpoint). This will enable cross-fertilisation at the data-level and may also lead to new services for exploiting ARIADNEplus Linked Data.

## Innovation and partnership with industry

*> Refers to RI Programme expected impact statement [4].*

In archaeology, private sector commercial actors are contract archaeologists and consultancies, which provide professional services for developers and heritage management agencies in preventive or development-led archaeology.

Archaeological businesses, which are often spin-offs or otherwise related to archaeological research centres, can benefit from using ARIADNEplus services and datasets, but may also share fieldwork reports and data through their repositories. Such sharing must be promoted by national or regional authorities and implemented as part of their data management system or mandated respositories, as in the case of ADS in the UK and DANS in the Netherlands.

In ARIADNEplus innovation in this field focuses on using Cloud-based Natural Language Processing (NLP) technologies to extract information from grey literature reports of preventive archaeology. Ongoing work on NLP services aim to make the user interface and tools easy to use by archaeological data managers and researchers. A large demonstration pilot will be created by INRAP, using reports from their preventive archaeology work.

Cloud-based Visual Media Services (VMS) are considered relevant for cultural heritage institutions and businesses which create high-quality imagery and 3D products for museums and heritage sites. One of the ARIADNEplus task forces connects with interested institutions and businesses and will, together with the CNR-ISTI VC Lab, present them the VMS and explore their existing demands and specific requirements.

## Use of services beyond research

*> Refers to RI Programme expected impact statement [9].*

The main user groups for the ARIADNE e-Infrastructure for research data are archaeological researchers and data managers (repositories, databases), including heritage administrators, and professionals in preventive archaeology.

However, the ARIADNEplus Portal can be used openly and freely by anybody interested in discovering and accessing archaeological data. Thus the portal is a form of "public archaeology" by making data of different providers findable and accessible.

The project aims to go beyond this by addressing user groups engaged in citizen science projects, educators and students, who want to learn about archaeological sites and artefacts and actively engage with the portal to undertake digital archaeological activities. For example, educators and students may use the accessible data for scientific or cultural study work.

ARIADNEplus integrates information on finds discovered by metal-detectorists, and other finds by the public in countries where this is permitted, and registration of finds in national databases has been enabled. Therefore one of the planned ARIADNEplus Pilots aims to allow public to classify their finds in the same way as an archaeological subject expert, and share the information in an online environment.

Additional approaches to involve citizen scientists, educators and students online are currently being investigated in a study of the literature and good practice in archeology, cultural heritage, and various other domains.

## TNA, training activities and materials

*> Refers to RI Programme expected impact statement [5].*

ARIADNEplus started its Transnational Access (TNA) programme in 2020, but due to the COVID-19 crisis only two of the 13 TNA candidates were able to visit a competence centre. The TNA programme has been suspended, and the possibility of a call in autumn 2021 for TNA visits and summer schools in 2022 will be evaluated in due course.

However, the ARIADNEplus partnership provides a range of opportunities for online training and learning activities, all tailored to researchers and data managers in archaeology and cultural heritage, with a focus on digital skills and practices.

These include the ARIADNEplus Training Hub of 60 carefully selected Web-accessible training resources for different topics from both partners and other providers, in formats such as online courses, training modules with videos, downloadable tools and tutorials, and more. In the period January–May 2021, the thematic overview page of the Training Hub received 2,256 visits, 273 visitors moved on to thematic sub-pages, of which most interest attracted the themes "Metadata and vocabularies for archaeological datasets" and "Applying open/the FAIR Principles to archaeology".

ARIADNEplus partners also provided training in-person (when possible) and as online workshops and webinars with over 170 participants. In addition, there were thematic workshops primarily for members of the large networks of ARIADNEplus and SEADDA, but also invited presenters and participants, and the results published online.

Taking account of the still difficult situation due to the COVID crisis, but also the increased importance of access to scientific data and online research environments, the ARIADNEplus directors also launched workshops aimed to help keep the project focussed and raise the spirits of the partners (e.g. "The Way Forward" workshop in February 2021 with 74 participants).

## Dissemination and communication

*> Refers to RI Programme expected impact statement [6].*

The ARIADNEplus dissemination and communication activities support the outreach to, and involvement of, the archaeological research and data management community in Europe and beyond. In addition to the training, learning resources, and workshops, ARIADNEplus produced publications, participated in conferences and other events, and promoted the project via the website and social media channels.

**Publications**

Since the start of the project, partners have published 34 academic publications, 32 are either "gold" open access (a journal or conference paper, book chapter etc. published open access), or "green" open access, deposited in an open access repository. The "gold" publications include the 17 chapters of the open access book "The ARIADNE Impact", published by Archeolingua. Since October 2019 there were 1,009 unique downloads of the book from the Zenodo repository.

Several papers from partners and allies promote sharing of open access data. A special mention is deserved for "An Aegean History and Archaeology Written through Radiocarbon Dates" (Katsianis et al. 2020), a data paper which describes this large open access dataset; a dataset record is also included in the ARIADNEplus data catalogue and portal.

**Conferences and other events**

The ARIADNEplus partners have (co-)organised and attended many conferences (sessions, round tables), workshops and other events, giving presentations and networking with participants. Through

June 2021, partners participated in 43 conferences and other events, which they (co-)organised or where they presented ARIADNEplus' goals, work and results. The reported total number of participants is 2,364, with an average of 55 participants per event.

The largest participation of around 300 was in the online conference "3D Digital Cultural Heritage for Resilience, Recovery and Sustainability" (27 May 2020), which ARIADNEplus and Inception s.r.l. (a creative business start-up company) organised in collaboration with the European Commission, DG CONNECT. The conference was live-streamed on YouTube and the YouTube views counter shows nearly 2,800 views for the video recording.

ARIADNEplus was of course present with sessions at the two main annual archaeology conferences for the project, the annual meeting of the European Association of Archaeologists (EAA) and the Computer Applications and Quantitative Methods in Archaeology (CAA) conference. Unfortunately, the CAA 2020 had to be cancelled due to the COVID-19 crisis. Forthcoming is the session at the EAA 2021, with eight accepted papers, which will highlight the importance of having access to data, not only during a pandemic.

**Website and social media**

In the period June 2020 to May 2021, the ARIADNEplus website attracted 6,994 visits, with around 14% being return visitors, and a total of 20,616 pages viewed. The overall performance was consistent with the previous period, i.e. the website quickly reached and retained a high level of interest.

The main social media channel of the project is Twitter which is used regularly to bring attention to outputs, notify users of events of interest, and retweet items of interest. Over the last year, the average number of views per month was 6,690, with 10 new followers attracted per month.

Facebook is used by some people in preference to Twitter, so a presence is maintained for the small following of 22 members in order to have maximum coverage. More important is the project's Slideshare account for making available selected presentations and reports. It enables promotion of the project to audiences who are looking for specific topics of interest. While most products receive a small number of views, in total, a large amount of awareness of the ARIADNE initiative is being generated.

# 3     Reference framework of the impact evaluation

This chapter describes the reference framework of the ARIADNEplus initial impact evaluation. The framework is largely determined by the fact that the project is being funded as an Integrating Activity project under the European Union's Horizon 2020 Work Programme 2018-2020 for European Research Infrastructures, including e-Infrastructures.

The Integrating Activity scheme of the Work Programme prescribes that projects have to carry out a defined set of activities according to the Integrated Infrastructures Initiatives (I3) Model: Networking activities, Trans-national Access (in-person or virtual) service activities, and Joint Research activities.

On top of these come 10 statements of the Work Programme on "Expected Impacts" which such projects should aim to achieve, through carrying out the set of I3-Model activities a project has defined and are approved with the grant agreement. In the ARIADNE final impact evaluation results for the I3 Model activities and RI programme expected impact statements were addressed separately (ARIADNE 2017a), whereas for this report an integrated approach has been developed.

The sections that follow describe in greater detail the Integrating Activity scheme, give some important background for the "Expected Impacts" statements, and briefly comment the 10 statements. More background and explanation is given in the different sections on the initial results for the impacts expected by the Work Programme.

## 3.1     ARIADNEplus as an Integrating Activity

ARIADNEplus is an Integrating Activity funded under the Horizon 2020 Work Programme 2018-2020 for European Research Infrastructures, including e-Infrastructures (European Commission 2020), henceforth short: RI Programme. The project will run from January 2019 to December 2022.

ARIADNEplus is an Integrating Activity for Advanced Communities (INFRAIA-01-2018-2019), where "Advanced" means that the original ARIADNE project (until January 2017) moved the field of Archaeology in Europe from a "Starting" to an Advanced Community in terms of RI Programme, *"whose research infrastructures show an advanced degree of coordination and networking"* (European Commission 2020: 43).

Particularly important to note is the RI Programme's requirement that *"an Integrating Activity shall combine, in a closely co-ordinated manner:*

*(i) **Networking activities**, to foster a culture of co-operation between research infrastructures, scientific communities, industries and other stakeholders as appropriate, and to help develop a more efficient and attractive European Research Area;*

*(ii) **Trans-national access or virtual access activities**, to support scientific communities in their access to the identified key research infrastructures;*

*(iii) **Joint research activities**, to improve, in quality and/or quantity, the integrated services provided at European level by the infrastructures.*

*All three categories of activities are mandatory as synergistic effects are expected from these different components"* (European Commission 2020: 44, emphasis added).

The combination of these three components of activities is called the Integrated Infrastructures Initiatives (I3) Model, and a section of the RI Programme defines further "Specific features for Research Infrastructures" for Integrating Activities (European Commission 2020: 113-117).

The ARIADNEplus project has been set up following the I3 Model, hence it combines Networking activities, Trans-national access and virtual access activities, and Joint research activities. The

evaluation of the impact of the ARIADNEplus project takes account of the fact that these activities are mandatory and therefore there results should be reported.

It is worth noting that there is no established common framework for the evaluation of the impact of Integrating Activities and comparison between them. Such a framework does not exist, despite the fact that across all disciplines about 90 such projects have been funded under the 7th Framework Programme (European Commission 2014) and many new ones in Horizon 2020 for starting and advanced communities. The reason seems to be that significant differences of the projects with regard to disciplines, types of research infrastructures and user communities do not allow the application of a common evaluation framework.

## 3.2 RI Programme expected impacts

The main reference for the evaluation of impacts of the ARIADNEplus project is the list of impacts expected from Integrating Activities for Advanced Communities funded RI Programme. In addition, regarding specific activities, the RI Programme section "Specific features for Research Infrastructures – Part D: Integrating Activities" is taken account of (European Commission 2020).

### 3.2.1 Background for the expected impacts

The RI Programme states 10 expected impacts which are listed below with brief comments. More background is given in the different sections on the initial results for the impacts expected by the RI Programme. Indeed, some of the statements require a significant amount of background information to be considered appropriately.

This is because the RI Programme statements do not distinguish between different types of research infrastructures which the programme funds, e.g. between natural science laboratories and an e-Infrastructure for research such as ARIADNEplus. Although the statements are meant for all RI types, some tend to have physical research facilities in mind, hence need to be interpreted and specified for digital or e-Infrastructure.

Furthermore, the expectation statements have not been updated to take account of the new research policies for FAIR data and the European Open Science Cloud, although these are mentioned in the section "Specific Features for Research Infrastructures" (and many other parts of the RI Programme).

The "Specific Features" section, under Part (i) Networking Activities, includes the suggestion that activities could focus on *"definition of data management plans to organise the efficient curation, preservation and provision of access to data collected or produced under the project, in line with the FAIR principles"*; under Part (iii) Joint Research Activities the document demands, *"Digital services developed under the joint research activities should be exposed under the EOSC catalogue"*. Indeed, at the current stage of development of the FAIR data agenda and the EOSC initiative these activities must of course be carried out.

### 3.2.2 Commented list of RI Programme impact expectations

This section addresses the RI Programme's list of 10 statements of expected impacts, given below in bold italics. For each statement brief comments are given on the implied activities, followed by where in this report these are covered and the initial impact results reported:

**[1]** ***Researchers will have wider, simplified, and more efficient access to the best research infrastructures they require to conduct their research, irrespective of location. They benefit from an increased focus on user needs.***

- These statements essentially concern the ARIADNEplus data portal which integrates datasets from the underlying research infrastructures such as national or institutional repositories. Wider, simpler and more efficient access to the datasets is enabled by the portal through data discovery and access across all repositories. In addition, other new and advanced RI services are being developed or already available which are addressed under [2].

- For both, the ARIADNEplus data portal and these services, activities have been carried out to understand and support the particular needs of the users. Regarding the data portal the further development based on identified priority needs has turned the portal from a data discovery into an effective research tool which exploits the integrated rich metadata of the connected data repositories.

- Related activities and results are covered in the following sections:

  o Access to integrated knowledge-based resources (*Section 4.4*)

  o Community needs survey (*Section 4.1.4*)

**[2]** *New or more advanced research infrastructure services, enabling leading-edge or multi-disciplinary research, are made available to a wider user community.*

- This statement concerns the development and provision of new and advanced ARIADNEplus data services and virtual research environments (VREs).

- Related activities and results are covered in the following section:

  o New services and virtual research environments (*Section 4.5*)

  o Regarding user needs particularly: VRE use cases workshops (*Section 4.5.3*)

**[3]** *Operators of related infrastructures develop synergies and complementary capabilities, leading to improved and harmonised services. There is less duplication of services, leading to an improved use of resources across Europe. Economies of scale and saving of resources are also realised due to common development and the optimisation of operations.*

- This statement concerns the contribution of the project to the coordinated development of major e-Infrastructures for digital humanities, cultural heritage content, heritage science (e.g. material studies and conservation), and ARIADNEplus for archaeology.

- A major focus of the coordination activities has been the development and alignment of data catalogues. Furthermore, joint activities for instance focused on common goals such as the implementation of the FAIR data principles or particular data objects such as 3D models.

- Meanwhile, however, the European Open Science Cloud (EOSC) has become the core initiative for enabling the goals mentioned in the RI Programme statement (i.e. synergies between RIs services, saving of resources through sharing, economies of scale).

- Related activities and results are covered in the following sections:

  o Research infrastructures coordination (*Section 4.6*)

  o Standardisation of archaeological datasets (*Section 4.2*)

**[4]** *Innovation is fostered through a reinforced partnership of research organisations with industry.*

- For the area of archaeology this statement concerns archeological businesses which carry out fieldwork in preventive or so-called developer-led archaeology. Furthermore, ARIADNEplus considers that some of the digital services could be relevant to cultural and creative businesses.

- Related activities and results are covered in the following section:

  o Innovation and partnership with industry (*Section 4.8*)

**[5]** *A new generation of researchers is educated that is ready to optimally exploit all the essential tools for their research.*

- This statement concerns the training opportunities offered by the project, which include Trans-national Access (TNA) to ARIADNEplus competence centers, training courses and resources. The training offer of course includes guidance on the application of the FAIR data principles, and tools for the development and evaluation of data management plans (DMP) for archaeological data.

- Related activities and results are covered in the following sections:

  o Supporting the FAIR data agenda in archaeology (*Section 4.2*)

  o TNA, training workshops and materials (*Section 4.10*)

**[6]** *Closer interactions between a larger number of researchers active in and around a number of infrastructures facilitate cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry.*

- This statement concerns the cross-disciplinary fertilisations promoted by the ARIADNE research e-Infrastructure initiative through involving research groups and sharing of datasets from different fields of archaeological research. ARIADNEplus extends the cross-fertilisation potential further by incorporating many more archaeological research communities and types of data.

- Innovative new or advanced services can also be used by archaeological businesses as well as cultural and creative businesses.

- Related activities and results are covered in the following sections:

  o Extension of the stakeholder community (*Section 4.1*)

  o Cross-disciplinary fertilisation and sharing of resources (*Section 4.7*)

  o Innovation and partnership with industry (*Section 4.8*)

  o Dissemination and communication (*Section 4.10*)

**[7]** *For communities which have received three or more grants in the past, the sustainability of the integrated research infrastructure services they provide at European level is improved.*

- Not applicable – Explanation: The archaeological research community so far has been supported twice by Integrating Activity grants, for ARIADNE and ARIADNEplus. Nevertheless, the ARIADNE initiative of course strives to sustain the implemented RI services at the European level beyond the current ARIADNEplus project.

**[8]** *The integration of major scientific equipment or sets of instruments and of knowledge-based resources (collections, archives, structured scientific information, data infrastructures, etc.) leads to a better management of the continuous flow of data collected or produced by these facilities and resources.*

- This statement essentially concerns the work of ARIADNEplus on the aggregation of datasets of digital archives and collections and their integration for search and access through the data portal. This aggregation and integration requires the application of data description standards so that the resources actually become knowledge-based, i.e. based on established ontologies and terminology of the domain of knowledge (archaeology, cultural heritage). Such standardisation is also a key requirement for making datasets FAIR.

- Related activities and results are covered in the following sections:

  o Supporting the FAIR data agenda in archaeology (*Section 4.2*)

  o Standardisation of archaeological datasets (*Section 4.3*)

  o Access to integrated knowledge-based resources (*Section 4.4*)

**[9]** *When applicable, the integrated and harmonised access to resources at European level can facilitate the use beyond research and contribute to evidence-based policy making.*

- The main intended user groups of the ARIADNEplus data access services are archaeological researchers and data managers, cultural heritage administrators and practitioners, and professionals in preventive archaeology. However, ARIADNEplus provides open and free access to the online services of the research infrastructure. Therefore anybody interested can access and use the services and data resources, although for some future virtual research environments (VREs) of research communities this may require registration.

- In addition, activities are planned to address potential user groups beyond archaeological research and data management, citizen scientists, educators and students, for instance. A particular use case will be metal-detector and other finds by amateurs described in established national databases from which ARIADNEplus aggregates information (images, description).

- Contributions to evidence-based policy making by researchers who use ARIADNEplus services and data may be possible, but this has not been defined as a core focus of the ARIADNE initiative in its current phase.

- Related activities and results are covered in the following section:

  o Use of services beyond research (*Section 4.9*)

**[10]** *When applicable, the socio-economic impact of past investments in research infrastructures from the European Structural and Investment Funds is enhanced.*

- Not applicable – Explanation: The RI Programme considers socio-economic impact only related to research infrastructures which have been built with (co-)investment from the European Structural and Investment Funds, which does not apply for ARIADNE or underlying digital repositories or databases. It concerns large physical facilities, e.g. laboratories and research instruments, in fields such as energy, materials or life sciences research, often with related companies for industrial innovation and development. Such research infrastructures should demonstrate significant socio-economic impacts in the region, i.e. contribute to employment, economic prosperity and growth.

# 4    Full report of the initial impact results

This chapter describes in detail the work and results in 11 areas of project activities. Its parts are structured as follows: the first section addresses the RI Programme expected impact and the general approach of the project for the related activities. This is followed by sections which describe the activities carried out and results achieved. Each part also includes a brief summary of the results. These summaries are brought together in the summary report (*Chapter 2*).

## 4.1    Extension of the stakeholder community

### 4.1.1    Expectation & project approach

**RI Programme expectation**

The list of statements on expected impacts of the RI Programme does not include an explicit statement on the extension of the stakeholder community. However, building a community and promoting interaction between different organisations, researchers and data managers is essential for the impact of a research infrastructure.

This is acknowledged by the expected impact statement [6] *"Closer interactions between a larger number of researchers active in and around a number of infrastructures facilitate cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry."*

The statement recognises the importance of sharing of resources by the different stakeholders involved by research infrastructures. For e-Infrastructures like ARIADNEplus this is indeed essential to expand the pool of knowledge-based data resources, drive adoption of the RI services, and maintain the data-centered and other services. A broad stakeholder community is also necessary to ensure the sustainability of the research infrastructure services.

The section "Specific features for Research Infrastructures" of the RI Programme, Part D, (i) Networking Activities, suggests activities aimed to grow and jointly manage data resources, for instance, *"joint management of access provision and pooling of distributed resources"* and *"development and maintenance of common databases for the purpose of networking and management of the users and infrastructures"*.

Actually these suggested Networking activities are organisational and technical, while stakeholders first need to be committed to share knowledge-based data resources or support other project activities, such as promotion of FAIR good practices, for instance.

**Project approach**

In January 2019 ARIADNEplus started with a consortium of 41 partners[1] while the initial ARIADNE project had 23 partners. The consortium now comprises 37 formal partners from 23 European countries and one each from the United States, Argentina, Israel and Japan. These are the Arizona State University (Center for Digital Antiquity, tDAR repository) in the United States, the Instituto de Antropología de Córdoba (CONICET-IDACOR) in Argentina, the Israel Antiquities Authority, and the National Research Institute for Cultural Properties (NARA) in Japan. Thus the ARIADNE initiative is present now not only more strongly across Europe but also in other world regions.

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[1] ARIADNEplus partners, https://ariadne-infrastructure.eu/partners/

Special attention regarding other stakeholders is being devoted to the coordination with major archaeological agencies and associations, e.g. European Archaeological Council, European Association of Archaeologists, American Association of Archaeologists, CAA International, and others; new institutional associated partners in Central and Southeastern Europe; and associated projects with a regional or international focus.

ARIADNEplus is being recognised by archaeological institutions and projects as leading the development of research data infrastructure and services for the sector. Therefore ARIADNEplus increasingly receives requests to join the ARIADNE network as associate partner or project.

### 4.1.2    High-level recognition and support

In the first round of the ARIADNE initiative the core institutions of both the archaeological domain and the research infrastructures domain in Europe already acknowledged ARIADNE's leading role in building infrastructure and services for sharing and accessing archaeological data.

The **European Strategy Forum on Research Infrastructures (ESFRI)** in their Roadmap 2016 acknowledged ARIADNE's role as the leading integrator of archaeological research data infrastructures: *"In the archaeological sciences the ARIADNE network developed out of the vital need to develop infrastructures for the management and integration of archaeological data at a European level. As a digital infrastructure for archaeological research ARIADNE brings together and integrates existing archaeological research data infrastructures so that researchers can use the various distributed datasets and technologies"* (ESFRI 2016: 175).

From the perspective of archaeology, the **European Archaeological Council (EAC)** strongly encouraged organizations to participate in the ARIADNE initiative. The EAC is comprised of heads of national bodies responsible under law for the management of the archaeological heritage in the Council of Europe member states. In their Amersfoort Agenda, setting the agenda for the future of archaeological heritage management in Europe, the Council emphasises *"the need to share, connect and provide access to archaeological information with the help of digital technologies. The key to this aspiration is to improve collaboration – we need to share rather than exchange. It is essential to encourage the development of European data-sharing networks and projects in the field of archaeology. The ARIADNE project is an excellent European initiative in this regard and participation in this project should be strongly encouraged"* (Schut et al. 2015: 21).

**Representation of the EAC and EAA in the ARIADNEplus Scientific Advisory Board**

The recognition of ARIADNE as the leading integrator of archaeological data resources and driving the FAIR data agenda in the domain is confirmed by the participation in the ARIADNEplus Scientific Advisory Board of Leonard de Wit, former President and now Honorary Member of the EAC Board, and the Presidents of the EAA, Felipe Criado Boato (member of the board until August 2020), and Eszter Banffy (from September 2020).

This ensures a regular dialogue with both organisations, for example the EAA Board has proposed a collaboration with ARIADNEplus for the implementation of the FAIR principles in archaeology. The EAC Board involves for this purpose the SEADDA network (see below), which includes all ARIADNEplus archaeological partners.

### 4.1.3    Growing the ARIADNEplus community

The ARIADNEplus network extends globally and works with many organisations and initiatives whose aims vary widely. Some are focussed on the provision of specialised services, others have geographical or thematic remits. Several of the project partners are members of and/or involved with these

organisations, fostering collaboration and communication across the network. This section covers the growth of the ARIADNEplus initiative through associated institutions and projects. Cooperation with ongoing European research infrastructure projects and the European Open Science Cloud (EOSC) initiative is addressed in *Section 4.6*.

## ARIADNEplus and SEADDA

SEADDA (Saving European Archaeology from a Digital Dark Age)[2] is a COST Action aimed to foster the development of archaeological data repositories in countries where the research community lacks an appropriate repository. SEADDA brings together archaeologists and data management specialists to share expertise, provide knowledge and training in matters of data archiving and access.

SEADDA is being led by ARIADNEplus partner Archaeology Data Service (ADS) and several other partners are members of the project consortium, with representation from nearly all European countries, not only those in the EU. ARIADNEplus and SEADDA have complementary goals. SEADDA fosters the development of FAIR archaeological data repositories, while ARIADNEplus supports finding and accessing data that is being shared through existing and new repositories.

## Associated organisations

Associated organisations sign a cooperation agreement with ARIADNEplus which confirms interest in progressing shared goals and defines joint activities which can take various forms, e.g. contribution of data, development of tools, cooperation on training activities, for instance.

It is worth noting that seven of the cooperation agreements signed with the first ARIADNE project led to major institutions becoming formal partners of ARIADNEplus. In Europe new partners joined the project from Denmark, Iceland, Norway, Portugal and Spain. New partners from other countries are the Israel Antiquities Authority and the Digital Antiquity consortium at Arizona State University, which hosts their large digital repository tDAR - The Digital Archaeological Record. Other cooperations are continued, for example, with the archaeological data publication platform Open Context (Alexandria Archive Institute, USA), which is being used by projects in different countries.

There is a growing number of requests to join the ARIADNEplus network as associated partner or project. The following organisations have already joined ARIADNEplus as associated partners[3]:

- ***The Monuments Board of the Slovak Republic (MBSR)*** is the State administration authority in Slovakia established by law for the protection of monuments and historic sites, including archaeology. At present, the MBSR carries out the Monument Information System project, which aims to utilise geospatial technologies in the management of monuments and historic sites and in the registers of archaeological sites and fieldworks, as well as make these datasets available to professionals and the general public. The MBSR participates in ARIADNEplus working groups, possibly co-organises training activities, tests the ARIADNEplus portal and services, and contributes to the development of tools for data analysis.

- ***The Directorate for Protection of Cultural Heritage (DPCH)*** is a governmental administrative body under the ***Ministry of Culture of the Republic of North Macedonia***: The Directorate coordinates the implementation of national and strategically significant programmes and projects for the protection of cultural heritage. The DPCH is also in charge of maintaining the national register of cultural heritage and the largest database of digitised content related to archaeological monuments and sites. The DPCH is interested staying up to date with the latest technological

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[2] SEADDA - Saving European Archaeology from the Digital Dark Age (COST Action), https://www.seadda.eu

[3] ARIADNEplus: Our network, https://ariadne-infrastructure.eu/our-network/

developments, possibly co-organise training activities, and contribute to the development of data analysis tools.

- **The Institute of Archaeology in Zagreb** *(Croatia)* is the leading scientific institution for applied archaeological research in the Republic of Croatia, covering all archaeological periods and methods. The Institute also develops ARHINDOKS, the Archaeological Information Documentation Centre, with thematic databases of archaeological sites and finds. Furthermore, it publishes scientific and professional journals, monographs and proceedings, as well as organises international events in Croatia. The Institute participates in ARIADNEplus working groups, investigates a potential contribution of data, and supports the testing of the data portal and new other services.

- **University of Minho, Archaeology Unit** *(Portugal):* The Archaeology Unit of the University of Minho (UAUM) carries out research and develops databases in different themes of ARIADNEplus. UAUM will provide datasets for the portal, with an initial contribution of two datasets of Roman coins.

- **The British School at Athens (BSA)** promotes research in all disciplines pertaining to Greek lands, from fine art to archaeometry and in all periods to modern times. The BSA will provide for the ARIADNEplus portal a dataset of archaeological project activities (e.g. excavations, surveys, study seasons, laboratory work) they conducted and facilitated from 1889 to the present day. They will also contribute to the development of pilot applications and testing of the ARIADNEplus portal and other new services.

- **The British Institute At Ankara (BIAA)** supports research in Turkey and the Black Sea region in a wide range of fields including archaeology, ancient and modern history, heritage management, and others. The BIAA has a library, plant, bone, epigraphic and pottery collections and an archive of source materials produced in the course of archaeological research from the 1940s to the present day. The BIAA aims to establish a regional digital repository and currently standardises its datasets, e.g. toponyms, georeferences, etc. (Çayırezmez 2020). The BIAA will provide data to ARIADNEplus when it is converted into the appropriate new formats.

- **Takin.solutions Ltd.** (Bulgaria) is a consultation and services company that supports the implementation of information management systems in the cultural heritage sector. The company has developed solutions based on semantic models and techniques for international clients, including the Canadian Heritage Information Network (CHIN), the Max Planck Institutes for the History of Science and for Art History (Bilotheca Hertziana), and the Swiss Art Research Infrastructure (SARI). Takin.solutions is also an official service provider for the ARCHES Heritage Inventory and Management System. They participate in ARIDANEplus working groups, test the project portal and new services, and contribute to the development of tools for data analysis and synthesis.

- **University College London, Department of Information Studies** *(UK)* is an associated technical partner working with ARIADNEplus partner University of South Wales on advanced Natural Language Processing tools for the extraction of terms from archaeological documents. These tools use controlled vocabularies and linguistic patterns to automatically suggest subject metadata for archaeological texts, such as grey literature reports.

- **University of Innsbruck, Department of Archaeologies** *(Austria):* Conducts research projects in fields of Pre- and protohistory, Classical Archaeology and Archaeology of the Roman Provinces as well as the Middle Ages and Modern Period. The department will provide a dataset of open research data created in the project "Prehistoric copper production in the eastern and central Alps", contribute to the development of an application profile for such data, and develop a mapping to CIDOC-CRM.

- ***University of Naples L'Orientale, Interdepartmental Center for Archeology Services – CISA*** *(Italy):* CISA provides various data acquisition, management and processing services for archaeologists of the university and related organisations. The center is interested to organise joint training activities, participate in working groups, and to develop and test tools and services.

## Associated and related projects

The following are associated projects based on a cooperation agreement (already signed or in progress) and selected others with which there is a close cooperation:

- ***PeriodO*** provides the space-time gazetteer for sharing cultural periods information which is being used by ARIADNEplus. A cooperation agreement with PeriodO[4] was signed already in the first ARIADNE project. The project contributed to PeriodO a large collection of cultural periods from the Paleolithic to Modern times for 24 European countries and regions[5]. In ARIADNEplus partners and associates already provided additional periods to PeriodO, e.g. ARUP-CAS, IAVP and ROCEEH (see *Section 4.3.3*).

- ***ROCEEH - The Role of Culture in Early Expansions of Humans****:* Initiated in 2008 by the Heidelberg Academy of Sciences and Humanities, the mission of the multidisciplinary research project ROCEEH is to generate a systemic understanding of "becoming human", focusing on the development until 20,000 years before present in Africa and Eurasia. Research centres of the long-term project are located at the Universities of Heidelberg and Tübingen and the Senckenberg Research Institute in Frankfurt am Main. ROCEEH is an associated project that already works on making their palaeontology records from the ROAD database available in the ARIADNEplus data catalogue and portal (Kanaeva & Kande 2021; ROCEEH 2021: 6-9, on their commitment to FAIR data).

- ***NAHAN - North African Heritage Archive Network***: NAHAN has been initiated by ARIADNE partners and is being led AIAC. The project aims to catalogue and make accessible online North African excavation archives held by regional and European institutions. The regional focus currently is on archives in Morocco and Tunisia. Among the European institutions for example is the Centre Camille Jullian of the Université d'Aix-Marseille and CNRS[6] with the Archives nationales d'outre-mer. A data platform has been implemented by Archéologie et Philologie d'Orient et d'Occident (AOrOc), a research centre of the CNRS, and work is ongoing to produce records based on standards promoted by ARIADNEplus.

- ***EAMENA - Endangered Archaeology in the Middle East and North Africa***, is a project led by the Oxford School of Archaeology that has developed a database of mapped and remotely sensed at-risk archaeological sites in the MENA region. They have agreed to collaborate with ARIADNEplus to generate Linked Open Data (LOD) of their database for integration with ARIADNEplus LOD.

- ***Pelagios***, is a long running initiative that has built a platform and tools for linking Ancient and Classical World research resources (e.g. historical texts, maps, images) to the places these refer to; this is being done with the Recogito Web-based annotation tool and gazetteers; Pelagio's Peripleo platform currently includes over 917,000 items from 48 data resources, including resources of some ARIADNE partners; a Memorundum of Understanding is currently being prepared to define areas of further collaboration.

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[4] PeriodO (Institute of Classical Archaeology, University of Texas), https://perio.do

[5] PeriodO: ARIADNE collection of cultural periods, http://n2t.net/ark:/99152/p0qhb66

[6] CNRS - Centre National de la Recherche Scientifique, ARIADNEplus partner with the digital humanities research infrastructure Huma-Num, involving the archaeological Consortium MASA, and the Université de Tours, Laboratoire Archéologie et Territoires.

- ***Thanados - The Anthropological and Archaeological Database of Sepultures***, provides a database of investigated burials of Early Medieval cemeteries (600 until 1100 AD) from the area of present day Austria. The Thanados database and research tools are based on the OpenAtlas system and use CIDOC-CRM and other domain vocabularies. Thanados is being maintained by the Natural History Museum Vienna. Based on an agreement with the ARIADNEplus directors in May 2021 the research and development team at the museum aims to integrate their database with related datasets of the ARIADNEplus catalogue.

## Coalition for Archaeological Synthesis (CfAS)

The Coalition for Archaeological Synthesis (CfAS, founded in 2017)[7] promotes large-scale collaborative research projects to address major cross-disciplinary research questions, which can only be tackled by the aggregation and integration of large re-useable datasets. ARIADNEplus partner Arizona State University (ASU) has a leading role in CfAS, and the project is among the CfAS cyberinfrastructure providers.

Initially focused on America, the CfAS now involves also European institutions and projects. In September 2019, ARIADNEplus coordinator Franco Niccolucci (PIN) participated in a CfAS workshop at the Amerind Foundation in Dragoon, Arizona. The workshop was co-sponsored by the Society for American Archaeology (SAA) and the European Association of Archaeologists (EAA), with assistance from the Society for Historical Archaeology (SHA). In January 2020, the deputy coordinator, Julian Richards (ADS) attended the CfAS sponsored "Forum: Archaeological Synthesis: Building Arguments for Contemporary Relevance" (10 January 2020) at the SHA annual conference in Boston.

The workshop in Arizona focused on the theme of "Human Migration as Understood from a Long-Term Perspective" and was attended by 19 participants from seven countries, representing work ranging from the Palaeolithic to contemporary migrants (CfAS 2019). The "design workshop" set up three groups working on different aspects of human migrations and preparing research proposals to the National Science Foundation (NSF) and other funding agencies; also a joint position paper published in the Proceedings of the National Academy of Sciences (PNAS) resulted from the workshop (Altschul et al. 2020).

At the 2020 EAA (virtual) conference the session "Collaborative Synthesis: The EAA-SAA Human Migration Projects" (27 August 2020) took place, organised by the CfAS co-presidents, Jeff Altschul (SRI Foundation) and Keith Kintigh (ASU), and Julian Richards (ADS). Felipe Criado-Boado, the EAA president, and Eszter Banffy, incoming EAA president and member of the ARIADNEplus Scientific Advisory Board, participated in the session.

Among the highlighted activities was "Leveraging Archaeology for Migrations in the Present (LAMP)", one of the projects designed in the CfAS workshop in September 2019 and thereafter elaborated. The LAMP project proposal was submitted in September 2020 to the NSF (USA) and AHRC (UK) under their scheme for international research collaboration (still pending final decisions). Besides a research group at University of York also the ARIADNEplus associated project ROCEEH is involved in LAMP, bringing their expertise in the exploration of the deep past of human history and managing the large interdisciplinary ROAD database, from which data records will be ingested in the ARIADNE data catalogue and portal.

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[7] Coalition for Archaeological Synthesis (CfAS), http://www.archsynth.org

## 4.1.4   Understanding community needs

### Survey of community needs

In the third quarter of 2019 ARIADNEplus conducted an online survey of community needs regarding data sharing, access and (re)use, new services, and related training needs (ARIADNEplus 2019a). The reported survey results are based on 484 fully or sufficiently questionnaires. Questionnaires were received from all 27 ARIADNEplus partner countries and a few other countries. 93% of the respondents are professionally based in a European country; 46% said the organisation they work for is a member of the ARIADNEplus consortium.

The organisational background of most respondents is a university or public research organisation (53%), museum (19%), governmental institution (15%) or a private company or research institute (8%). Regarding professional activities, 53% are archaeological researchers (field work), 9% laboratory-based researcher, 13% managers of an institutional repository or other data access services, 7% managers of project databases, 7% directors of an archaeological institute or research centre/laboratory, 12% other (various academic, technical and data management activities). Results of the survey were compared, where possible, to those of the ARIADNE survey in 2013 (ARIADNE 2014).

**Selected important results**

Here we include mainly results for two topics of the survey, the helpfulness of existing and planned new or advanced data services, and current training needs of archaeologists regarding data management and processing. These are of immediate relevance for developing the portfolio of ARIADNEplus services.

Results for the questions on data sharing practices, barriers to open data sharing, and (re)use of data are of course taken account of, currently also by SEADDA where further studies on data sharing and (re)use, from the perspective of data repositories are being carried out.

### Online services for researchers and data managers

The survey included a question intended to help ARIADNEplus in the evaluation of which existing, planned and potential future services are particularly relevant for archaeologists' research and data management.

The question included 16 services, each concisely described from the perspective of what users could do with it. The question was answered by 337 respondents, giving their view of how helpful the services would be for their research or data management. The services on top were considered as very helpful or helpful by 93.5–96.3% of respondents, those in the middle range by 78.3–83%, and the lowest ranked still by slightly lower than 75%.

*Services which ARIADNE/plus already provides:* A very encouraging survey result is that these are among the highest ranked services. These services are:

- o   Register a dataset in a portal that allows searching data from many providers
- o   Discover & access archaeological data stored in repositories in different European & other countries
- o   Spatially and/or chronologically defined search options

*Multi-lingual search:* This service is also already implemented in the data portal but was appreciated significantly less than the ones above. This does not speak against support of multi-linguality when portal users search for particular subjects, because it still ranks much higher than other services on the list.

*Top on the list of new services* – Search and visualize geo-spatial/GIS datasets: These services are the highest ranked among the new services, and are part of the plan of services ARIADNEplus will implement.

*Lowest on the list* – Map a database (schema) to the CIDOC-CRM extended for archaeological research data: This result did not come as a surprise because the service is specifically for data managers (databases, repositories) and these made up only 20% of the survey respondents.

*Services in the middle range:* All other services were in the middle range of appreciation, listed according to the percentages of approval (more to less):

- o Use Linked Data to interlink own and other datasets
- o Annotate images (e.g. artefact or laboratory images) and link them with other content
- o Post a picture of an object and get suggestions for similar ones (*)
- o Display and manipulate visual data objects (e.g. RTI images, 3D models, LiDAR data)
- o Link and present together visual media (e.g. a 3D model) and related documentation
- o Process many documents (using Natural Language Processing) to find those on certain topics or specific information they may contain (*)
- o Identify & extract information from textual sources (e.g. a document repository) to produce metadata
- o Annotate texts (e.g. fieldwork or laboratory reports) and link them with other content
- o Align own vocabulary terms with international thesauri (e.g. Getty Arts & Architecture Thesaurus)

This list includes two potential future services which are not considered in the work plan of the project, indicated with (*). Services that considered are addressed in *Section 4.5*.

### Training needs

The ARIADNEplus survey 2019 also investigated current training needs of archaeologists regarding data management and processing. In a survey question eight activities were suggested, with the option to add comments, e.g. suggest other topics, which no respondent did.

The 330 respondents who answered the question approved the different areas of training as very helpful or helpful between 86.6–94.5%. Therefore the thematic areas were later adopted for structuring the training resources included in the ARIADNEplus Training Hub[8]; the two closely related themes of metadata and vocabularies were combined, and use of research infrastructures added.

The survey results for training needs can be summarised as follows:

- o *On top: the FAIR data principles:* Training in the application of the FAIR data principles in archaeology was appreciated most, and ARIADNEplus is committed to promote the principles in the archaeological sector.

- o *Other interesting topics:* Next on respondents' wish-list for training came depositing project datasets in a digital repository, managing datasets of a large archaeological project, and data science skills.

- o *Less appreciated:* Significantly less appreciation was expressed for training in how to create and implement a data management plan (DMP), manage a digital repository, produce metadata and use domain vocabularies to describe archaeological datasets.

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[8] ARIADNEplus Training Hub, https://training.ariadne-infrastructure.eu

That there were many more researchers than data managers among the survey respondents had a considerable impact on the results. Responses to the survey question on barriers to data deposition and sharing show that researchers worried about the work effort for providing data and metadata in the required formats, a perceived barrier for 74% of respondents. This explains why training on DMPs, metadata and vocabularies is appreciated less than other training topics.

Inconsistently, however, training on data deposition appeared to be welcome – despite the (not recognised) fact that this would require dealing with data formats, metadata and vocabularies. Awareness of increasing requests of research funders to deposit open access data may have contributed to this result.

*Increase in readiness to sharing open access data?:* The survey participants were also asked if they agreed with the statement: *"In the last 5 years the readiness of archaeologists to share data through publicly accessible repositories or databases increased"?* – 83.2% of 376 respondents agreed. However, several respondents perceived a higher awareness among archaeologists that data should be made available, but little increase in readiness to do so. Others felt that the increase is taking place only slowly. More has to be done to foster data sharing.

### ARIADNE surveys – an important resource for the sector

The ARIADNE surveys in 2013 and 2019 are the only existing large surveys on data management practices of archaeologists in Europe. The 2013 survey could include over 600 filled questionnaires in the analysis, the 2019 survey 484 questionnaires (ARIADNE 2014; ARIADNEplus 2019a). Comparison of 2013 and 2019 survey results, and 2019 results to those of large surveys with respondents from various disciplines, allow understanding common patterns and differences.

Consequently, results of ARIADNE/plus surveys are now often referenced by researchers to explain developments in digital archaeology and to underpin own arguments (e.g. Brandsen et al. 2021: 3; De Bruin 2019: 70; Faniel et al. 2020: 2; Huvila et al. 2021; Lombardo et al. 2020: 3; PARTHENOS 2016: 34; Štular 2021). For example Huvila et al. (2021), introducing a session at the CAA 2021 conference, acknowledge their usefulness for understanding the *"practices of knowledge production in and about archaeology"*.

### 4.1.5 Summary of results

The leading role of the ARIADNE initiative as integrator of archaeological data resources and driving the FAIR data agenda in the domain is confirmed by its growth and recognition by the main bodies for archaeology in Europe.

The ARIADNEplus project started in January 2019 with a consortium of 41 partners, up from 23 of the initial ARIADNE project, including now also a partner each from the United States, Argentina, Israel and Japan. Thus the ARIADNE initiative is now present not only more strongly across Europe but also in other world regions.

The archaeological partners of ARIADNEplus participate in the COST Action SEADDA (Saving European Archaeology from a Digital Dark Age), a partnership with representation from nearly all European countries, not only those in the EU.

SEADDA and ARIADNEplus have complementary goals. SEADDA fosters the development of archaeo-logical data repositories, while ARIADNEplus supports finding and accessing data that is being shared through existing and new repositories.

ARIADNEplus increasingly receives requests by organisations to join the ARIADNE network as associated partner or project. Meanwhile 10 European organisations have joined the network as

associated partners, including heritage authorities, archaeological institutes, and domain research and technology centres.

Through associated projects the ARIADNE network expands regionally, e.g. through the North African Heritage Archive Network (NAHAN), and thematically, e.g. through the ROCEEH project in the field of Palaeanthropology in regions of Africa, the Levant, Eurasia and Europe.

The importance of the ARIADNE initiative is recognised by the European Archaeological Council (EAC) and the European Association of Archaeologists (EAA). The President of EAA and the former President of the EAC both sit on the ARIADNEplus Scientific Advisory Board, ensuring regular dialogue with both organisations.

The ARIADNE research infrastructure clearly supports community needs for services enabling data sharing, discovery and access. The results of the community needs survey in 2019, with responses of 484 researchers and data managers from all partner countries and others included in the analysis, confirmed high appreciation of the initial ARIADNE services and planned advanced and new services.

The extended stakeholder community also welcomes guidance from ARIADNEplus in the application of the FAIR data principles in archaeology.

## 4.2 Supporting the FAIR data agenda in archaeology

### 4.2.1 Expectation & project approach

**RI Programme expectation**

The list of statements on expected impacts in the RI Programme does not include a statement on FAIR data, although the European Commission has been one of the first adopters of the FAIR principles.[9] However, the section "Specific features for Research Infrastructures" of the RI Programme, Part D, (i) Networking Activities, suggests that activities could focus on *"definition of data management plans to organise the efficient curation, preservation and provision of access to data collected or produced under the project, in line with the FAIR principles".*

Meanwhile the implementation of the FAIR principles has become a cornerstone of the research data policy of the European Commission and national research funders (Expert Group on FAIR Data 2018). Available FAIR data are also a core requirement for the success of the European Open Science Cloud initiative (EOSC FAIR Working Group 2020).

**Project approach**

ARIADNEplus is funded under the Horizon 2020 Programme as the Integrating Activity for archaeological research datasets. ARIADNEplus therefore is committed to promote the FAIR data agenda in the archaeological sector in Europe (and beyond), in line with the respective policies of the European Commission and EU member states on open access to research publications and data.

The promotion of the FAIR data agenda takes various forms, including work on recommendations for major archaeological bodies and organisations, provision of FAIR guidance documents, development of a FAIR data management plan (DMP), FAIR as part of training activities, and an online hub of training materials.

### 4.2.2 Collaboration with major European archaeological bodies

The European Archaeological Council (EAC) supports the management of the archaeological heritage throughout Europe and provides a forum for the national bodies enabling close co-operation and exchange of information. In February 2020, the EAC Board decided to collaborate with SEADDA, the sister project of ARIADNEplus, on progressing the FAIR data agenda in the archaeological sector.

The EAC Board has chosen SEADDA for this purpose as its network comprises partners engaged in archaeological data management from almost all European countries. The EAC has also taken a keen interest in the SEADDA review of the situation of archaeological data management in the European countries as well as the United States, Argentina, Israel and Japan. The EAC co-sponsored the open access publication of already available review reports in the journal *Internet Archaeology* (Jakobsson et al. 2021).

In March 2020, Felipe Criado-Boado, the president of the European Association of Archaeologists (EAA), informed the managing directors of ARIADNEplus that the EAA Board endorses the FAIR principles and proposed a collaboration with ARIADNEplus for the implementation of the principles in archaeology.

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[9] The FAIR data principles were published in March 2016 (Wilkinson et al. 2016), and were quickly adopted by the European Commission, for example, in the Guidelines on FAIR Data Management in Horizon 2020, 26 July 2016, for Open Data Pilot projects (European Commission 2016).

The outbreak of the COVID-19 pandemic has also impacted the progress with these suggested collaborations as both high-level bodies were more concerned with supporting sector organisations in other respects. For example, the EAC in August 2020 conducted a survey among members on the impact of COVID-19 (EAC 2020) and organised a "COVID 19 and Archaeology" webinar following their general assembly on 19 March 2021 (EAC 2021).

### 4.2.3    International initiative for FAIR data in archaeology

An international initiative for FAIR data in archaeology has been formed in February 2020 at a workshop organised by ARIADNEplus partner Arizona State University (ASU). The workshop, held in Tempe, Arizona, focused on the challenges of archiving complex archaeological datasets in ways that they can easily be re-used. The workshop was also related to the Coalition for Archaeological Synthesis (CfAS) in which members aim to progress synthetic research based on such datasets (see *Section 4.1.3*).

Among the American participants were the multi-institutional organisation Digital Antiquity, who manage the large repository Digital Archaeological Record (tDAR, hosted at ASU), the Open Context archaeological data publishing platform, and the DataONE platform for environmental and ecological science. From Europe ADS, SEADDA and ARIADNEplus were represented, as was the ROCEEH project of the Heidelberg Academy of Sciences. ROCEEH is an associated project of ARIADNEplus and participates in a CfAS research initiative on human migration from a long-term perspective.

The workshop resulted in the formation of the umbrella group FAIRArchaeology, lead by Digital Antiquity, with the main goal to develop and support FAIR data implementation guidelines for key stakeholders in archaeology. The stakeholders for example include the Society for American Archaeology (SAA), the American Cultural Resources Association (ACRA), the European Association of Archaeologists (EAA), and other associations as well as research funders. For example, the CONICET research council in Argentina is developing a consortium of repositories for archaeology and has organised two workshops with ARIADNEplus in Buenos Aires to promote the adoption of the FAIR principles nationally (see *Section 4.11.3*).

### 4.2.4    FAIR data guidance

Ever more research funders now require researchers to create and share FAIR data. Therefore researchers in archaeology and related domains need guidance on what is meant by FAIR data and how to create and make it available. For this purpose ARIADNEplus adopted the FAIRify guide developed by the PARTHENOS humanities and social sciences research infrastructures cluster[10], in which members of ARIADNEplus had leading roles, also regarding these guidelines.

The FAIRify guide offers twenty guidelines to align the efforts of research data producers and archivists to make the data as reusable as possible based upon the FAIR Principles. Each guideline has recommendations for both researchers and archives as it is recognised that different priorities may apply to each case. ARIADNEplus and SEADDA support the dissemination of the FAIRify guide, which is already available in several languages.

A webpage on the ARIADNEplus website presents the list of the currently available (9) language versions[11] , while the documents are stored in the open access Zenodo repository. Zenodo provides download figures for each language version which stand as follows:

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[10] PARTHENOS (H2020, 5/2015-10/2019), http://www.parthenos-project.eu

[11] ARIADNEplus: Guidelines to FAIRify data management and make data reusable, https://ariadne-infrastructure.eu/resources/other-reports/

*Table 1: Guidelines to FAIRify data management and make data reusable,
views and downloads per 14.06.2021:*

| Language versions | views | unique views | downloads | unique downloads |
|---|---|---|---|---|
| English | 2348 | 1990 | 1294 | 1108 |
| Portuguese | 399 | 352 | 295 | 271 |
| Turkish | 489 | 422 | 315 | 257 |
| German | 518 | 446 | 247 | 219 |
| Czech | 312 | 279 | 218 | 198 |
| Italian | 248 | 206 | 143 | 132 |
| French | 185 | 147 | 134 | 115 |
| Greek | 247 | 199 | 124 | 106 |
| Hungarian | 129 | 102 | 60 | 56 |
| | **4875** | **4143** | **2830** | **2462** |

The figures show that the description of the FAIRify guidelines has often been looked up (views) and that the documents reached a high number of unique downloads of 2,462. Not surprisingly the English version has been downloaded most (1108). But also the downloads of other language versions are significant, e.g. the Portuguese (271), Turkish (257), German (219) and Czech (198) versions.

The FAIRify guide is relevant for both researchers and repositories, indeed, the repositories struggle as much as the researchers with understanding and getting to terms with FAIR data requirements (Dunning et al. 2017; LIBER 2019)[12]. The FAIRify guidelines are being promoted by ARIADNEplus and SEADDA. While SEADDA supports the building of FAIR data repositories, ARIADNEplus has a stronger focus on researchers and research organisations. A common element is data management plans (DMPs), which ever more research funders now require researchers to create with to goal to share FAIR data.

### 4.2.5    Data management plan (DMP) for archaeological data

ARIADNEplus promotes the standardisation of data management plans (DMPs) and practices of archaeological researchers and research groups. Many generic templates for a DMP are available from research support centers. However, there is a growing understanding that different domains of research have common but also different requirements, which should be taken account of.

### ARIADNEplus Archaeological Data Protocol

In Europe domain-specific DMP protocols are being promoted by Science Europe (Science Europe 2018 and 2021a). Science Europe is an association of major public research funders and research organisations in Europe. Among their priorities are cross-border collaboration, research assessment, open access publications, research data and research infrastructures.

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[12] These surveys are on various repositories whereas an ongoing survey of ARIADNEplus on archaeological repositories includes questions on FAIR.

The task to develop a DMP protocol for archaeological data has been taken on by ARIADNEplus partner DANS. The ARIADNEplus Archaeological Data Protocol has been presented by Peter Doorn (DANS) in a Science Europe webinar on 27 January 2021 (Doorn 2021; Science Europe 2021b). The webinar took place related to the publication of the updated Science Europe guide for international alignment of research data management (Science Europe 2021a), which was progressed 2018-2019 under the chairmanship of Doorn.

In the Science Europe webinar Doorn presented the ARIADNEplus domain protocol for archaeological research data which meets the Science Europe evaluation criteria for assessing DMPs. By following this protocol, DMPs of archaeological researcher should comply with the criteria of major research funding bodies across Europe.

## ARIADNEplus online DMP tool

A team of ARIADNEplus researchers and data managers led by project coordinator PIN has developed a comprehensive DMP for archaeological data which complies with standard criteria of the domain. It is a ready-made model DMP which works according to the principle of "comply or explain" (ARIADNEplus 2020d: 29-61) and is implemented in an online tool. The ARIADNEplus online DMP tool[13] is temporarily stored on a server of the project coordinator in order to ease its development and testing. Tests by a larger number of ARIADNEplus colleagues proved that the tool is very useful and suggestions for improvements have been implemented. By using the tool archaeological researchers can save a lot of time in drawing up a fit for purpose DMP.

When the tool is fully consolidated it will be decided how to best make it available to the archaeological research and data management community. This may take the form of a toolset, including supporting tools developed by other ARIADNEplus partners. For example, there is work ongoing by DANS on a Policy Wizard tool that advises on aspects of data management such as preferred data formats, i.e. formats which are frequently used, have open specifications, and are independent of specific software (ARIADNEplus 2020d: 15-16).

## Collaboration with OpenAIRE on a machine-actionable DMP

A collaboration between ARIADNEplus and OpenAIRE started in April 2020 to align each other's DMP oriented activities and exchange know-how that complements current work and accelerates new advancements. OpenAIRE supports in many ways the European Commission's policies on open access to research publications and data and other Open Science practices. In particular, OpenAIRE fosters the adoption of standardised procedures by research data managers and repositories to enable aggregation of metadata from open access repositories.

Therefore collaboration with OpenAIRE is a good approach to ensure optimal alignment with the still ongoing DMP standardisation activities and ensure impact of the ARIADNEplus efforts dedicated to the archaeological domain. One of the joint activities of ARIADNEplus and OpenAIRE that goes beyond the current level of DMP standardisation focuses on making DMPs machine-actionable, i.e. based on standards for syntactic and semantic interopability (i.e. XML and RDF) and software applications that can procees the information.

Activities in this direction have been carried out by the team responsible for the development of the ARIADNEplus online DMP tool and the OpenAIRE group working on the ARGOS tool[14], which aims to support standardised domain DMP templates. Results of this work included improved support of researchers' data management literacy, navigation of the DMP tools, compliance with the Research

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[13] ARIADNEplus: Researcher DMP template for archaeological datasets (online tool), https://vast-lab.org/dmp/ariadneplus/form/

[14] ARGOS, https://argos.openaire.eu

Data Alliance (RDA) Common Standards, and testing of information import and export (ARIADNEplus 2020d: 12-15; Papadopoulou 2020).

## 4.2.6    Summary of results

ARIADNEplus is committed to promote the FAIR data agenda in the archaeological sector in Europe (and beyond), in line with the respective policies of the European Commission and EU member states on open access to research publications and data.

The Board of the European Association of Archaeologists (EAA) endorsed the FAIR principles and proposed a collaboration with ARIADNEplus for their implementation in archaeology. The European Archaeological Council (EAC) works with SEADDA, the sister project of ARIADNEplus, on progressing the FAIR data agenda in the sector.

Furthermore, an international collaboration on the implementation of the FAIR data principles in archaeology has been initiated, currently involving American and European archaeological research centres, data repositories and initiatives, the Coalition for Archaeological Synthesis (CfAS), for instance. The overall goal is to advance comparative and synthetic research in archaeology for which FAIR datasets are required to enable aggregation and analysis.

The immediate promotion of FAIR data by ARIADNEplus takes different forms, including recommend-dations and dissemination of guidance, a FAIR data management plan (DMP) template for archaeologists, FAIR as part of training activities, and an online hub of training materials.

Researchers and data managers in archaeology look for practical guidance on what is meant by FAIR data and how to create and make it available. ARIADNEplus and SEADDA adopted the PARTHENOS FAIRify Guidelines and support the dissemination of version in different languages in the archaeological community.

Meanwhile there were nearly 2,500 unique downloads of the guidelines from the Zenodo repository, comprising downloads of the available versions in Czech, English, French, German, Greek, Hungarian, Italian, Portuguese and Turkish.

ARIADNEplus promotes the standardisation of Data Management Plans (DMPs) and appropriate practices of archaeological researchers and projects, taking account of particular requirements of archaeological datasets. A domain-specific DMP protocol has been prepared, corresponding to the respective guidance for domain-specific DMPs of the Science Europe group of research funders and organisations.

An ARIADNEplus team has developed an online DMP tool that supports archaeological researchers to elaborate a DMP for their project, conforming to standard criteria of the domain. Furthermore, in a collaboration with OpenAIRE the requirements for making the DMP machine-actionable have been investigated.

## 4.3    Standardisation of archaeological datasets

### 4.3.1    Expectation & project approach

**RI Programme expectation**

The list of statements on expected impacts in the RI Programme does not include a statement that addresses standardisation explicitly, but need of standardisation is implied in statement [8], *"The integration of major scientific equipment or sets of instruments and of knowledge-based resources (collections, archives, structured scientific information, data infrastructures, etc.) leads to a better management of the continuous flow of data collected or produced by these facilities and resources."*

Integration of knowledge-based resources is hardly possible without standardisation, because standardisation makes data resources knowledge-based, i.e. based on established ontologies and terminology of the domain of knowledge. An explicit statement on standardisation can be found in the section "Specific features for Research Infrastructures" of the RI Programme, Part D, (i) Networking Activities, which considers as a useful activity *"definition of common standards, protocols and interoperability"*.

**ARIADNEplus approach**

Archaeology is a multi-disciplinary field of research in which researchers need knowledge and data from different domains of research. ARIADNEplus integrates data resources from many more archaeological domains and methods than the initial ARIADNE project. For example, this includes paleo-anthropology, bioarchaeology and environmental archaeology, studies of inorganic materials such as metals or ceramics, satellite and aerial imagery from remote sensing, and more.

ARIADNEplus aims for high quality integration of datasets from this wide range of archaeological domains of research based on the ISO standard CIDOC Conceptual Reference Model (ontology) and domain-specific extensions. This integration requires data providers to produce standardised descriptions of records of different types of data according to CRM-based Application Profiles, which must be jointly developed by domain researchers, data managers and vocabulary experts.

The Application Profiles allow mapping of the schemas used in domain databases to the common CIDOC CRM and appropriate extensions, e.g. CRMarcheo for archaeological excavation or CRMba for standing structures as studied in buildings archaeology. The Application Profiles also recommend general and domain-specific vocabularies for metadata elements, for example, for locations WGS84, for cultural periods PeriodO, and for subjects the Getty Art & Architecture Thesaurus.

Data records from databases mapped to appropriate Application Profiles can be aggregated and integrated in the ARIADNEplus catalogue and search portal as well as used by other services and virtual research environments.

### 4.3.2    CIDOC CRM based standardisation of datasets

ARIADNEplus promotes standardisation of archaeological datasets based on the ISO standard CIDOC Conceptual Reference Model (ontology) and domain-specific extensions. While always building on the core CRM, such extensions allow a richer representation of conceptual relations of particular domains of archaeological research.

In the first ARIADNE project the CRM extensions CRMarcheo for excavations, CRMba for archaeological buildings, and CRMtex for the study of ancient texts (e.g. epigraphy) have been developed.[15] Promoted further by ARIADNEplus these extensions, especially CRMarcheo, are increasingly being adopted by archaeological database development and research projects. Hence there is already a significant impact of the CRM-based standardisation of archaeological data management and research promoted by the ARIADNE initiative.

Moraitou et al. (2019) and Gergatsoulis et al. (2021) acknowledge the ARIADNE CRM-extensions as key resources for semantic interoperability of data resources in archaeology. Examples from ARIADNE partners in France using CRMarchaeo illustrate that the usage ranges from a whole digital research ecosystem like OpenArchaeo of the MASA Consortium[16] (Marlet et al. 2019a; Marlet & Rodier 2019), to large databases such as ArSol soil archives (Marlet et al. 2016), on to single excavation archives (Marlet et al. 2019b).

There are a number of other database projects from ARIADNEplus network organisations as well as others using ARIADNE CRM-extensions in Europe (e.g. Aspöck et al. 2016; De Haas & Van Leusen 2020; Rousset et al. 2019; Tufféry & Le Goff 2017; Van Ruymbeke et al. 2018, particularly CRMba). But the standardisation extends to other world regions as well. A particularly interesting example in international cooperation is the BE-ARCHAEO project, one of the Marie Skłodowska-Curie RISE Actions which bridge R&I domains in Europe and worldwide. In the BE-ARCHAEO project the CRMarcheo is being used for data from excavations of Kofun period sites in Japan (Lombardo et al. 2020).[17]

Importantly, the ARIADNE initiative not only provides CRM extensions but also FORTH-ICS's 3M - Mapping Memory Manager system[18], the most advanced tool for mapping databases to the CRM and extensions or application profiles. The system can be accessed and used in the ARIADNEplus D4Science space.

### 4.3.3    Using and extending common vocabularies

A major part of the practical standardisation work of the ARIADNE initiative in the field of archaeology is using and extending essential vocabularies for data integration. This section highlights the work with two such vocabularies, the PeriodO gazetteer for cultural period definitions and the Getty Art and Architecture Thesaurus.

#### Sharing cultural periods through PeriodO

The PeriodO initiative of Adam Rabinowitz and colleagues (Institute of Classical Archaeology, UT Austin)[19] developed a gazetteer for cultural period definitions that transparently records the spatial and temporal boundaries assigned to a given period by an authoritative source. PeriodO is a Linked Data gazetteer, which means that the description of a named period includes a unique identifier (URI) which allows clear and stable linking of data resources which refer to the same period (Rabinowitz 2014; Rabinowitz et al. 2016; Shaw et al. 2018).

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[15] CIDOC Conceptual Reference Model: Compatible models & Collaborations, http://www.cidoc-crm.org/collaborations

[16] Mémoires des Archéologues et des Sites Archéologiques (MASA) is the archaeological consortium of the large Huma-Num digital research infrastructure, https://masa.hypotheses.org

[17] BE-ARCHAEO (MSCA-RISE project, 2/2019-7/2023), https://www.bearchaeo.com

[18] FORTH-ICS: Mapping Memory Manager (3M), http://www.ics.forth.gr/isl/3M; source code, https://github.com/isl/Mapping-Memory-Manager

[19] PeriodO - Periods, Organized, http://perio.do

When the PeriodO started, ARIADNE decided to contribute to this essential resource for the integration of data resources for studies in archaeology, ancient world and more recent history. ARIADNE signed a cooperation agreement with PeriodO and contributed to the system a large collection of over 600 named periods from Paleolithic to Modern times (including time-ranges) for 24 European countries and regions.[20] With PeriodO URIs these periods allow stable linking and integration of data resources which concern the same period.

Furthermore, when users of the ARIADNEplus portal conduct searches using named periods, e.g. "Iron Age", they can discover resources from different countries, although the "Iron Age" has a different time-span in France, England and Ireland, for instance. Moreover, with Natural Language Processing techniques it is possible to identify named periods in archaeological articles and reports on research in different regions and include these in the ARIADNE stock of linked resources.

ARIADNEplus partners now provide additional periods to PeriodO, for example, ARUP-CAS in 2019 provided 133 periods from the AMCR Periods Vocabulary[21], and the Institute of Archaeology "Vasile Pârvan" 24 periods from the Romanian Dobruja Periodization.[22] The associated project The Role of Culture in Early Expansions of Humans (ROCEEH) provided 134 named periods common in Paleoanthropology, including a set of period labels in Africaans.[23] These named periods relate to regions of Africa, the Levant, Eurasia and Europe. They come from the ROCEEH Out of Africa Database (ROAD), from which data records are being integrated in the ARIADNEplus catalogue and portal.

Through the PeriodO system also other institutions and projects can use the cultural periods mobilized by the ARIADNE initiative. ARIADNEplus promotes the use of PeriodO to allow wider interlinking of data resources relating to certain periods in Linked Data initiatives based on the unique and stable URIs of the periods.

## Mapping terms to the multilingual Getty AAT

The Getty Institute provides several vocabulary resources as Linked Open Data in RDF/SKOS format.[24] These include the widely used, very rich and multilingual Art and Architecture Thesaurus (AAT), which ARIADNE has selected as a common semantic "hub" for the subjects of data collections and records.

In order to enable subjects-based searches across collections and records, partners map subject terms from their thesauri or term lists to the Getty AAT (Binding & Tudhope 2016). For such mappings ARIADNE partner USW provides a browser-based application, the interactive Vocabulary Matching Tool[25], which meanwhile has been ported to the ARIADNEplus space in the D4Science platform. Other data interoperability initiatives where providers use different vocabularies can benefit from using this freely available service.

In ARIADNE 12 partners already mapped over 6,400 terms (in different languages) from 27 national or local vocabularies (thesauri, term lists) to the AAT. The mappings ranged from below 100 terms to extensive mappings required to cover large resources. For example, INRAP uses many terms of the

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[20] PeriodO: ARIADNE Consortium (2015): ARIADNE Data Collection, http://n2t.net/ark:/99152/p0qhb66

[21] PeriodO: ARUP-CAS / Kuna M. & Novák D. (2019): Archaeological Map of the Czech Republic (AMCR) Periods Vocabulary, http://n2t.net/ark:/99152/p0wctqt

[22] PeriodO: Institute of Archaeology "Vasile Pârvan" (2020): Romanian Dobruja Periodization for ARIADNEplus, http://n2t.net/ark:/99152/p02kbfn

[23] PeriodO: ROCEEH Research Center (2020): ROCEEH Out of Africa Database (ROAD), http://n2t.net/ark:/99152/p0s2rwk

[24] Getty Vocabularies as Linked Open Data, http://www.getty.edu/research/tools/vocabularies/lod/index.html

[25] USW: Interactive Vocabulary Matching Tool, http://heritagedata.org/vocabularyMatchingTool/; source code for download and installation available on GitHub, https://github.com/cbinding/VocabularyMatchingTool

PACTOLS thesaurus[26] for the subject metadata of their catalogue of archaeological reports (DOLIA). Over 1,600 PACTOLS terms have been mapped to the AAT. Most partners used the tools provided by USW, the Vocabulary Matching Tool or a simpler spreadsheet template[27] (which are available open source).

In ARIADNEplus the total number of mappings so far climbed to over 15,700, comprising mappings of at present 22 partners. Among the larger contributions for example are 2,492 mappings by ARUP-CAS (bilingual, Czech/English terms), and 1,364 mappings of by KHM-UO (bilingual, Norwegian/ English); for example, the latter are find categories (136) and artefact terminology (1,228). Most of the new mappings or revisions have been carried out with the Vocabulary Matching Tool in the ARIADNEplus space on the D4Science platform.

The mapped terms are quite common in cultural heritage and archaeology and therefore covered by the Getty AAT, i.e. an exactMatch, closeMatch or at least broadMatch with an AAT term can be applied in the mapping. In view of incorporating in the ARIADNEplus portal some domain-specific data resources, a more granular classification for some categories of archaeological subjects would be beneficial. How to extend the AAT to cover such classification has been discussed between USW and the Getty AAT team (e.g. in the context of the International Terminology Working Group meeting at the Getty Center in Los Angeles, 6-7 February 2020). This activity will be progressed when the specific terminology needs are clarified by ARIADNEplus.

### 4.3.4    Enhancement of the ARIADNE catalogue model

The original ARIADNE Catalogue Data Model (ACDM) has been developed using a subset of classes and properties of the CIDOC CRM to map the metadata schemas of data resources to this model, which allows to aggregate and integrate the metadata in the data catalogue. In the ARIADNE project the data resources were mainly monument and site inventories, artefact databases, fieldwork reports and archives. ARIADNEplus now mobilizes a wider range of data types from different archaeological domains of research, and aims to integrate them as far as possible at item level.[28]

In the PARTHENOS project[29], led by ARIADNE coordinator PIN and involving other partners, a more sophisticated data catalogue model has been developed. The PARTHENOS CRMpe model[30], created as a model for any humanities and heritage catalogues, covers actors, activities, procedures, datasets and software (Frosini et al. 2018). The CRMpe model has been taken up by ARIADNEplus to enhance its data catalogue with the new AO-Cat (ARIADNE Object Catalogue) model which allows greater flexibility and detail for representing data collections as well as individual items.

Still this model is intended for a common level of semantic description of data resources, while more domain-specific descriptions require richer CRM-based Application Profiles, particularly when the goal is to achieve item-level integration and linking of the data items. Basically such Application Profiles specify further the AO-Cat ontology by including specific classes and properties to better describe the domain data.

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[26] PACTOLS Thesaurus (FRANTIQ, CNRS), http://pactols.frantiq.fr

[27] USW: ARIADNE subject mappings, spreadsheet template, https://github.com/cbinding/ARIADNE-subject-mappings

[28] On the the difference between collection- and item-level access see *Section 4.4.4*.

[29] PARTHENOS (H2020, 5/2015-10/2019), http://www.parthenos-project.eu, has been a cluster project of humanities and social sciences research infrastructures.

[30] CRMpe stands for CIDOC Conceptual Reference Model (CRM) – Parthenos entities (pe).

## 4.3.5    Preparation of domain-specific application profiles

ARIADNEplus works to incorporate datasets from many more domains of archaeological research than the first ARIADNE project. These include palaeo-anthropology, bio-archaeology, ancient DNA, inorganic materials study and dating, burial archaeology, environmental archaeology, maritime and underwater archaeology, standing structures (e.g. ancient buildings), inscriptions (epigraphy, rock carvings), furthermore remote sensing (e.g. LiDAR and satellite data), and spatio-temporal/GIS data, which is relevant for most domains.

Standardisation and integration of datasets from different thematic domains is a time-consuming and iterative process. With the ARIADNEplus CRM-based approach it requires definition of a common application profile (the AO-CAT data model) and more specific profiles for some types of domain datasets.

Basically such domain-specific Application Profiles specify further the AO-Cat ontology by including specific classes and properties to better describe the domain data. These are taken from the overall CRM ontology or available extensions such as CRMarcheo (excavations), CRMsci (scientific investigations in general), and others. For example, the Application Profile for material studies includes, among others, specific classes and properties from CRMsci for Analysis, which describe the kind of analysis used in the study, and Sample, which describes the sample of material being analysed.

When the domain-specific Application Profile is defined, subsequent work includes mapping relevant datasets to it, data aggregation and transformation to CRM compatible records, testing of results, possible improvements, new data ingestion, etc.

Therefore a phased approach was adopted where the data providers were divided into fourteen groups of archaeological sub-domains, und let groups with known datasets from the first ARIADNE project (e.g. monuments and sites inventories) start applying and testing the new AO-CAT data model.

Meanwhile other groups can prepare the more specific CRM-based Applications Profiles and vocabularies required for their datasets, whilst the first datasets for the ARIADNEplus portal were worked on, i.e. mapped, aggregated, tested, etc. Available versions of these datasets also allowed evaluation of the portal search and presentation results in a test version of the new data portal.

Meanwhile several domain-specific Application Profiles have come out of this exercise which include (ARIADNEplus 2020i; ARIADNEplus 2021b):

- Heritage Science - CRMhs (completed), the most elaborated profile, to be applied for e.g. inorganic materials studies and dating,

- Ancient DNA (completed), may be aligned with the CRMhs as there are many similarities,

- CRMtex for the study of ancient texts (near completion), to be applied for epigraphical content (e.g. inscriptions on amphorae),

- Mortuary Archaeology (advanced draft), finalisation according intended level of detail,

- Paleoanthropology (draft), could become a CRMhs version with adjustments,

- Environmental archaeology (draft), could become a CRMhs version with adjustments.

As formal and associated partners provide numismatics resources an additional Application Profile for such resources is being discussed. In the exercise it was also found that not all the thematic sub-groups needed to develop a specific Application Profile as the AO-Cat model profile turned out to be sufficient for core aspects of their datasets. These sub-groups include,

- Spatio-temporal/GIS data,

- Remote sensing

- Metal detector finds

- Standing structures (e.g. ancient buildings)

- Maritime and underwater archaeology

When the domain-specific Application Profiles are consolidated, the domain datasets have to be mapped and the cycle of ingestion and testing carried out until all these various types of datasets have been included in the portal. Importantly, once established, the domain-specific Application Profiles can be used by new ARIADNEplus data providers as well as other projects with a specific focus on data from one or more of the domains of archaeological research.

## 4.3.6 Summary of results

ARIADNEplus promotes standardisation and integration of archaeological datasets based on the ISO standard CIDOC CRM (Conceptual Reference Model) and domain-specific extensions, for example, CRMarcheo for excavations. Created in the first ARIADNE project, meanwhile CRMarchaeo has been adopted by many archaeological database development and research projects.

Importantly, the ARIADNE initiative not only provides CRM extensions but also FORTH-ICS's 3M (Mapping Memory Manager) system, the most advanced tool for mapping datasets to the CRM and extensions or application profiles. The system can be accessed and used in the ARIADNEplus D4Science space.

The data catalogue developed in the first ARIADNE project (ACDM) initiated the CRM-based standardisation of data catalogues in archaeology, cultural heritage and related fields of the humanities. Based on the jointly developed expertise, the new ARIADNE data catalogue model (AO-Cat) provides greater flexibility and detail to describe data collections as well as individual items.

Deeper integration of domain-specific datasets is progressed by ARIADNEplus through the creation of CRM-based Application Profiles, which specify further the AO-Cat ontology by including specific classes and properties to better describe datasets of domains such as archaeometry (e.g. material studies and dating) and ancient DNA studies, but also cultural studies of inscriptions (e.g. rock carvings, inscriptions on amphorae), for instance.

A major part of the practical standardisation work of the ARIADNE initiative in the field of archaeology is demonstrating the power of using common vocabularies for data integration. The core examples here are the Getty Art and Architecture Thesaurus (AAT) and the PeriodO gazetteer for cultural period definitions.

For the subjects of their data resources partners create semantic mappings of terms of "local" vocabularies (thesauri, term lists) to concepts/terms of the large multilingual Getty AAT. This enables subjects-based searches on the ARIADNE Data Portal across the different data collections and records. In ARIADNE 12 partners already mapped over 6,400 terms (in different languages) from 27 national or own vocabularies (thesauri, term lists) to the AAT. In ARIADNEplus the total number of mappings so far climbed to over 15,700, comprising mappings of at present 22 partners.

Again, as in the case of the FORTH 3M system (for CRM mapping), a state-of-the-art tool for vocabulary mappings is being provided with USW's Vocabulary Matching Tool. This tools is also available for users in the ARIADNEplus space in the D4Science platform.

The PeriodO gazetteer system provides unique identifiers (URIs) for cultural period definitions which allow clear and stable linking of archaeological, ancient world and historical data resources which refer to the same period. Started in the first ARIADNE project with the largest contribution of cultural chronologies and periods for 24 European countries and regions, the collection is now being extended

by ARIADNEplus partners and associated projects (e.g. ROCEEH provided 134 named periods common in Paleoanthropology, including a set of period labels in Africaans).

The semantic integration of datasets based on the AO-Cat, the Getty AAT and PeriodO allows users of the ARIADNE Data Portal, for example, find relevant data for "Iron Age" research from different countries, although the "Iron Age" has a different time-span in France, England and Ireland. Indeed, the Data Portal has become an effective research tool for researchers in archaeology and cultural heritage.

## 4.4 Access to integrated knowledge-based resources

The previous section addressed that standardisation makes data resources knowledge-based, i.e. based on established ontologies and terminology of the domain of knowledge (e.g. archaeology, cultural heritage). This section continues from the standardisation procedures describe in that section, first describing the enhancements of ARIADNEplus data portal, followed by the current status of dataset ingest, and portal access and usage.

### 4.4.1 Expectation & project approach

**RI Programme expectation**

[8] *"The integration of major scientific equipment or sets of instruments and of knowledge-based resources (collections, archives, structured scientific information, data infrastructures, etc.) leads to a better management of the continuous flow of data collected or produced by these facilities and resources."*

Integration and access to knowledge-based resources such as digital archives and collections is a core focus of EU funded Integrating Activities of research domains with an e-Infrastructure component. The e-Infrastructure is put in place to allow aggregation, discovery and access to data from distributed domain archives and databases, i.e. the flow from data generators to data users, though not necessarily directly from scientific instruments.

In most cases of e-Infrastructure there is no direct flow of data from the scientific instruments to users, not even access to the massive raw data generated with the instruments. Rather, the data is prepared for access and (re)use from digital repositories and databases. Also the ARIADNE e-Infrastructure has not been built specifically to access data-generating scientific instruments but digital repositories providing access to different data resources, including scientific data.

**Project approach**

The ARIADNEplus European-level research infrastructure integrates international/national and thematically oriented data resources (databases, repositories) of different providers, and the Data Portal allows efficient search of and access to datasets across the integrated resources. The Data Portal services are provided openly and freely to all researchers as well as other users, such as heritage professionals, citizen scientists, students, for instance. The sections that follow first describe the enhancements of the ARIADNEplus data portal, which turned it into an effective research tool, followed by the current status of dataset ingest, and portal access and usage.

### 4.4.2 Enhancement of the ARIADNE data portal

After the funded period of the first ARIADNE project, a lack of funds did not allow enhancements of the data portal and incorporation of more data types and resources. But the data portal has been kept

online to demonstrate the achieved data integration, search and access capability. Also of course the underlying technical setup has been maintained by the ARIADNE partner Institute of Information Science and Technologies (ISTI) of the National Research Council of Italy (taking it over from the initial provider, the Digital Curation Unit of ATHENA RC, Greece).

Already before the start of the ARIADNEplus project, CNR-ISTI reworked the technical setup and ported it to their Cloud-based D4Science platform in view of supporting the further development of the ARIADNE data infrastructure and portal. The implementation of the new ARIADNE data portal has been carried out in collaboration with the team at SND. Besides using D4Science as the portal hosting platform, D4Science also has many inbuilt services and tools that can be made available through the portal or in dedicated virtual research environments (VREs) (see *Section 4.5.3*).

**Release of the new portal with many enhancements**

Meanwhile the new ARIADNE data portal has been released[31] with advanced data search, visualisation and exploration facilities. The following list gives an overview of important enhancements from the user perspective:

- Map-based search facility:

    - Six different layer types are now available (Open Street Map, Open Topology and four Google layers, e.g. satellite-view)

    - Use enabled for polygon-shaped areas of interest as well as other geometric structures

    - Distinction between exact and derived location points

    - Direct links to identified resources of interest

    - The use of historical maps is currently being explored

- Timeline search facility:

    - Search in the facility based on archaeological/cultural time periods

    - Minor changes regarding the date-range based search and timeline display

- Improved filters:

    - Various filters such as the enlarged list of resource types, subjects of the Getty Art and Architecture Thesaurus covered, dating / cultural periods, the list of publishers and the (larger) list of contributors; each filter shows the number of records available per entry (e.g. per publisher, subject, etc.)

    - All filters can be applied to the results from both the Map and Timeline search facilities

- Resource landing pages:

    - Have been updated with more features to find similar resources directly from these page

    - The pages now also provide a preview of visual content (thumbnail images)

It is worth noting that the extra effort invested on the Map search facility has been informed by results of the ARIADNEplus user community needs survey, which showed a particularly high interest in location-based search of available data resources.

The next development phase will focus on adding the multi-lingual capability, which was available in the first portal but required rework and will provide advanced capability, e.g. entry or selection of a term will search across many languages, auto-completion of keyword entry and other such features.

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[31] ARIADNEplus data portal, https://portal.ariadne-infrastructure.eu

Pablo Millet, lead developer for the data portal at SND, notes regarding the already achieved enhancements, *"that the user interface and functionality have been adapted to specifications and requests, but that the main changes are back-end, in the technology behind the interface. The page may look more or less the same, but the system has been given an enormous makeover and modernisation, and this will give the user a better experience. What the user will see is that we've added several new functions to improve the search options. Smart filters that adapt to your searches make it much easier to limit searches. For one thing, you can now use the map to limit a search area, and the filter options will adapt to that specific area. That way, you can also combine aspects such as place and time period"* (SND 2021). Regarding the latter part of Millet's statements, the portal indeed has been turned into a research tool.

### 4.4.3    The portal as an effective research tool

As highlighted by deputy director Julian Richards (ADS) in the project workshop "The Way Forward", ARIADNEplus has turned the original data portal into an effective research tool. Use of different search filters allows new types of research, for example for comparison of settlement patterns in different regions and periods, patterns of artefacts found in different regions of a country or different countries, etc. (ARIADNEplus 2021b). Now possible research on the portal has also been highlighted in the "national launch" of the portal in the UK (ARIADNEplus 2021c; *Section 4.4.5*).

Such research was not possible to achieve so effectively before. The director also suggested that statistical routines could be built into the portal as a further enhancement for researchers. As more data from different providers becomes available, such services for researchers will be added to the portal or provided in Virtual Research Environments (see *Section 4.5.3*). Demonstration of the effective new capabilities will also likely promote a strong increase of portal usage.

It is important to note that a research e-Infrastructure such as ARIADNE generates impact through improved access to research data, new research tools and environments, networking and collaborative research, among others. Geser (2020) argued that in addition to innovation in research the gain in efficiency through the enhanced access to data and and tools should be considered.

In the case of the Archaeology Data Service (ADS), a national-level data repository, the increase in research efficiency of the users has been calculated to be worth at least five times the costs of operation (Beagrie & Houghton 2013). Similar effects may be achieved in future by ARIADNEplus at the European level and internationally by reducing researchers' effort to discover, combine and use data for comparative research. Actually, the new ARIADNE data portal supports these tasks in an integrated way, and with the ingest of datasets from different countries the potential to exploit this will increase ever more.

### 4.4.4    Ingestion of datasets

During the first phase of the ARIADNEplus project the focus was on the preparation, testing and implementation of improved data models (AO-CAT, domain Application Profiles) which can accommodate datasets from many new archaeological sub-domains.

Following the phased development described in *Section 4.3.5*, the preparation of data for the new ARIADNE Portal has taken around two years to bear fruit as the CRM-based standardisation and other procedures were a far more complex process than initially envisaged. The impact of the COVID-19 crisis has added to slowing down the process.

Consequently, the remapping of existing datasets and addition of new ones over the last few months has seen the first datasets being ingested into the new portal at the beginning of January 2021. At the

close of the first ARIADNE project in January 2017, 16 data publishers had provided 24 datasets, some with many contributors or sub-sets of own resources, which resulted in 1,905,922 records in the ARIADNE data portal.

On the 16th of June 2021 the new portal stood at 1,782,988 records based on the advanced AO-CAT data model. These are records from 10 of the project's data providers (*Table 2*), while datasets from several others are being made ready for ingestion in the portal. Indeed, the separate "staging portal", which is being used to test ingestions, includes already 1,938,470 records from 13 providers.

Another 17 partners and associates are actively preparing records for aggregation and transformation in the ARIADNEplus data catalogue. Exact numbers for these records cannot be given at this point, but it is expected that in the coming months the total of cross-searchable records will climb over 2 million records.

*Table 2: Records in the data portal as of 16/06/2021*

| *Publisher* | *No. records* |
|---|---|
| ADS - Archaeology Data Service, UK | 1,427,851 |
| Archaeological Information System of the Czech Republic (managed by ARUP-CAS) | 151,697 |
| DANS - Data Archiving and Networked Services, NL | 95,444 |
| HNM - Hungarian National Museum | 59,686 |
| Swedish Rock Art Research Archives (hosted by SND) | 24,122 |
| AIAC - International Association for Classical Archaeology | 13,980 |
| ZRC SAZU - Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Institute of Archaeology | 8,776 |
| NIAM-BAS - National Institute of Archaeology with Museum, Bulgarian Academy of Sciences | 945 |
| SND - Swedish National Data Service | 484 |
| University of Patras (Dept. Cultural Heritage Management and New Technologies), GR | 3 |
| **Total per 16/06/2021** | **1,782,988** |

It must be noted that the number of records alone does not give an adequate account of the available content. In some cases one record describes and directs the portal user to an accessible collection or archive, e.g. a fieldwork archive, which may contain from a few to thousands of research objects (i.e. texts, images, data sheets, maps, GIS files, and others).

For example, of the three records from University of Patras one describes and links to a dataset of radiocarbon dates for Aegean history and archaeology, 3159 radiocarbon samples from 353 sites, indeed, the largest collection so far of such data from Greece (Katsianis et al. 2020). The other two records point to archives of the fieldwork at the Paliambela Kolindros site (survey, excavation). The Paliambela Kolindros survey archive contains data such as a digital terrain model of the site area, geological layers, geomagnetic survey data, 3D shapefiles for borehole location, geological layers and survey units, modern and past aerial images, landscape features, and more. The excavation archive includes all geospatial and thematic information recorded for Trench 01 at the Paliambela Kolindros Archaeological Project.

This is called collection-level access, while item-level records describe and link to a single content item, e.g. excavation report, map or 3D model. Thus there are data collections from which each item can be found directly on the portal while in other cases only indirectly by following a link in the record of the collection served by the portal.

This difference between item-level access versus collection-level access is due to the technical setup of some data collections which make it difficult to provide records of individual items. In other cases it is preferable to provide access at a higher level, e.g. the description of a collection or database in a repository, rather than individual items without required contextual information. Therefore, in ARIADNEplus for each new and updates of some of the already present data collections in the ARIADNE catalogue the best integration approach must be defined taking account of the content and technical setup of the collection.

### 4.4.5    Portal access and usage

The statistics for the new portal start from January 2021, which is when the upgraded version was implemented with the enhanced search facilities, following in early February when the portal was announced to the ARIADNEplus partners and first "national launches" of the portal (see below).

In the period January–May 2021, there were 1,966 unique visits of the new ARIADNEplus data portal. These accesses came from different channels, including the project website, a search engine like Google, social media such as Twitter or Facebook, and others. Below we provide overviews of the visitor regions and countries, use of portal features, and the effect of social media messages on bringing visitors to the portal.

#### Visitor regions & country of origin

In the period January–May 2021 the portal was accessed from different world regions, most of course from Europe (85% of the total), followed by North America (7.6%) and Asia (3.7%), and minor shares of other regions. Among the European countries, the UK stands out with 44.8% of all 1,966 accesses, followed by Italy with 6.4%, Bulgaria with 6.2%, France and Netherlands each with 4.5%, Germany and Sweden with 2.7%.

*Table 3: Portal visitors per region, 31/05/2021*

| Regions & Countries | Visitors | | Regions & Countries | Visitors | |
|---|---|---|---|---|---|
| **Europe** | **1678** | | **… & neighbours** | **15** | |
| Austria | | 17 | Turkey | | 9 |
| Belgium | | 38 | Russia | | 3 |
| Bulgaria | | 121 | Ukraine | | 3 |
| Croatia | | 3 | **Middle East and Africa** | **12** | |
| Cyprus | | 6 | Israel | | 7 |
| Czechia | | 12 | Jordan | | 1 |
| Denmark | | 6 | Libya | | 1 |
| Estonia | | 1 | Nigeria | | 1 |
| Finland | | 11 | South Africa | | 2 |
| France | | 89 | **North America** | **150** | |
| Germany | | 54 | United States | | 140 |
| Greece | | 35 | Canada | | 10 |
| Hungary | | 34 | **South America** | **21** | |
| Ireland | | 16 | Argentina | | 11 |
| Italy | | 126 | Brazil | | 4 |
| Kosovo | | 2 | Chile | | 1 |
| Lithuania | | 3 | Colombia | | 2 |
| Netherlands | | 59 | Mexico | | 1 |
| Norway | | 13 | Peru | | 1 |
| North Macedonia | | 4 | Puerto Rico | | 1 |
| Poland | | 5 | **Asia** | **73** | |
| Portugal | | 21 | China | | 43 |
| Romania | | 11 | India | | 3 |
| Slovakia | | 5 | Japan | | 24 |
| Slovenia | | 14 | South Korea | | 3 |
| Spain | | 30 | **Australia & New Zealand** | **17** | |
| Sweden | | 54 | Australia | | 15 |
| Switzerland | | 7 | New Zealand | | 2 |
| United Kingdom | | 881 | **TOTAL** | **1966** | **1966** |

## Use of portal facilities

Among the portal accesses 1,348 uses of portal facilities could be identified (69% of all accesses). These include 121 look-ups of the "About" page and 209 of the "Services" page, which describes and links services available from partners, for example, vocabulary resources and tools (e.g. the Vocabulary Matching Tool of University of South Wales), the Visual Media Service and MeshLab software of CNR-ISTI's Visual Computing Lab, general and specialised databases, e.g. ARACHNE of the German Archaeological Institute or the DCCD for dendrochronology (maintained by DANS), and various other resources.

Regarding the search facilities for the "where", "when" and "what" dimensions, with 433 searches most interest attracted the map search facility ("where"), followed by 397 keyword-based searches

("what"). There were 96 uses of the word-cloud for searches (also for "what"), and with 92 uses also not many of the timeline ("when"), although this search option is very useful as a secondary filter for narrowing down search results to within a specified time period. Obviously some guidance will be needed for optimal use of this search facility.

### National launch campaigns

The new portal is being promoted using a "soft launch" approach. As several of the datasets come from national providers it was agreed that the best approach at this stage would be for each provider of a batch of new data to carry out a national dissemination campaign. Such campaigns using social media and other information channels should encourage their archaeological community members to visit the portal and explore their datasets along with all the others already there. This approach ensures that the portal will have a growing number of visitors, with newly available data matched to addressed potential users. It also allows the lead of the ARIADNEplus dissemination work to evaluate different dissemination approaches. For example, forthcoming "national launches" may be combined with focus groups of users or thematic workshops.

*Figure 1: Distribution of portal visits and effects of "national launches", January–May 2021.*
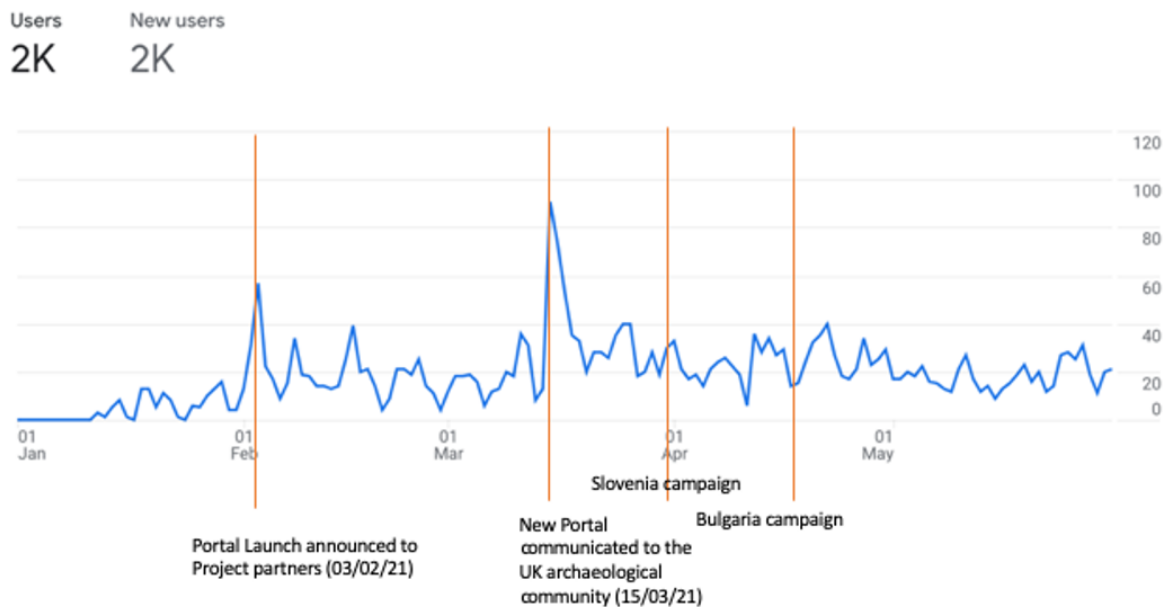


*Figure 1* shows that the new portal was first announced to the project partners on the 2nd of February 2021, producing a spike of around 60 visits and some more thereafter. The first "national launch" started on 15th March in the UK with ADS who ran a week-long Twitter campaign, blogged using examples of data searches, and also had an article published on a website popular with archaeologists, the British Archaeological Jobs Resource (BAJR). Before this campaign portal visits from the UK stood at 172, while two weeks later at 243 (plus 41%). Visits thereafter increased massively to a total of 881 in the period January–May 2021. Promotion of the portal in Slovenia was not that successful, bringing only few new visitors. However, Slovenia has a rather small community of archaeologists. The Bulgarian campaign, started 15th April, was quite successful, bringing the number of visits before the campaign until 31th May from 86 up to 121.

### 4.4.6    Summary of results

The new ARIADNE Data Portal exploits the enhanced integration of knowledge-based data resources, i.e. resources described with the CRM-based data catalogue model (AO-Cat) and common terminology of the domain of knowledge, AAT, PeriodO and other vocabularies. These complex enhancements,

including definition, implementation, remapping of datasets, testing and revisions, have required almost two years. The impact of the COVID-19 crisis has added to slowing down the planned progress.

**The new Data Portal as an effective research tool**

Meanwhile the new ARIADNE Data Portal has been released with advanced data search, visualisation and exploration facilities. These include many new features of the Map-based search (e.g. different layer types, polygon-shaped areas of interest), various options for filtering data records, which all can be applied to both the Map and Timeline search, improved resource landing pages, and more.

Results of the community needs survey have been duly considered, for example, with the extra effort invested on the Map search facility to support users high interest in location-based search of data resources.

The initial ARIADNE data search and access portal has been turned into an effective research tool for researchers in archaeology and cultural heritage. Use of different search filters allows new types of research, for example to explore settlement patterns in different regions and periods, patterns of artefacts found in different regions of a country or different countries, etc.

Such research was not possible to achieve so effectively before. It reduces researchers' effort to discover, combine and use data for comparative research. The new ARIADNE data portal supports these tasks in an integrated way, and with the ingest of more datasets from different countries the potential to exploit this will increase ever more.

**Ingestion of datasets**

At present the new ARIADNE Data Portal contains 1,782,988 data records (16 June 2021), which are based on the advanced semantic AO-CAT data model and domain vocabularies. These are records from 10 of the project's data providers, while datasets from several others are close to ingestion in the portal (then up to 1,938,470 records), and more being prepared for aggregation and transformation in the data catalogue. In the coming month the total of cross-searchable records will climb over 2 million records.

**Portal access and usage**

In the period January–May 2021, there were nearly 2,000 unique visits of the Data Portal, mostly from Europe (85%), followed by North America (7.6%) and Asia (3.7%), and minor shares of other regions. Among the European countries, the UK stands out with 44.8% of the visits, followed by Italy with 6.4%, Bulgaria with 6.2%, France and Netherlands each with 4.5%, Germany and Sweden with 2.7%.

Analysis of the portal usage showed that visitors looked up the "About" page and "Services" page, and conducted various searches. With 433 searches most interest attracted the map search facility, followed by 397 keyword-based searches, and 92 uses of the timeline-based search.

The promotion of the Data Portal follows a "soft launch" approach with national announcements when new data of partners from different countries has been added. Thereby the number of visitors is expected to grow as potential portal users are invited to explore newly added datasets from their country along with all the others already there.

## 4.5 New services and virtual research environments

### 4.5.1 Expectation & project approach

**RI Programme expectation**

[2] *"New or more advanced research infrastructure services, enabling leading-edge or multidisciplinary research, are made available to a wider user community."*

**Project approach**

Archaeology is a multi-disciplinary field of research in which researchers require knowledge and data from different domains of research. Therefore, ARIADNEplus aims to integrate data resources from many more archaeological domains and methods than the initial ARIADNE project. For example, this includes paleo-anthropology, bioarchaeology and environmental archaeology, studies of inorganic materials such as metals or ceramics, satellite and aerial imagery from remote sensing, and more. The new CIDOC CRM based catalogue data model (AO-CAT) and domain application profiles support the integration and linking of the various data resources for advanced resource discovery and access.

The available new data portal is already an effective research tool which exploits the integrated information on the "what", "where" and "when" of archaeological research objects. Thereby new types of research can be carried out by experimenting with the various filters, for example comparison of settlement patterns or artefacts found in different regions relating to different cultural periods. This type of research was not possible to achieve so effectively before.

As more data is ingested in the portal, the possibilities of what can be achieved will also increase with the addition of advanced and new e-research tools. ARIADNE already offered e-research services like the Visual Media Services (VMS), which enable effective online publication and exploration of enhanced images (e.g. Reflectance Transformation Imaging - RTI) and 3D models of buildings and artefacts. In ARIADNEplus the initial Visual Media, Natural Language Processing (NLP) and other services are being advanced and new ones developed, geo-spatial/GIS data services, for instance.

Also among the next steps beyond ARIADNE are Virtual Research Environments (VREs) for e-archaeology on the Cloud-based D4Science platform. In addition to data discovery and access such environments combine more specific services and tools which research communities can use for different tasks and types of data. Such VREs may be configured to support the specific needs of domains of research and inter-/multidisciplary projects.

On a general note, providing research tools online in Cloud-based environments avoids researchers investing effort to acquire, implement, maintain and upgrade them. Instead of dealing with IT issues the researchers can focus on their research questions and collaboration.

### 4.5.2 New and advanced research services

This section gives a brief overview of the planned new and advanced research services, including envisaged or already active use of services. Use of these services is generally intended on the CNR-ISTI D4Science platform.

The overview does not include the tool for mapping database schema to the CIDOC CRM (FORTH' 3M Tool) and the tool for aligning local vocabulary terms to the Getty AAT (USW's Vocabulary Matching Tool). These tools are already in the ARIADNEplus space on the D4Science platform, and have been actively used by partners (see *Sections 4.3.2* and *4.3.3*).

Some of the new and advanced services will be used in ARIADNEplus Pilots to demonstrate to the archaeological research community and other user groups innovative applications of the services and datasets.

## Overview of new and advanced research services

**Cloud-based Geoserver**: The CNR-ISTI Cloud-based Geoserver provides common geospatial/GIS functionality, for example, buffer definition, layer selection, proximity, viewshed analysis and so on. How to enhance with the Geoserver services of the Data Portal is currently being investigated. The Geoserver has already been employed for a small Cloud-based demonstrator in D4Science of the Istituto Centrale per l'Archeologia (ICA) for location and other information on shipwrecks. A larger ARIADNEplus Pilot of ICA and ICCU will focus on a part of ancient Rome.

**Space-time query services**: The space-time query services are implemented and can be used on the Data Portal. They allow users apply powerful searches and filters on the integrated data enabling them to explore research question (see *Section 4.4.3*).

**Archaeological image annotation**: An annotation tool specialised for annotation of archaeological objects which contain written/symbolic information has been developed by AMZ with support by CNR-ISTI VCLab. Among other functionalities the Digital Autoptic Process (DAP) tool[32] allows annotation in a CIDOC-CRM compliant way images of such objects.

**Text and image annotation**: A more broadly useable annotation tool is being developed by USW to enable semantic annotation of text and image items with terms of different vocabularies (e.g. fieldwork reports, artefact or laboratory images).

**Advanced text mining and NLP services**: GATE NLP framework based tools have been developed in ARIADNE, and experimented with on documents in English, Dutch and Swedish (Binding et al. 2018; Vlachidis & Tudhope 2016). The GATE NLP based approach has been enhanced by partners in an EOSCpilot demonstrator (Textcrowd[33]), with documents in Italian (Felicetti et al. 2018). The EOSCpilot tools have already been implemented on the D4Science platform. Further development in ARIADNEplus particularly focuses on making the user interface and tools easy to use by archaeological data managers and researchers. A large demonstration pilot is intended by INRAP using reports in French from their preventive archaeology work.

**3D documentation of an archaeological excavation**: The EpHEMERA[34] system of CYI-STARC allows documentation of archaeological excavations in 3D, specifically of the excavation layers and related documentation; how to bring it on the CNR-ISTI Cloud-based D4Science platform is currently being explored.

**Advanced Visual Media Service (VMS)**: The original ARIADNEplus VMS[35] already allowed effective publication, rendering and exploration of enhanced images (e.g. Reflectance Transformation Imaging - RTI) and high-quality 3D models of buildings and artefacts. Released in early 2015, 460 users have uploaded, processed, and visualized some 1500 visual media resources; around 1000 are still online of which 300 are publicly accessible. Users of the VMS have mainly been university based creators of 3D models and applications. Many have also used it for academic courses and work for a master degree or PhD. Recent further development of the VMS by the VCLab enables users linking documentation to selected parts of a 3D model of a monument or artefact. This will be used in one of the ARIADNEplus Pilots by CYI-STARC. The VCLab and ICCU plan to present the advanced VMS in Q1/2022 to museums

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[32] Digital Autoptic Process (DAP) tool, http://tss.isti.cnr.it/dap

[33] TEXTCROWD (EOSCpilot demonstrator): https://eoscpilot.eu/science-demos/textcrowd

[34] EpHEMERA, http://ephemera.cyi.ac.cy

[35] Visual Media Service https://visual.ariadne-infrastructure.eu

and creative businesses to explore potential demand and related requirements. Major ongoing development aims to make the VMS ready to effectively handle LiDAR data. LiDAR visualization tool algorithms (normals, shaded surfaces, color bands and level sets) are ready but need to be integrated into Openlime. When completed this new service will be employed in an ARIADNEplus Pilot by ZRC-SAZU.

### 4.5.3 VRE use cases and development

#### VRE basic concept

Virtual Research Environments (VREs) are one of the most ambitious innovation goals of ARIADNEplus in the field of archaeological research. A VRE can generally be defined as an online working environment for a community of researchers that provides services and tools for various research tasks. The services could be two or more of those described in the previous section, adapted to the specific needs of researchers in a domain of archaeological research..

The envisaged ARIADNEplus VREs are intended to support data-related research tasks beyond what the Data Portal already allows. They will be implemented on the CNR-ISTI D4Science platform which provides VREs-as-a-service to support open science practices (Assante et la. 2016; Assante et al. 2019). VREs-as-a-service provide generic services (e.g. user authentication & authorization, communication, data storage, metadata, etc.) as well as more research-specific applications (e.g. Data Miner, R-Studio for statistical and other analysis).

#### VRE use cases

Most archaeologists are not familiar with or even aware of VREs as envisaged by ARIADNEplus, and technological VRE developers with an archaeological background are rare as well. Therefore, "a bicycle made for two" approach (Pollard & Bray 2007) is necessary in which archaeologists and technology experts learn from each other in a process of co-designing relevant and fit for purpose VREs.

In order to start this process, a series of VRE use cases workshop is planned. Their purpose is to promote thinking by archaeological research communities represented in ARIADNEplus about which data-related research tasks could be supported by services of a VRE. This is expected to generate "wish lists" and general and domain-specific community requirements for services, which provide a basis for functional descriptions of VREs seen as relevant.

Such functional descriptions will mainly define which data-related research tasks should be supported, the functionality services should provide for the tasks, a basic understanding of how researchers will interact with the services, but not the technical setup and inner workings of the envisaged VRE. This is the realm of the technical VRE developers, which are involved in the VRE use case workshops, but not sitting on the front seat of the "bicycle". The co-design then proceeds with the functional description of the envisaged VRE.

#### VRE workshops

Two workshops have taken place already, with participation of partners, affiliates and external experts; the results are published on the project website.

**First VRE use cases workshop: Geospatial and Mortuary Data and Research** (28th January 2021)

The first workshop explored interesting uses of geospatial/GIS data services, presented by David Novák (ARUP-CAS), and applications researchers in mortuary research would need to tackle their research questions, as explained by Edeltraud Aspöck (ÖAW ACDH-CH); she also gave an example of a "wish-

list" of research tools. Thanados[36] was presented by Jan Hasil (ARUP-CAS) as a state-of-the-art system in the field of mortuary archaeology. Lateron this resulted in an agreement with the developer team at the Natural History Museum in Vienna to integrate datasets.

A highlight of the workshop were also examples of successful uses of D4Science VREs in the field of environmental sciences, which concerned invasive species and monitoring of maritime protected areas. The examples were presented by Massimiliano Assante (CNR-ISTI Infra) and gave the workshop participants an idea of what can be achieved by using VREs. The workshop had 52 participants and results are summarised in an article on the project website (ARIADNEplus 2021a).

**Second VRE use cases workshop: Ancient DNA and Environmental Data and Research** (6 May 2021)

In the focus of the second workshop were ancient DNA (aDNA) and Environmental Archaeology data and research and what VREs could offer these two new scientific domains in the ARIADNE initiative. Eugenia Tabakaki (FORTH-IMBB aDNA lab) highlighted the many uses and also issues faced by aDNA researchers. Maria Theoridorou (FORTH-ICS) introduced the workshop participants to the ARIADNE-plus Application Profile for aDNA data. Both presentations had a focus on samples of archaeological material used for aDNA studies, particularly the context of the sampling. The topic of samples is important for many domains of archaeological research.

Philip Buckland (Umeå University) presented the Strategic Environmental Archaeology Database (SEAD)[37] and how it is being used for environmental reconstructions. He explained that this requires a lot of data processing and analysis, for which CNR-ISTI Infra colleagues suggested to use their "RStudio-as-a-Service". Rachel Opitz (University of Glasgow) presented dataARC[38], a community backed interdisciplinary research environment for understanding human-environment interactions in the North Atlantic region. Addressing design principles of VREs and how to encourage use, she noted that it is important to take account of concerns of researchers regarding data sharing and re-use in VRE. The workshop had 22 participants and results are summarised in an article on the project website (ARIADNEplus 2021f).

**Next two VRE use cases workshops**

***Workshop 3 (Q4 2021): Archaeological Sciences***: will be organised by CYI-STARC and continue the analysis of potential applications of VREs to scientific data domains present in ARIADNEplus (i.e. Paleo-archaeology, Bio-archaeology, Inorganic Materials Study, Dating methods such as Dendrology.

***Workshop 4 (Q4 2021): Spatial Applications***: will be organised by ZRC-SAZU and focus specifically on the spatial research dimension of VREs, available services (e.g. the Cloud-based Geoserver), and data resources for the research, remote-sensing data like LiDAR, for instance. The workshop will also support ARIADNEplus Pilots in which the spatial dimension plays a particularly important role.

## 4.5.4 Summary of results

**New and advanced e-research services**

While the ARIADNE Data Portal already provides an effective research tool, new and advanced e-research services while be added or provided in virtual research environments (VREs). These e-research services will be demonstated in some of the planned ARIADNEplus Pilots.

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[36] Thanados - The Anthropological and Archaeological Database of Sepultures, https://thanados.net

[37] SEAD - Strategic Environmental Archaeology Database, www.sead.se

[38] dataARC – Enabling Research on the Long-Term Human Ecodynamics of the North Atlantic, www.data-arc.org

Use of VRE services is generally intended on the Cloud-based D4Science platform provided by CNR-ISTI, where the previously mentioned CIDOC CRM and vocabulary mapping tools are already in productive use.

Some services may also allow enhancing the Data Portal, for example, the available CNR-ISTI's Cloud-based Geoserver which provides geospatial/GIS functionality. Already planned is an ARIADNEplus Pilot by the Istituto Centrale per l'Archeologia (ICA) which aims to allow users explore the spatio-temporal development of a part of ancient Rome.

Among the advanced services are the Visual Media Services (VMS) of CNR-ISTI VCLab, which enable effective online publication and exploration of enhanced images (e.g. Reflectance Transformation Imaging - RTI) and 3D models of buildings and artefacts. Released in early 2015, the original VMS have so far been employed by 460 researchers and other users.

The advanced VMS will have new functions, for example, users can link documentation to selected parts of a 3D model of a monument or artefact. This will be used in one of the ARIADNEplus Pilots by CYI-STARC. A major ongoing development aims to make the VMS ready to effectively handle LiDAR data. When completed, this new service will be employed in an ARIADNEplus Pilot by ZRC-SAZU.

Advanced Natural Language Processing (NLP) has already been implemented building on the expertise gained in the first ARIADNE project and subsequent developments, e.g. in an EOSCpilot demonstrator (Textcrowd). Experiments have so far been conducted on archaeological documents in Dutch, English, Italian and Swedish. A large demonstration pilot is intended by INRAP using reports in French from their preventive archaeology work.

The planned portfolio of e-research services also includes annotation and linking of text and image items (e.g. fieldwork reports, artefact or laboratory images), to enable multidisciplinary, Linked Data based referencing of items.

**Virtual Research Environments (VREs)**

VREs are one of the most ambitious innovation goals of ARIADNEplus in the field of archaeological research. VREs combine and tailor services for the specific research tasks and data types of a community of researchers. VREs must be co-designed by archaeologists and technical experts to ensure that a relevant and fit for purpose research environment is being developed.

To kick-start the development, a series of VRE use cases workshop is planned. Their purpose is to promote thinking by archaeological research communities represented in ARIADNEplus about which data-related research tasks could be supported by services of a VRE. This is expected to generate "wish lists" and general and domain-specific community requirements for services, which provide a basis for functional descriptions of VREs seen as relevant.

Two workshops have already been held, each involving two of the thematic domains represented in ARIADNEplus: Geospatial and Mortuary Data and Research (January 2021), and Ancient DNA and Environmental Data and Research (May 2021). Two further workshops are planned which will be held in the last quarter of 2021: Archaeological Sciences (involving domains in addition to aDNA research), and Spatial Applications, in view of ARIADNEplus Pilots in which the spatial dimension plays a particularly important role.

## 4.6 Research infrastructures coordination

### 4.6.1 Expectation & project approach

**RI Programme expectation**

[3] *"Operators of related infrastructures develop synergies and complementary capabilities, leading to improved and harmonised services. There is less duplication of services, leading to an improved use of resources across Europe. Economies of scale and saving of resources are also realised due to common development and the optimisation of operations."*

*"Digital services developed under the joint research activities should be exposed under the EOSC catalogue",* statement in section "Specific features for Research Infrastructures" of the RI Programme, Part D, (iii): Joint Research Activities.

**Project approach**

The goal here is to contribute significantly to the coordination among related research e-Infrastructures in order to enable synergies through joint development, optimisation and combination of complementary capabilities. Already fostered coordination with other major research infrastructures, particularly their e-Infrastructure component, will be continued regarding harmonised data models and vocabulary, e.g. data catalogues, use of the CIDOC CRM and domain extensions of the ontology, and appropriate domain vocabularies. This promotes integration of data and saving of resources through re-use of knowledge assets such as CRM extensions, for instance.

However, the overall strategy of ARIADNEplus regarding improved use of resources, economies of scale and cost-savings now is Cloud-based virtualisation and integration in the European Open Science Cloud – EOSC (cf. Richards & Niccolucci 2019: 23). Therefore ARIADNEplus will register its portfolio of Cloud-based and other web services in the EOSC catalogue of resources. This will allow other research e-Infrastructures in the EOSC eco-system use complementary ARIADNEplus resources (services, data) relevant for their operation, and *vice versa*.

ARIADNEplus aims for full integration into the EOSC and, depening on the functionality provided, joint development of digital services with providers of related fields (i.e. heritage sciences, various humanities) and relevant others, such as environmental and geo-sciences data services, for instance.

### 4.6.2 Coordination areas and activities

Coordination with related e-Infrastructures in the field of humanities and heritage research started in the first ARIADNE project through networking with the major European projects already active at that time, CENDARI, CLARIN, DARIAH and Europeana. CENDARI built an e-Infrastructure for historical archives[39]; CLARIN connects language resources and tools into a central platform; DARIAH focuses on supporting digital practices of scholars in a wide range of arts and humanities domains (tools, methods, training).

The knowledge exchange on common topics continues particularly with Europeana as their core focus is making accessible digital/digitised cultural heritage content, including archaeology content. Close relations exist with the research infrastructure E-RIHS for heritage science, which is an ESFRI Roadmap initiative since 2016.[40] In future also cooperation with the Distributed System of Scientific Collections

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[39] Unfortunately, the CENDARI - Collaborative European Digital Archive Infrastructure project (2012-2016), with a focus on digital archives for the Medieval and World War I eras was not continued.

[40] ESFRI Roadmap: E-RIHS, http://roadmap2018.esfri.eu/projects-and-landmarks/browse-the-catalogue/e-rihs/

(DiSSCo)[41], on the ESFRI Roadmap since 2018[42], could become relevant, with a focus on standardised digital description of samples[43], in archaeology specifically samples taken in fieldwork and used in further research.

Overall, however, today the main common point of coordination between research infrastructures, particularly their e-Infrastructure component, is the European Open Science Cloud (EOSC) initiative.

## Standardisation of data catalogues

A major strand of joint development has been CIDOC CRM based models for catalogues of humanities and heritage data resources. The initial model created by ARIADNE for archaeology has been taken up by the PARTHENOS[44] humanities and social sciences e-Infrastructures cluster project (which included from the humanities the European platforms CLARIN and DARIAH, and leading national institutions). In turn, the PARTHENOS CRMpe catalogue model (Frosini et al. 2018) has been developed further by ARIADNEplus with the new AO-Cat (ARIADNE Object Catalogue). While advanced considerably, the model still allows alignment of digital humanities, archaeology and heritage science data catalogues models, enabling significant synergies between the different research infrastructures and domains of research they serve (see *Section 4.3.4*).

## ARIADNEplus and E-RIHS

ARIADNEplus is closely allied to E-RIHS[45], the distributed European Research Infrastructure for Heritage Science. Several partners were involved in the preparatory phase of E-RIHS (E-RIHS PP, until September 2020)[46], e.g. the ARIADNEplus coordinator PIN (Italy), CYI-STARC (Cyprus), CENIEH (Spain), DANS (Netherlands), IAA (Israel), LNEC (Portugal), among others.

Particularly relevant for ARIADNEplus are scientific data from advanced methods of material analyses and conservation of artifacts. As some ARIADNEplus partners employ such methods the CIDOC CRM extension CRMhs (heritage science) has been created, also as a contribution to the future E-RIHS DIGILAB component. The first showcase implementation of the CRMhs is intended by the repository of scientific data of ARIADNEplus partner INFN, from which records will be included in the ARIADNE data portal.

The HESCIDA project of E-RIHS Belgium partner Royal Institute for Cultural Heritage (KIK-IRPA) develops their BALaT+ repository for art history further as an exemplary local repository for the DIGILAB component of E-RIHS. HESCIDA, which may adopt the CRMhs, was presented at the ARIADNEplus workshop "The Scientific Laboratory", 15 September 2020 (see *Section 4.10.3*).

## ARIADNEplus and Europeana

Among the current common topics of ARIADNEplus and Europeana are the growing importance of 3D content, use of Cloud-based solutions, and the adoption of the FAIR principles by cultural heritage institutions. These were strongly present in an EOSC-focused workshop and sessions of the Europeana Conference 2019 (November 2019), with chairs and contributions of ARIADNEplus partners CARARE, ICCU and PIN (EOSC Secretariat 2019; Europeana 2019).

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[41] DiSSCo - Distributed System of Scientific Collections, https://www.dissco.eu

[42] ESFRI Roadmap: DiSSCo, http://roadmap2018.esfri.eu/projects-and-landmarks/browse-the-catalogue/dissco/

[43] DiSSCo has developed a "Digital Specimen" model, and other such models are being proposed (DiSSCo 2021).

[44] PARTHENOS (H2020, 5/2015-10/2019), http://www.parthenos-project.eu

[45] E-RIHS - European Research Infrastructure for Heritage Science, http://www.e-rihs.eu

[46] E-RIHS PP (2/2017-9/2020, https://cordis.europa.eu/project/id/739503

The main liaison of ARIADNEplus with Europeana regarding the archaeology theme is through our partner CARARE. Archaeology content items aggregated since 2013 by CARARE[47] for Europeana represent the largest part of such items in Europeana, 76% of the currently 2.6 million "Archaeology" tagged items. Particularly relevant for ARIADNEplus is to explore common approaches for connecting user groups such as students, educators and citizen science projects with archaeological content and data resources (see *Section 4.9*). An exemplary project in this regard has been Europeana Archaeology (until October 2020)[48], with participation of ARIADNEplus partners CARARE, DANS, ICCU and INP (National Heritage Institute of Romania). CARARE was an associated partner providing support for the aggregation of additional content to Europeana.

## European Open Science Cloud (EOSC)

The European Open Science Cloud (EOSC) is a pan-European vision and initiative aimed to provide a Cloud-based infrastructure for researchers across Europe that enables the storage, management, analysis and re-use of research data compliant with the FAIR Principles for data management.

The EOSC provides a common strategy and virtual platform for research e-Infrastructues to enable use of shared resources (services, data), economies of scale and cost-savings in the development and operation of e-Infrastructures. ARIADNEplus aims for full integration into the EOSC and, depening on the functionality provided, joint development of digital services with providers of related fields, i.e. cultural history, natural history, heritage sciences, and relevant others such as environmental and geo-sciences data services, for instance.

Therefore ARIADNEplus will register its portfolio of Cloud-based and other web services in the EOSC "marketplace" (catalogue of resources). This will allow other research e-Infrastructures in the EOSC eco-system use complementary ARIADNEplus resources (services, data) relevant for their operation, and *vice versa*.

A mapping of the catalogue models has been carried out, and descriptions of some Cloud-based services provided by CNR-ISTI for ARIADNEplus can already be found in the EOSC Portal Catalogue and Marketplace; for example, the Visual Media Service VRE[49] and the more generic RPrototypingLab VRE[50]. In addition, there is a platform-level integration of the D4Science platform with the EOSC which allows connecting the ARIADNEplus part of D4Science in a transparent way with the EOSC, for example the federated identity service.

Future inclusion of data resources provided to ARIADNEplus also in EOSC is being discussed. It seems unlikely that this would go beyond collection-level access, i.e. registration of repositories and databases as provided by services of the institutions themselves.

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[47] CARARE - Connecting Archaeology and Architecture in Europe started as a project 2010-2013 and in 2016 became a non-profit membership organisation, established in Dublin, Ireland, http://www.carare.eu

[48] Europeana Archaeology (EU CEF project, lead University of Vilnius, 2/2019-10/2020), https://europeanaarchaeology.carare.eu

[49] D4Science Infrastructure: Visual Media Service VRE, https://marketplace.eosc-portal.eu/services/visual-media-service-virtual-research-environment

[50] D4Science Infrastructure: RPrototypingLab VRE, https://marketplace.eosc-portal.eu/services/rprototypinglab-virtual-research-environment

### 4.6.3   Summary of results

Coordination with related e-Infrastructures in the field of humanities and heritage research started in the first ARIADNE project through networking with the major European projects already active at that time, CENDARI, CLARIN, DARIAH and Europeana.

A regular exchange with Europeana has been continued as the core focus of Europeana is making accessible digital/digitised cultural heritage content, including archaeology content. Among the common topics with Europeana research groups are the growing importance of 3D content, use of Cloud-based solutions, and the adoption of the FAIR principles by cultural heritage institutions.

A major strand of joint development of the ARIADNE initiative with other research data infrastructures has been CIDOC CRM based models for catalogues of humanities and heritage data resources. The initial model created by ARIADNE for archaeology has been taken up by the PARTHENOS humanities and social sciences e-Infrastructures cluster project (which included CLARIN and DARIAH, and leading national digital humanities centres). In turn, the PARTHENOS catalogue model provided the basis for the current ARIADNEplus model (AO-Cat).

While advanced considerably, the model still allows alignment of digital humanities, archaeology and heritage science data catalogues, enabling significant synergies between the different research infra-structures and domains of research they serve.

Close relations exist with the research infrastructure E-RIHS for heritage science as several partners were involved in the preparatory phase of E-RIHS. Particularly relevant for ARIADNEplus are scientific data from advanced methods of material analyses and conservation of artifacts. As some ARIADNEplus partners employ such methods, the CIDOC CRM extension CRMhs (heritage science) has been created, also as a contribution to the future E-RIHS DIGILAB component.

The first showcase implementation of the CRMhs is intended by the repository of scientific data of ARIADNEplus partner INFN, from which records will be included in the ARIADNE data portal.

Overall, however, today the main common point of coordination between research infrastructures, particularly their e-Infrastructure component, is the European Open Science Cloud (EOSC) initiative. ARIADNEplus aims for full integration into the EOSC. Therefore ARIADNEplus will register its portfolio of Cloud-based services in the EOSC "marketplace" (catalogue of resources).

Some Cloud-based services provided by CNR-ISTI for ARIADNEplus can already be found in the EOSC Portal Catalogue and Marketplace; for example, the Visual Media Service VRE and the more generic RPrototypingLab VRE. In addition, there is a platform-level integration of the D4Science platform with the EOSC which allows connecting the ARIADNEplus part of D4Science in a transparent way with the EOSC (e.g. through a federated identity service).

## 4.7 Cross-disciplinary fertilisation and sharing of resources

### 4.7.1 Expectation & project approach

**RI Programme expectation**

[6] *"Closer interactions between larger number of researchers active in and around a number of infrastructures facilitate cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry."*

**Project approach**

Large-scale, single-sited research infrastructures may promote cross-disciplinary fertilisation as scholars from different backgrounds visit and use their special instruments (e.g. synchrotrons, advanced spectroscopy, etc.), exchange ideas and maybe start a joint project.

In the ARIADNE research e-Infrastructure initiative cross-disciplinary fertilisation is being promoted by the participation of research groups and sharing of datasets from different fields of archaeological research. ARIADNEplus extends the cross-fertilisation potential further by incorporating many more archaeological research communities, including those using natural sciences techniques, i.e. archaeometrical and biological research methods.

More specifically, cross-fertilisation is fostered by the common objective of research groups to share and integrate data to enable comparative research and synthesis. This requires use of appropriate data models, ontologies (e.g. CIDOC CRM extensions), and domain vocabularies, which allow interlinking and exploitation of shared data based on Linked Data methods and technologies.

A strong cross-fertilisation is also being fostered between scholars and developers of e-research services, for example, in the VRE use cases workshops in which service developers learn about the requirements of scholars' projects, and scholars learn how VREs could support their research tasks (see *Section 4.5.3*).

Furthermore, collaboration with external developers is foreseen specifically with developers of Linked Data applications, who can can access and build on ARIADNEplus Linked Data through an interface (SPARQL endpoint). This will enable cross-fertilisation at the data-level and may also lead to external developers offering additional technical applications for exploiting the ARIADNEplus Linked Data.

As addressed in *Section 4.8* on innovation through partnership with industry, the sharing of data and tools between research organisations and businesses will be encouraged by ARIADNEplus. All services are generally open for use also by businesses active in archaeology and cultural heritage, e.g. service providers for preventive archaeology and heritage management. The same applies to cultural and creative businesses which may benefit especially from using the advanced visual data tools and services, particularly to create products for museums, monuments and sites.

### 4.7.2 Cross-fertilisation areas and activities

Cross-fertilisation has been fostered in the building of CIDOC CRM application profiles, takes place in the development of VRE use cases, and will also be promoted through joint use of ARIADNEplus Linked Data.

**Building of CRM application profiles**

Cross-disciplinary fertilisation has been promoted in the effort to create CIDOC CRM application profiles for different domains of archaeological research in ARIADNEplus (see *Section 4.3.5*). Such

domains for example are palaeo-anthropology, bio-archaeology and ancient DNA, environmental archaeology, material studies and dating, among others.

Using the CIDOC CRM as the common conceptual basis, the development of the application profiles for the integration of different domain databases contributed to building common understanding and cross-fertilisation. Differences and communalities became clearer in the process.

### Development of VRE use cases

Cross-fertilisation is also being promoted in the development of ARIADNEplus virtual research environments (VREs) for archaeological research communities (see *Section 4.5.3*). The VREs must be co-designed by scholars and technical experts. In the co-design process the technologists can understand better the research purposes and requirements of the scholars, and the scholars can learn how VRE services and tools can support their research tasks.

### Joint use of ARIADNEplus Linked Data

In ARIADNEplus the data records of the different providers are harmonized and transformed to Linked Data format RDF. The datasets in this format are included and integrated in the ARIADNEplus Content Cloud. The database which contains the Linked Data, an RDF triple store, is being used for internal services (e.g. the data portal services), but will also be accessible by external developers through an interface (SPARQL endpoint).

This will enable cross-fertilisation at the data-level and among application developers. Developers can explore the FAIR ARIADNEplus Linked Data and seek to link it with data of other projects. Currently the ARIADNEplus Linked Data interface and data is experimented with by a developer group at University of Tours.

At a later stage, propably towards the end of 2021, external developers will be invited to explore the ARIADNEplus Linked Data and integrate it with data of other projects. It is also considered to organise joint "hackathons", in which archaeologists are paired with Linked Data application developers to create case studies of data integration across projects. This may result in additional applications being developed for the ARIADNEplus data portal or virtual research environments.

It is also worth noting that provision of datasets to ARIADNEplus to produce Linked Data is not a one-way street. Data providers can get their datasets back, but transformed to the semantic web standard RDF. Thus they can use it for other purposes, linking it to external resources, for instance. This can be done in the ARIADNEplus RDF triple store, thus partners do not need to set up an own triple store.

## 4.7.3    Summary of results

In the ARIADNE research e-Infrastructure initiative cross-disciplinary fertilisation is being promoted by the participation of research groups and sharing of datasets from different fields of archaeological research, which has been greatly extended by ARIADNEplus.

Cross-fertilisation is particularly being fostered by the common objective of research groups to share and integrate data to enable comparative research and synthesis, which ARIADNEplus supports through advancing the semantic interoperability of data resources.

CIDOC CRM application profiles, with a common CRM core and specifications for datasets of different archaeological domains, could play an important role in future cross-disciplinary research.

In ARIADNEplus the work on such application profiles has significantly contributed to building common understanding and cross-fertilisation. Different and common aspects of domain datasets became clearer in the process.

A strong cross-fertilisation is also being fostered between scholars and developers of e-research services in the ARIADNEplus VRE use cases workshops. VREs must be co-designed by scholars and technical experts. In the process service developers learn about the requirements of scholars' projects, and scholars learn how VREs could support their research tasks.

Collaboration with external developers is foreseen specifically with developers of Linked Data applications, who can can access and build on ARIADNEplus Linked Data through an interface (SPARQL endpoint). This will enable cross-fertilisation at the data-level and may also lead to new services for exploiting the ARIADNEplus Linked Data.

## 4.8 Innovation and partnership with industry

### 4.8.1 Expectation & project approach

#### Programme expectation

[4] *"Innovation is fostered through a reinforced partnership of research organisations with industry."*

#### Project approach

The notion of industrial innovation of the Research Infrastructures (RI) Programme is informed by RIs in fields such as energy, materials or life sciences research and development. In these fields innovation may result from advances in the construction of RIs involving industrial providers of components (e.g. procurement of innovative instrumentation), joint R&D projects, or the use of experimental facilities by industrial researchers and developers (ESFRI Innovation Working Group 2018).

In archaeology, private sector commercial actors are businesses of contract archaeologists and consultancies, that provide professional services for developers and heritage management agencies in preventive archaeology. In some European countries such contract archaeology has become the dominant form of field archaeology (e.g. in the Netherlands and the UK), while in others (semi-)public bodies play a greater role (e.g. ARIADNEplus partner INRAP in France).

Archaeological businesses, often spin-offs or otherwise related to archaeological research centres (i.e. as a charitable trust), can benefit from using ARIADNEplus services and datasets, but may also share fieldwork reports and data through underlying repositories. Making such reports and data accessible together with academic studies can allow all actors to benefit from a common resource of information.

This means that partnership and collaboration on such information would have to be promoted by national or regional authorities and implemented in their data management system or recommended respositories. This has happened in the Netherlands and UK, where DANS and ADS are mandated repositories. In other countries heritage authorities receive fieldwork documentation from preventive archaeology, but access to it is often limited to authorised user, i.e. cultural heritage administrators, registered archaeologists and consultants.

This issue may by addressed by the SEADDA project, which recently has carried out reviews of the situation of archaeological data management in several countries and regions (Jacobsson et al. 2021). In ARIADNEplus innovation in this field focuses on using Cloud-based Natural Language Processing (NLP) technologies to extract information from grey literature reports of preventive archaeology.

Furthermore, cultural and creative businesses have been identified as potential user of the ARIADNEplus Cloud-based Visual Media Services, particulary businesses which create products for museums, monuments and sites. Such products are websites presenting museum collections, virtual reconstructions, multimedia exhibitions, and educational digital games, among others. One of the

ARIADNEplus task forces addresses such businesses and together with the CNR-ISTI Visual Computing Lab will present their Visual Media Services and explore existing demand and specific requirements.

## 4.8.2    Selected innovation areas

The main innovation areas considered at present concern the ARIADNEplus Cloud-based NLP and Visual Media Services. The NLP services concern reports of fieldwork reports from preventive archaeology, which is mostly carried out by archaeological businesses. The Visual Media Services are considered relevant for businesses which support the creation of products based on cultural heritage 3D models and other imagery.

### Cloud-based NLP services

In ARIADNEplus innovation in this field focuses on using Natural Language Processing (NLP) techno-logies to extract information from fieldwork reports of preventive archaeology. Experimental work on this started in the first ARIADNE project with promising results, for reports in English, Dutch and Swedish.

Building on the GATE NLP framework, different Named Entity Recognition (NER) techniques were employed, based on vocabularies as well as annotated text corpora as training data for machine learning algorithms (ARIADNE 2016; ARIADNE 2017b; Binding et al. 2018; Vlachidis & Tudhope 2016).

Further developments have been carried out in TEXTCROWD[51], which was an EOSCpilot demonstrator of innovative capabilities provided by Cloud-based solutions. Again Named Entity Recognition based on vocabularies and with annotated text corpora was executed. But with the NLP management interface and processing pipeline not on a desktop computer but Cloud-based, on the D4Science platform of CNR-ISTI. In this project fieldwork reports in Italian language have been processed (Felicetti et al. 2018).

In ARIADNEplus further work on the Cloud-based NLP services is being carried out, particularly to make the user interface and tools easy to use by archaeological data managers and researchers. A large demonstration pilot is intended by INRAP using reports from their preventive archaeology work.

### Cloud-based Visual Media Services

In the COVID-19 crisis many closed-down museums, monuments and sites resorted to using social media platforms (e.g. Twitter, Instagram, Facebook) and re-use existing digital content collections, virtual museum exhibitions and tours.

It became clear that for being prepared for future demand, new and more attractive products should be prepared, educational content with 3D models of artefacts, for instance. Collaboration of cultural heritage institutions on such products with creative businesses, educators and technology service providers could be helpful in this regard, indeed contribute to the resilience of the institutions.

This was also made clear in the online conference "3D Digital Cultural Heritage for Resilience, Recovery and Sustainability" (27 May 2020), co-organised by ARIADNEplus and Inception s.r.l. in collaboration with the European Commission, DG CONNECT, Unit G.2 – Interactive Technologies, Digital for Culture & Education (ARIADNEplus & Inception 2020; see *Section 4.11.3*). DG CONNECT has funded research & development of advanced digital content for culture and education for many years, and wishes to see more take-up by institutions and businesses of the sector.

A report of the Europeana 3D Content Task Force (2020) showed that advanced 3D content solutions have not reached many institutions so far. 3D content, where available, often means videos of objects,

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[51] TEXTCROWD (EOSCpilot demonstrator): https://eoscpilot.eu/science-demos/textcrowd

while 3D models that can be directly and meaningfully used are rare. The availability of more functional and high-quality 3D content should be supported.

Therefore the ARIADNEplus Visual Media Services (VMS) for 3D models and other imagery are considered relevant for cultural heritage institutions and businesses which support the creation of products based on such content. The Cloud-based Visual Media facility of CNR-ISTI VCLab provides Web services for easy publication, visualization and exploration of high-resolution images, Reflectance Transformation Images (RTI), and high-resolution 3D models.[52] One of the ARIADNEplus task forces, including the VCLab, will present the VMS to interested institutions and businesses and explore existing demand and specific requirements.

### 4.8.3    Summary of results

In archaeology, private sector commercial actors are businesses of contract archaeologists and consultancies, which provide professional services for developers and heritage management agencies in preventive archaeology.

Archaeological businesses, often spin-offs or otherwise related to archaeological research centres, can benefit from using ARIADNEplus services and datasets, but may also share fieldwork reports and data through underlying repositories. Such sharing must be promoted by national or regional authorities and implemented in their data management system or mandated respositories, as in the case of ADS in the UK and DANS in the Netherlands.

In ARIADNEplus innovation in this field focuses on using Cloud-based Natural Language Processing (NLP) technologies to extract information from grey literature reports of preventive archaeology. Ongoing work on the implemented NLP services aims to make the user interface and tools easy to use by archaeological data managers and researchers. A large demonstration pilot is intended by INRAP using reports from their preventive archaeology work.

The Cloud-based Visual Media Services (VMS) are considered as relevant for cultural heritage institutions and businesses which create high-quality imagery and 3D products for museums and heritage sites. One of the ARIADNEplus task forces looks for interested institutions and businesses and will, together with the CNR-ISTI VC Lab, present them the VMS and explore existing demand and specific requirements.

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[52] ARIADNE: Visual Media Service, product examples, http://visual.ariadne-infrastructure.eu

## 4.9 Use of services beyond research

The previous section addressed organisational users of ARIADNEplus services, such as cultural heritage institutions and businesses, who could use services for other purposes than archaeological research. This section considers end-users of services that are not archaeologists, such as people engaged in citizen science projects, educators and students, and others.

### 4.9.1 Expectation & project approach

**Programme expectation**

[9] *"When applicable, the integrated and harmonised access to resources at European level can facilitate the use beyond research and contribute to evidence-based policy making."*

**Project approach**

Serving various users groups beyond archaeological researchers and data managers (repositories, databases) is not a core objective of ARIADNEplus. The main intended user groups include also heritage administrations/managers and professionals in preventive archaeology, while others will be addressed where appropriate. In general, however, the ARIADNEplus portal provides open and free access to the available data discovery and access services.

Potential other users of the ARIADNEplus data portal and other services are citizen scientists, educators and students. For example, the project integrates information on metal-detector and other finds by amateurs in countries where this is permitted, and registration of finds in national databases has been enabled. Science educators and students could benefit from the availability of natural sciences data on archaeological remains. Access to relevant content may also stimulate study work and visits to archaeological museums and sites.

Policy-making for archaeological and cultural heritage is a complex matter, due to conflicting interests, especially protection vs. exploitation, different implementation of international conventions and actual heritage management practices across countries (EAC 2018). Contributions to evidence-based policy making by researchers who use ARIADNEplus services and data may be possible, but this has not been defined as a core focus of the ARIADNE initiative in its current phase.

### 4.9.2 Selected end-users beyond research

The ARIADNEplus data portal can be openly and freely accessed and used by anybody. Thus the portal is a form of "public archaeology" by making data of different providers available, not only for archaeological researchers and heritage management practitioners, but for all interested to access and use the data. With the implemented powerful search facilities and filters the portal already provides a research tool to search and compare results for different regions and time periods (see *Section 4.4.3*).

The project aims to go beyond this by addressing user groups such as citizen scientists who are interested to learn about archaeological sites and artefacts and actively engage them on the portal in digital archaeological practices. There are examples of "crowd sourcing" where citizens contributed data, for example, identifying potential archaeological sites on satellite images (e.g. *Field expedition: Mongolia*, Lin et al. 2014), transcribing archival material such as field notes, letters etc. of archaeologists (e.g. *UrCrowdsource*[53]) or museum legacy object cards of artefacts (e.g. *MicroPasts*[54]; Wexler et al. 2015).

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[53] The results of UrCrowdsource have been integrated in Ur-Online (University of Pennsylvania Museum and British Museum), http://www.ur-online.org

[54] MicroPasts (University College London, Institute of Archaeology), https://crowdsourced.micropasts.org

ARIADNEplus integrates information on metal-detector and other finds by amateurs in countries where this is permitted, and registration of finds in national databases has been enabled. By bringing records from these databases into the ARIADNEplus portal, contributions of citizens become visible also on the European level.

One of the planned ARIADNEplus Pilots, lead by Aarhus University (Dept. Archeology and Heritage Studies), aims to go beyond this one-way information flow by enabling public finders of artefacts to classify their finds and others like an archaeological subject expert and share the information in an online environment.

Initial ideas how this could be implemented include a Wiki set up related to the portal or in one of the ARIDNEplus virtual research environments on the D4Science platform. The Wiki could provide a manual and tools to describe the finds and reference concepts of authoritative thesauri (e.g. Getty AAT, FISH Archaeological Objects Thesaurus). Furthermore, the citizen scientists could showcase worked examples and engage others. For example, with a tool to create lists and showrooms of similar finds, which could be designed along various archaeological themes, areas and periods.

Additional approaches to involve citizen scientists, educators and students online are being investigated in a study of the literature and good practices in archeology, cultural heritage, and various other domains.

### 4.9.3    Summary of results

The main intended user groups of the ARIADNE e-Infrastructure for research data are archaeological researchers and data managers (repositories, databases), including from heritage administrations, and professionals in preventive archaeology.

However, the ARIADNEplus data portal can be used openly and freely by anybody interested to discover and access available archaeological data. Thus the portal is a form of "public archaeology" by making data of different providers findable and accessible.

The project aims to go beyond this by addressing user groups engaged in citizen science projects, educators and students, who are interested to learn about archaeological sites and artefacts and actively engage on the portal in some digital archaeological activities. For example, educators and students could use accessible data for scientific or cultural study work.

ARIADNEplus integrates information on metal-detector and other finds by amateurs in countries where this is permitted, and registration of finds in national databases has been enabled. Therefore one of the planned ARIADNEplus Pilots aims to enable public finders of artefacts to classify their finds and others like an archaeological subject expert and share the information in an online environment.

Additional approaches to involve citizen scientists, educators and students online are currently being investigated in a study of the literature and good practices in archeology, cultural heritage, and various other domains.

## 4.10    TNA, training activities and materials

This section addresses the Transnational Access (TNA) offer for researchers to visit ARIADNEplus competence centres, various training activities carried out, and the Training Hub implemented by the project. The TNA programme for 2020 started, but due to the COVID-19 crisis it had to be suspended. Instead, professional development and training offers are provided online.

Taking account of the still difficult situation, but also the increased importance of access to scientific data and online research environments, the project Board of Directors initiated a series of online workshops aimed to give orientation and keep the spirit high. The results of these orientation workshops are also reported in this section.

### 4.10.1   Expectation & project approach

#### Programme expectation

[5] *"A new generation of researchers is educated that is ready to optimally exploit all the essential tools for their research."*

#### Project approach

The programme expectation focuses on education (training) of researchers on using "essential tools" for their research. It remains unclear which tools the "new generation of researchers" would use specifically. But taking account of the Research Infrastructures (RI) context and new research policies, the set of tools (and related skills) would include: tools provided by RI services, specifically for digital and open science practices, including creation and sharing of FAIR data, based on a Data Management Plan (DMP). Indeed, researchers increasingly will need RI services for data-intensive research and, at the same time, are requested to acquire skills in data management and sharing, based on the FAIR data principles.

ARIADNEplus supports these requirements through provision of advanced portal and other data-centred services, Transnational Access (TNA) to partner competence centres, guidelines on FAIR good practices for researchers and data managers, FAIR data and other training (e.g. expert workshops), and an online Data Management Plan (DMP) tool. All these offers are of course tailored to researchers and data managers in archaeology and cultural heritage, with a focus on digital skills and practices.

### 4.10.2   Transnational Access (TNA)

The project includes the opportunity to offer researchers Transnational Access (TNA) to ARIADNEplus competence centres as individual study and training visit or participation in a summer school at a centre. The first TNA call for such in-house training at ADS and PIN was published in September 2019 on the project website and disseminated through social media channels as well as by project partners. A leaflet advertising the TNA offer was also distributed at the conference of the European Association of Archaeologists in Bern (September 2019).

In total, 16 TNA applications were received, equally divided between the training on CIDOC-CRM at PIN and for Data Stewardship at ADS. Based on the result of the internal and external evaluation procedure 13 applicants received offers. Two beneficiaries were able to complete their training at ADS and PIN prior to the COVID-19 travel restrictions (ARIADNEplus 2020a). The remaining candidates for TNA in 2020 have had their training places held until it would have been possible to travel once again which, however, was not feasible or advisable during 2020. Planned summer schools at CNR in 2020 had to be cancelled and rescheduled for 2021, but no TNA call was issued due to continued insecurity.

In summary, physical access as foreseen by TNA has been suspended due to COVID-19 travel restrictions and a generally insecure situation. The possibility of a call in autumn 2021 for TNA visits and summer schools in 2022 will be evaluated.

### 4.10.3   Project orientation workshops

As in all sectors, the work situation became difficult also in the field of archaeology and cultural heritage (see e.g. EAC 2020; ICOM 2020; NEMO 2021; UNESCO 2021). Adressing archaeological research specifically, during 2020 fieldwork campaigns of university-based and other projects were canceled or curtailed, closure of research centres and travel restrictions meant that researchers had difficulty accessing labs, archives and museum collections.

While some of the already planned work will be resumed, archaeologists may have a hard time securing funding for new projects from public and private non-profit agencies. The knock-on effect will be felt for long, particularly by graduate students and early-career archaeologists due to lack of fieldwork experience and reduced employment chances (Di Fiore 2020; Neves 2020). Scerri et al. (2020) argue that the field-based sciences must transform in response to COVID-19, building capacity for advanced remote collaboration based on digital research archives and platforms.

Taking account of the difficult situation, but also the increased importance of access to scientific data and research environments, the ARIADNEplus Board of Directors promoted a series of online workshops aimed to give orientation and keep the spirit high.

These workshops were for the project partners, newly associated or interested organisations. The results of the workshops have been published and promoted through the project website and social media. Below two of these workshops are summarised, "The Scientific Laboratory" and "The Way Forward", while two other workshops on Virtual Research Environments are described in *Section 4.5.3*.

### The Scientific Laboratory

The Scientific Laboratory workshop (15 September 2020) focused on the management and aggregation of scientific archaeological and heritage data, introducing the ARIADNEplus CIDOC CRM extension for heritage science (CRMhs) and presenting case studies that explore how the CRMhs can be used for different types of scientific data. These included the development of the INFN scientific data repository, perspectives and practices of scientific data management at other ARIADNEplus partners (ÖAW, CYI, HNM, LNEC), and the HESCIDA project at the Royal Institute for Cultural Heritage (KIK-IRPA). HESCIDA develops a scientific repository that is intended as a blueprint for such repositories of partners of the distributed E-RIHS research infrastructure for heritage science. The workshop had 62 participants. The programme, report and presentation videos are available online (ARIADNEplus 2020e/f/g).

### The Way Forward

The Way Forward workshop (16 February 2021) involved 74 participants in the presentation and discussion of the different strands of ARIADNEplus activities towards realising the overall vision and aspirations of the project. Presentations covered the already launched new data portal, aggregation of data collections, CRM-based application profiles for item-level data integration, new data services being developed, and planned virtual research environments and pilots (ARIADNEplus 2021b).

Deputy director Julian Richards (ADS) highlighted that the powerful search elements incorporated into the new portal make it much more than just a tool for data discovery and access, it is also a research tool in itself. Indeed, new types of research can be carried out simply by experimenting with the various filters, for example comparison of settlement patterns in different regions and periods. This type of

research was not possible to achieve so effectively before. It depends of course on the quality of the mappings to the Getty AAT (subjects) and PeriodO (space-time gazetteer) carried out by the partners.

*Figure 2: Virtual archaeology 2.0 – Towards virtual research environments (VREs)*
*for archaeology (references in the figure are included in the list of literature).*
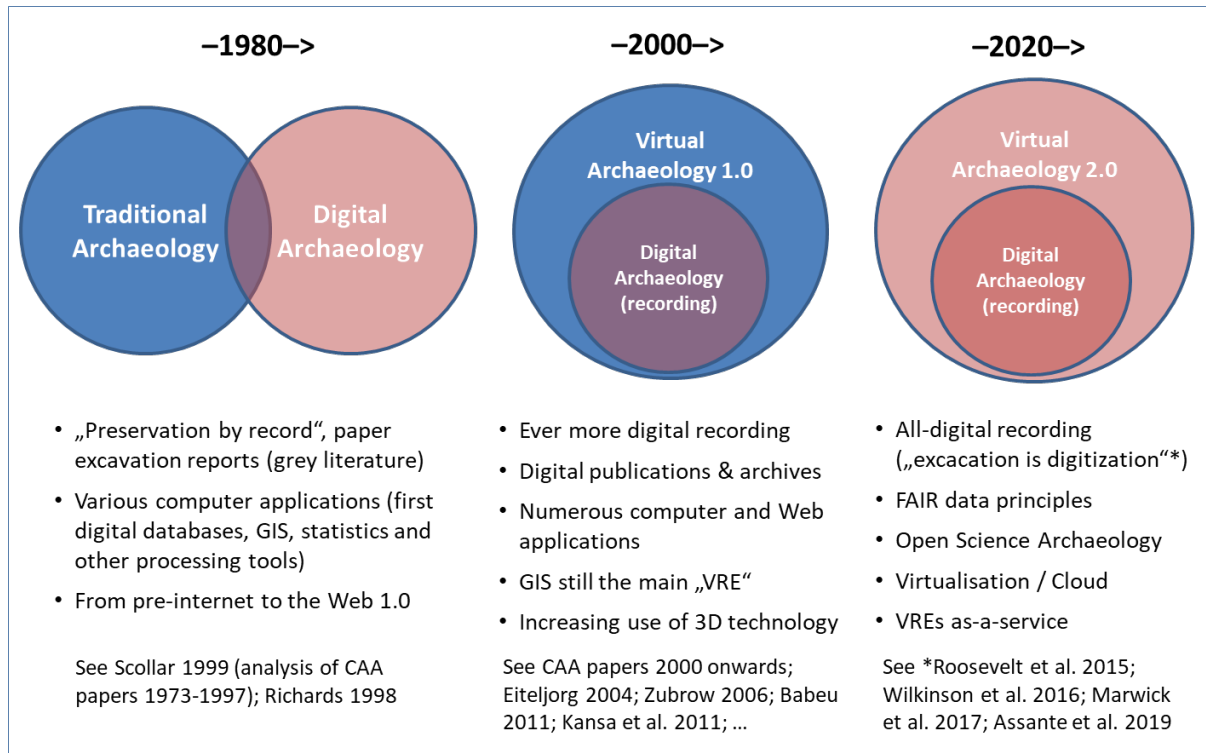


The project director of innovation, Guntram Geser (SRFG), highlighted the goal of ARIADNEplus to provide virtual research environments (VREs) for archaeologists, which allow them to carry out data-related research tasks online, even beyond what the ARIADNE data portal now allows. Such VREs correspond to the overall trend of virtualisation of research, Cloud-based platforms and services, such as the European Open Science Cloud (EOSC). The ARIADNEplus VREs-as-service will be implemented on the D4Science platform of project partner CNR-ISTI, co-designed by archaeologists and technical experts. *Section 4.5.3* describes the already held and planned VRE use cases workshops.

## Workshops of the SEADDA and ARIADNEplus collaboration

As most of the SEADDA partners are also members of ARIADNEplus we include two workshop of this synergetic collaboration. SEADDA fosters the development of FAIR archaeological data repositories, while ARIADNEplus provides the platform for cross-searching repositories, so that reseachers can discover and (re-)use data from repositories of different national and thematic research communities.

***Workshop on Stewardship of Archaeological Data*** (12 November 2019): This in-person workshop with 15 participants was hosted by the Swedish National Data Service in Gothenburg. The workshop explored requirements, obstacles and enablers of long-term curation of and access to open/FAIR archaeological data in different countries (SEADDA 2020a). The workshop was also the starting point for the production of reports on the situation of archaeological data management in different countries across Europe as well as the United States, Argentina, Israel and Japan. These reviews are already published in *Internet Archaeology* (Jakobsson et al. 2021).

***Workshop on Use and Re-use of Archaeological Data*** (31 March – 2 April 2020): Planned by ADS as a face-to-face workshop in York (UK) of the SEADDA network, including ARIADNEplus partners, this meeting had to be moved online. The sessions of the virtual workshop discussed the current landscape

of use and re-use of digital archaeological data, the perspectives of data creators, managers and users, and essential factors enabling data sharing and (re-)use such as trust and good practices regarding available metadata and search and access tools, for instance. The workshop had 63 participants. The available materials and videos of the presentations and discussions represent a rich resources on the topic (SEADDA 2020b).

## 4.10.4 Training workshops

This section highlights some training workshops at the national level or with considerable participation online. Not included are trainings of local reseach institutions and repositories, which often now focus on the FAIR data principles and how to develop a Data Management Plan. Hower, ARIADNEplus and SEADDA promote the use of the PARTHENOS FAIRify guide. Given the high download figures of the guide (see *Section 4.2.4*), it can be assumed that it is often used in such trainings or self-study by young researchers and data managers throughout Europe.

**MASA "Données Interopérables pour le Patrimoine"** (14-18 October 2019): A major training event was the 3-day thematic school of the Consortium MASA "Données Interopérables pour le Patrimoine" (DONIPAT) in Aussois, France, 14-18 Octobre 2019 (MASA 2019). MASA[55] is the archaeological consortium of the large Huma-Num digital humanities research infrastructure in France. Huma-Num is managed by ARIADNEplus partner CNRS. From ARIADNEplus three partners contributed substantially to the lectures, examples and discussion of the MASA school, FORTH-ICS, INRAP and University of Tours' CITERES (Laboratoire Archéologie et Territoires). In the CIDOC CRM part of the school, led by George Bruseker, FORTH-ICS, 50 researchers participated.

**Masterclass on Open Access Digital Publication** (21-22 November 2019): ADS director Julian Richards gave two classes to staff and students at the University of Pisa with 30 participants.

**Workshop on FAIR data management** (17 March 2020): This was planned by DANS as a face-to-face workshop for participants of ARIADNEplus, SEADDA and local researchers, to take place in the The Hague, Netherlands (16–18 March 2020). But due to the COVID-19 crisis it had to be redesigned, at very short notice, as a virtual workshop with a presentations and discussion format. This did not allow hands-on training elements as planned by DANS on FAIR data management and related trust concepts and standards. The reduced virtual workshop took place on 17 March 2020 with 42 participants (ARIADNEplus 2020b).

**CARARE #Connecting Archaeology webinars**: ARIADNEplus partner CARARE mobilised presenters from their network of experts in digital cultural heritage: *Using Vocabularies and Linked data* (30 April 2021): This webinar explored some of the ways that cultural heritage institutions can use controlled vocabularies and Linked Data to improve the discoverability of their content. While most institutions routinely use one or more controlled vocabularies, awareness of the benefits of using Linked Data increased in the last few years (ARIADNEplus 2021d). *Using AI to monitor historic towns and landscapes* (23 June 2021): This webinar explored some of the ways remote sensing and 3D technology, in combination with artificial intelligence applications, can be used to monitor developments at sites and buildings (ARIADNEplus 2021h).

**Training for use of ARIADNEplus services**

Such training has so far been provided only to partners preparing datasets for inclusion in the ARIADNEplus catalogue and portal. These trainings in small groups or individually focused on using FORTH's 3M system for mapping database schema to the AO-Cat (CRM-based catalogue data model),

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[55] MASA, Mémoires des Archéologues et des Sites Archéologiques, https://masa.hypotheses.org

and USW's Vocabulary Matching Tool, which allows data providers to link own terms to matching ones of the Getty AAT. Both tools can be used in the ARIADNEplus space on the D4Science platform.

In future training will be provided for using ARIADNEplus services, including the data portal, individual services and virtual research environments. For example, the new search facilities have turned the portal from a data search tool into a powerful research total. This will require some guidance on how to exploit the tool effectively (e.g. a tutorial, worked examples, etc.).

### 4.10.5   Training Hub

To support perceived training needs of the ARIADNEplus user community a content-rich training resource has been set up with materials selected specifically for archaeological researchers and data managers. The thematic areas of the ARIADNEplus Training Hub correspond to the ones suggested in the community needs survey (ARIADNEplus 2019a: 115-125). The survey included a question on "current training needs of archaeologists regarding data management and processing". The around 330 respondents who answered it approved the different areas of training as very helpful or helpful between 86.6–94.5%. In the Training Hub the two closely related themes of metadata and vocabularies were combined, and use of research infrastructures added.

*Figure 3: Overview of the Training Hub themes*
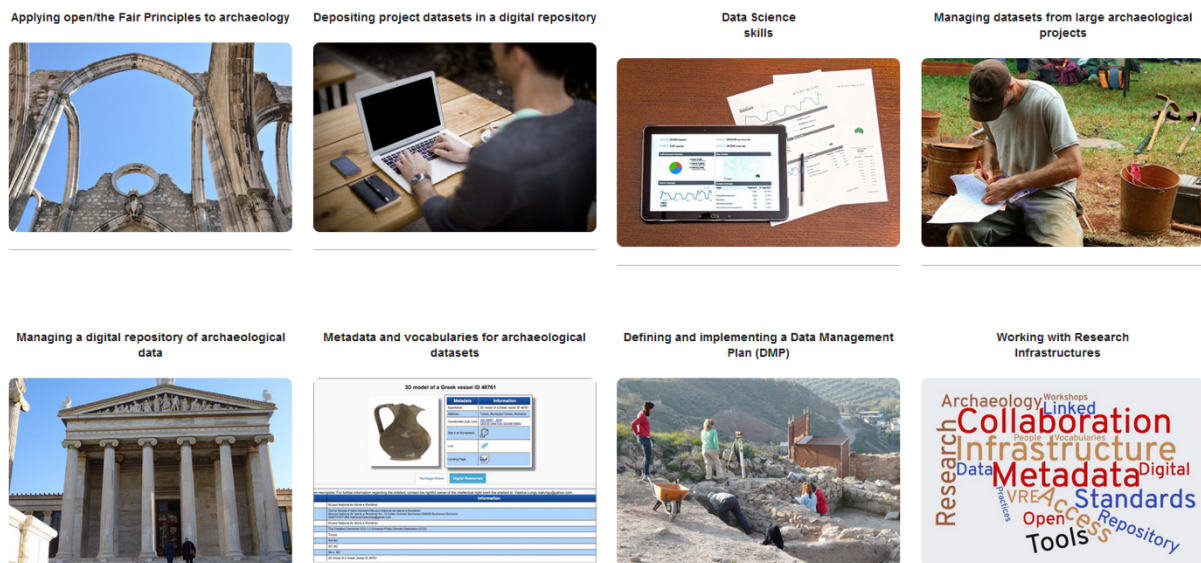


The Training Hub[56] was implemented during November-December 2020 with online accesses mainly by the ARIADNEplus developer and colleagues to see what has already been included und suggest useful additional resources.

Across the eight themes the hub currently comprises of 60 carefully selected Web-accessible resources in English of different providers, ARIADNEplus partners (e.g. ADS Guides to Good Practice) as well as others. The resources are in formats such as online courses, training modules (text & video), Web articles with links to training resources, video presentations, downloadable tools and tutorials, freely accessible books and other materials. Most of the training resources are considered as introductory-level while others, e.g. under Data Science Skills, will require some basics in using software and programming.

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[56] ARIADNEplus: Training Hub, http://www.training.ariadne-infrastructure.eu

*Figure 4: Training Hub audience overview 1 January 2021 – 31 May 2021*



In the period between 1 January 2021 and 31 May 2021 the site had 2,256 visitors who in 3,589 sessions looked which themes are covered by the Training Hub. 273 visitors moved on to thematic sub-pages to see what training resources are available and perhaps consult some of these (which could not be tracked). Most interest attracted the themes "Metadata and vocabularies for archaeological datasets" (73) and "Applying open/the FAIR Principles to archaeology" (53).

## 4.10.6  Summary of results

ARIADNEplus has started its Transnational Access (TNA) programme for 2020, but due to the COVID-19 crisis just two of the 13 TNA candidates could benefit from visiting one of the competence centres. The TNA programme has been suspended, the possibility of a call in autumn 2021 for TNA visits and summer schools in 2022 will be evaluated.

However, the ARIADNEplus partnership provides a range of opportunities for online training and learning activities, all tailored to researchers and data managers in archaeology and cultural heritage, with a focus on digital skills and practices.

These include the ARIADNEplus Training Hub of 60 carefully selected Web-accessible training resources for different topics from both partners and other providers, in formats such as online courses, training modules with videos, downloadable tools and tutorials, and more. In the period January–May 2021, the thematic overview page of the Training Hub received 2,256 visits, 273 visitors moved on to thematic sub-pages, of which most interest attracted the themes "Metadata and vocabularies for archaeological datasets" and "Applying open/the FAIR Principles to archaeology".

ARIADNEplus partners also provided training in-person (when possible) and as online workshops and webinars with over 170 participants. In addition, there are thematic workshops primarily for members of the large networks of ARIADNEplus and SEADDA, but also invited presenters and participants, and the results published online.

Taking account of the still difficult situation due to the Corona virus, but also the increased importance of access to scientific data and online research environments, the ARIADNEplus directors also launched workshops aimed to give orientation and keep the spirit high (e.g. "The Way Forward" workshop in February 2021 with 74 participants).

## 4.11    Dissemination and communication

### 4.11.1   Expectation & project approach

**RI Programme expectation**

[6] *"Closer interactions between larger number of researchers active in and around a number of infrastructures facilitate cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry."*

Dissemination and communication of ARIADNEplus supports the sharing of information and knowledge, albeit not "in and around" physical research infrastructures (e.g. laboratories) but through promoting the e-Infrastructure, services and shared data in conferences and workshops (which have been moved on the Web), publications, and broader dissemination through website articles and social media.

**ARIADNEplus approach**

The ARIADNEplus dissemination and communication activities support the outreach to, and involvement of, the archaeological research and data management community. This section summarises and highlights results regarding publications, conferences and other events, and the website and social media channels. Results of training and expert workshops are reported in *Section 4.10*).

### 4.11.2   Publications

Since project start in January 2019, partners have published 34 academic publications. Of these 32 have been made available open access, either "gold", i.e. journal or conference paper, book chapter etc. published open access, or deposited "green" in an open access repository. The "gold" publications include the 17 chapters of the open access book "The ARIADNE Impact" (Richards & Niccolucci 2019), published by Archeolingua.

**The ARIADNE Impact**

The articles of "The ARIADNE Impact" book document the impact that the ARIADNE and ARIADNEplus projects have had on the archaeological community across Europe and further afield, in Argentina and Japan. Several papers are case studies of how specific aspects of the e-Infrastructure initiative have influenced and affected the organisations involved, from the design and deployment of data management systems, the application of policies and standards to workflows, adopting the FAIR principles and using CIDOC-CRM. Overall, the book illustrates how the ARIADNE initiative has shaped many of the current data management practices in archaeology and will continue to do so. Since 7 October 2019 there were 1,009 unique downloads of the book from the Zenodo repository.[57]

**Promoting open access data**

Several papers from partners and allies promote sharing of open access data, among those not included in the book, e.g. Aspöck (2019), Katsianis et al. (2020), Marlet et al. (2019), McKeague et al. (2020). A special mention deserves "An Aegean History and Archaeology Written through Radiocarbon Dates" by Katsianis et al. (2020). This is a data paper in the *Journal of Open Archaeology Data* which describes an open access published dataset of radiocarbon dates for Aegean history and archaeology,

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[57] http://doi.org/10.5281/zenodo.3476712

3159 radiocarbon samples from 353 sites. It is the largest collection so far of such data from Greece. A data record of this collection is included in the ARIADNEplus data catalogue and portal.[58]

### 4.11.3  Conferences and other events

The ARIADNEplus partners have (co-)organised and attended many conferences (sessions, round tables), workshops and other events, giving presentations and networking with participants. Until Juni 2021, partners reported 43 conferences and other events which they (co-)organised or where they presented ARIADNEplus' goals, work and results. Here ARIADNEplus orientation and training workshops are not included (see *Section 4.10*). The reported total number of participants is 2,364, with an average of 55 participants per event.

The largest participation of around 300 was in the online conference "3D Digital Cultural Heritage for Resilience, Recovery and Sustainability" (27 May 2020), which ARIADNEplus and Inception s.r.l. (a creative business start-up company) organised in collaboration with the European Commission, DG CONNECT (see below); the conference was live-streamed on YouTube and the content on YouTube also got views thereafter, at present nearly 2,800.

**The EAA and CAA as key conferences**

For ARIADNEplus, there are two major annual archaeology conferences which are of key importance to the project. These are the annual meeting of the European Association of Archaeologists (EAA) and the Computer Applications and Quantitative Methods in Archaeology (CAA) conference of CAA International.

The EAA represents the main body of European archaeologists, and has over 15,000 members on its database from 60 countries world-wide working in prehistory, classical, medieval and later archaeology. The EAA Annual Meetings have an attendance of over 2,000 delegates und 150+ sessions. The ARIADNE/plus sessions stand out as there are few sessions dedicated to digital archaeology specifically. In many presentations at the EAA project databases play an important role, but the FAIR data agenda has only in recent years gained some traction, not least by the ARIADNE initiative. In 2020 the EAA president Felipe Criado-Boado proposed a collaboration with ARIADNEplus for the implementation of the FAIR principles in archaeology (see *Section 4.1.2*).

The annual Computer Applications and Quantitative Methods in Archaeology (CAA) conference is the main conference for more digitally inclined archaeologists, with an attendance of around 400 delegates. The CAA has also National Chapters which organise meetings and workshops.

In 2019, 2020 and 2021, ARIADNEplus has been present at all conferences of the EAA and the CAA, except the CAA 2020 planned to be held in Oxford, which was cancelled due to the COVID-19 crisis. The ARIADNEplus session on the 8th of September 2021 at the EAA 2021 is forthcoming, with eight accepted papers, which will highlight the importance of having access to data, not only in pandemic times.

**Selected highlights of other events**

Some selected events highlight ARIADNEplus' international cooperation, relation to the European Open Science Cloud (EOSC), and the use of new online event formats:

**Workshops with ARIADNEplus in Buenos Aires, Argentina** (19-21 November 2019): Through its partners CONICET (Argentina), INFN and PIN, in collaboration with the Italian Embassy and Italian Institute of Culture in Buenos Aires (IIC), the project organised a mission to Buenos Aires to meet with

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[58] https://portal.ariadne-infrastructure.eu/resource/0ADB502D-AE3B-3855-AC50-10F39C06C3A7

representatives of cultural heritage and archaeology in Argentina. During the mission two workshops were held on the 20th of November 2019: at the IIC on archaeological and heritage science (organised by IIC, INFN and PIN), and at the Fundación Williams, with a focus on archaeological FAIR data management in Argentina. This workshop was organised by Andrés Izeta (CONICET, Cordoba), the local ARIADNEplus partner, with the participation of the Argentinian Network on Archaeological Data. Meetings were also held at the University of San Martin (UNSAM) with the faculty and the rector, a visit to their facilities under construction, where an office may be allocated to this international collaboration, and other informal meetings with local researchers. There were plans to extend this collaboration to other Latin American countries in 2020, with a possible enlarged workshop at the end of the year, but they were put on hold for the COVID-19 pandemic emergency.

**Europeana Conference 2019** (27-29 November 2019): The conference programme included common topics of ARIADNEplus and Europeana, the growing importance of 3D content, use of Cloud-based solutions, and adoption of the FAIR principles by cultural heritage institutions. An EOSC-focused workshop and sessions on these topics were chaired or had contributions of ARIADNEplus partners CARARE, ICCU and PIN (EOSC Secretariat 2019; Europeana 2019).

**DH in the Time of Virus** (2 April 2020): ARIADNEplus was invited to make a presentation at this "Twitter Conference" (#DHgoesVIRAL) organised by APOLLONIS, the Greek digital humanities infrastructure. The presentation by PIN focused on archaeological research and data aspects, while a presentation from ICCU highlighted some new initiatives of the Italian Ministry of Culture resulting from the lockdown.

**3D Digital Cultural Heritage for Resilience, Recovery and Sustainability** (27 May 2020): This conference was co-organised by Inception s.r.l., a start-up company that emerged from the EU-funded INCEPTION project (completed in May 2019)[59], ARIADNEplus and the European Commission, DG CONNECT, Unit G.2 – Interactive Technologies, Digital for Culture & Education (ARIADNEplus & Inception 2020). The session "Sustainability: new sustainable ways of accessing and understanding cultural heritage with 3D digital technologies" was co-chaired by Anne Bajart (DG CONNECT) and ARIADNEplus coordinator Franco Niccolucci (PIN). Presenters from ARIADNEplus in this session were Sorin Hermon (Cyprus Institute) and Kate Fernie (CARARE). A presentation was also given in another session by Bogdan Sandric from the National Heritage Institute of Romania. The conference was streamed live on YouTube, with an audience participation count of 280-300 steady viewers, a pick of 420, and 2,100 total views on YouTube in the first 24 hours, at present 2,784 views.

**Realising the European Open Science Cloud** (16-19 November 2020): This conference has been organised by the projects EOSC-hub, FREYA and SSHOC and focused on the progress towards a FAIR research data landscape for the social sciences, humanities and beyond. ARIADNEplus represented the domain of archaeology. Deputy coordinator Julian Richards and Holly Wright (University of York & ADS) presented the ARIADNE infrastructure and community, including the work on user needs and the data aggregation tools and standards in use for the ARIADNE portal. As archaeology works with extremely diverse and difficult data types, the lessons learned are useful for establishing best practice relevant to a wide variety of areas across the social sciences and humanities.

**The Bled Strategic Forum: Third Latin American and Caribbean Days** (19-23 April 2021): At this international conference Petra Žagar from the Science Directorate of the Slovenian Ministry of Education, Science and Sport introduced projects in which partners from Slovenia cooperate with partners from the Latin American and Caribbean. Collaboration between ZRC-SAZU and CONICET-IDACOR (Instituto de Antropología de Córdoba), Argentina, in the framework of ARIADNEplus was present by Benjamin Štular (ZRC-SAZU); both use the ARCHES Heritage Inventory and Management

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[59] INCEPTION - Inclusive Cultural Heritage in Europe through 3D semantic modelling (H2020, 6/2015-5/2019), https://www.inception-project.eu

System for their data which allowed sharing their experience and working together to prepare their data for inclusion into the ARIADNEplus portal (ARIADNEplus 2021e).

## 4.11.4  Website access

The Google Analytics Audience Overview report provides a general view of the users who reached the ARIADNEplus website during the period between 1 June 2020 and 31 May 2021. The overall performance analysis was positive and the values of the main reference parameters were consistent with the previous period.

The site has attracted 6,994 visitors, with around 14% being return visitors, and a total of 20,616 pages viewed. The number of sessions, each one represents a single visit to the website, was around 10,000, the Page/Session ratio shows 2.07 pages per visit and the average session duration is 2:07 minutes, quite the same recorded in the previous period.

*Figure 5: Website audience overview*
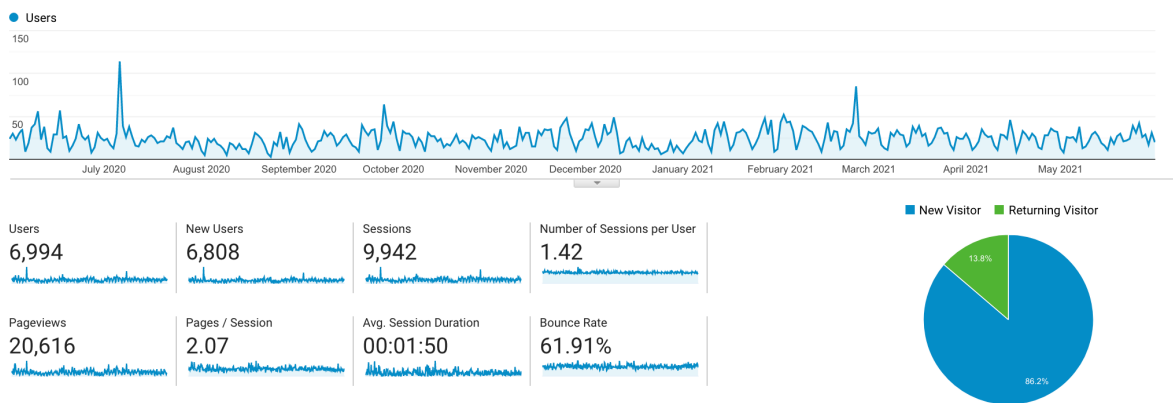


In terms of page views, the website's home page stays at the 1st place. In addition to the homepage, the other most visited pages showed the results of the homepage restyling launched online in month 18. The content was re-organised around four main areas of interest: the Portal, the ARIADNEplus Community, the project's ongoing work and outputs, and the Training Hub.

*Figure 6: Page views overview*
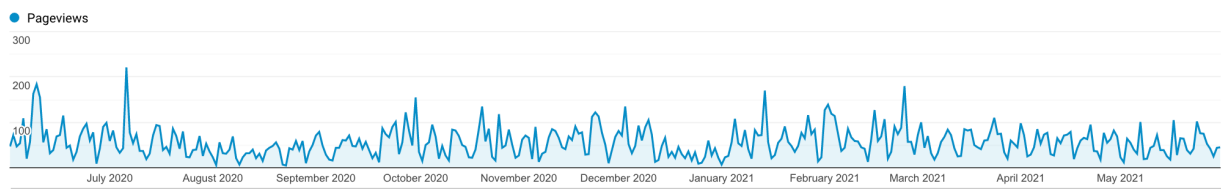
*Figure 7: Top page views*

| Page | Pageviews ↓ | Unique Pageviews | Avg. Time on Page |
|---|---|---|---|
| | **20,616**<br>% of Total: 100.00%<br>(20,616) | **16,593**<br>% of Total: 100.00%<br>(16,593) | **00:01:42**<br>Avg for View: 00:01:42<br>(0.00%) |
| 1.  / | **8,541** (41.43%) | 6,836 (41.20%) | 00:01:24 |
| 2.  /portal/ | **2,554** (12.39%) | 1,979 (11.93%) | 00:02:10 |
| 3.  /about-ariadne/ | **915** (4.44%) | 719 (4.33%) | 00:02:39 |
| 4.  /community/ | **632** (3.07%) | 518 (3.12%) | 00:01:31 |
| 5.  /partners/ | **541** (2.62%) | 487 (2.93%) | 00:02:21 |
| 6.  /resources/ | **472** (2.29%) | 373 (2.25%) | 00:00:55 |
| 7.  /resources/ariadneplus-deliverables/ | **421** (2.04%) | 378 (2.28%) | 00:01:45 |
| 8.  /our-network/ | **318** (1.54%) | 269 (1.62%) | 00:01:10 |
| 9.  /training-tna/ | **311** (1.51%) | 274 (1.65%) | 00:00:52 |
| 10.  /associate-partners/ | **302** (1.46%) | 247 (1.49%) | 00:01:09 |

## 4.11.5   Social media

### Twitter

Twitter is used regularly by the project to bring attention to outputs, notify users of events of interest and retweet items of interest. Over the last year, the average number of views was 6,690 with 10 new followers per month.

*Table 3: ARIADNEplus Twitter statistics, June 2020 – May 2021*

| Month | Tweets | Views | Profile Visits | Mentions | New followers |
|---|---|---|---|---|---|
| June 2020 | 1 | 11,100 | 92 | 10 | 13 |
| July 2020 | 2 | 5,901 | 69 | 5 | 7 |
| August 2020 | 0 | 3,756 | 66 | 9 | 12 |
| September 2020 | 3 | 4,969 | 146 | 5 | 15 |
| October 2020 | 3 | 6,280 | 131 | 10 | 12 |
| November 2020 | 2 | 4,995 | 109 | 11 | 9 |
| December 2020 | 1 | 3,716 | 170 | 2 | 3 |
| January 2021 | 0 | 1,603 | 165 | 4 | 2 |
| February 2021 | 13 | 13,900 | 385 | 9 | 10 |
| March 2021 | 5 | 11,600 | 593 | 13 | 26 |
| April 2021 | 3 | 6,706 | 917 | 13 | 3 |
| May 2021 | 4 | 5,758 | 276 | 1 | 5 |
| **Average pcm** | **3** | **6,690** | **260** | **8** | **10** |

It is worth noting that the tweets which attracted most interest concerned the new data portal turned into an innovative research tool (see *Section 4.4.3*). For example, the following message on February 2021 received 2,023 views: *"Amazing case study presented by Julian Richards of ADS. The Portal now has capability to answer questions about the data e.g. compare timelines for data provided by country and / or by provider. Settlement patterns can be compared - so many new possibilities!"*

### Facebook

Facebook is not considered to be a main means of communication for the project but it is used by some people in preference to Twitter, so a presence is maintained for the small following of 22 members in order to have maximum coverage.

### Slideshare

Several presentations and reports have been uploaded to the "ariadnenetwork" Slideshare account. This is a supplementary dissemination channel that enables promotion of the project to audiences who are looking for specific topics of interest. For example, the presentation "Preferred Formats = Pre-FAIRed Formats" by DANS data manager Valentijn Gilissen received 104 views since 28 April 2020. While this is a relatively small number, across all project products on Slideshare a lot of awareness of the ARIADNE initiative is being generated.

## 4.11.6 Summary of results

The ARIADNEplus dissemination and communication activities support the outreach to, and involvement of, the archaeological research and data management community in Europe and beyond. In addition to the training and learning resources, training and other workshops, here results regarding publications, conferences and other events, and the website and social media channels are reported.

### Publications

Since project start, partners have published 34 academic publications, 32 made available open access, either "gold", i.e. journal or conference paper, book chapter etc. published open access, or deposited "green" in an open access repository. The "gold" publications include the 17 chapters of the open access book "The ARIADNE Impact", published by Archeolingua. Since October 2019 there were 1,009 unique downloads of the book from the Zenodo repository.

Several papers from partners and allies promote sharing of open access data. A special mention deserves "An Aegean History and Archaeology Written through Radiocarbon Dates" (Katsianis et al. 2020), a data paper which describes this large open access dataset; a dataset record is also included in the ARIADNEplus data catalogue and portal.

### Conferences and other events

The ARIADNEplus partners have (co-)organised and attended many conferences (sessions, round tables), workshops and other events, giving presentations and networking with participants. Until Juni 2021, partners reported 43 conferences and other events which they (co-)organised or where they presented ARIADNEplus' goals, work and results. The reported total number of participants is 2,364, with an average of 55 participants per event.

The largest participation of around 300 was in the online conference "3D Digital Cultural Heritage for Resilience, Recovery and Sustainability" (27 May 2020), which ARIADNEplus and Inception s.r.l. (a creative business start-up company) organised in collaboration with the European Commission, DG CONNECT. The conference was live-streamed on YouTube and the YouTube views counter shows nearly 2,800 views for the video recording.

ARIADNEplus was of course present with sessions at the two main annual archaeology conferences for the project, the annual meeting of the European Association of Archaeologists (EAA) and the Computer Applications and Quantitative Methods in Archaeology (CAA) conference. Unfortunately, the CAA 2020 had to be cancelled due to the COVID-19 crisis. Forthcoming is the session at the EAA 2021, with eight accepted papers, which will highlight the importance of having access to data, not only in pandemic times.

**Website and social media**

In the period June 2020 to May 2021, the ARIADNEplus website attracted 6,994 visits, with around 14% being return visitors, and a total of 20,616 pages viewed. The overall performance was consistent with the previous period, i.e. the website quickly reached and retained a high level of interest.

The main social media channel of the project is Twitter which is used regularly to bring attention to outputs, notify users of events of interest, and retweet items of interest. Over the last year, the average number of views per month was 6,690, with 10 new followers attracted per month.

Facebook is used by some people in preference to Twitter, so a presence is maintained for the small following of 22 members in order to have maximum coverage. More important is the project's Slideshare account for making available selected presentations and reports. It enables promotion of the project to audiences who are looking for specific topics of interest. While most products receive a small number of views, across all a lot of awareness of the ARIADNE initiative is being generated.

# 5     Final remarks and outlook

The COVID-19 pandemic had a profound impact on the project work and communication from late February 2020 and made face-to-face meetings and events impossible. All joint activities are currently digital, which was made possible thanks to Web platforms and communication channels. The ARIADNEplus community adapting very well to this seismic change, carrying on their work from home and in recent months from their research centres.

During the lockdowns, most partners could continue working on their repositories based on implemented remote access or solutions set up to carry out work on data and metadata, see e.g. Nicholson (2020) for Digital Antiquity (tDAR respository, USA) and Cayırezmez (2020) for the associated partner British Institute at Ankara (BIAA), who are implementing a repository.

The COVID-19 crisis had negative effects on ARIADNEplus activities, particularly the Transnational Access programme, however, the crisis increased the recognition within the archaeology and wider heritage sector of the importance of proper data management, repositories of open/FAIR data, and discovery and access services. Thus the crisis will probably increase the impacts of ARIADNEplus and SEADDA in the sector.

The forthcoming joint session of the projects at the EAA 2021 conference will provide a forum to discuss *"the challenges, opportunities and lessons learned across all aspects of archaeological data management during the pandemic, and how it may change and inform our best practice going forward"* (ARIADNEplus 2021g).

How ARIADNEplus continues to increase the results of the project activities will be regularly observed and guided by the impact monitoring task. The outcomes will be presented in the Final Report on the Project Impact (D6.4, December 2022).

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