ARIADNE

D13.4: Final services implementation report

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Document history

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7th December 2016	Section 1 to 10 outlined	CNR, ATHENA
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Executive Summary

This document is a deliverable (D13.4 *Final services implementation report*) of the ARIADNE project ("Advanced Research Infrastructure for Archaeological Dataset Networking in Europe"), which is funded under the European Community's Seventh Framework Programme. It presents results of the work carried out in Task 13.2 "Services implementation". It represents the evolution and result of what presented in D13.2 "Initial services implementation report".

Task 13.2 was be devoted to implementing some of the services designed in Task 13.1 *Service design and specifications*, in a modular way, and to possibly integrate the already existing services provided by the consortium. The work of the task in the second half of the project was strongly integrated with WP12, as the definition of services in the ARIADNE Catalogue Data Model (ACDM), and the implementation of the ARIADNE Portal guided the implementation of the services.

The services in the final implementation of the portal are both a result of an ad-hoc implementation, and the integration of already existing entities. These are described in Sections 2 to 4, following the categories of services described in the ACDM.

Section 5 is dedicated to the outcomes of Task 13.3 "Long-term preservation services" which had the goal of preserving the data and metadata produced within the infrastructure.

Section 6 focuses on the fact that ARIADNE services also had an active role during the project, as they were used in the context of the TNA activities.

Services also underwent several cycles of informal and formal evaluation, resulting in a valuable source of information for the major updates. Some basic information about the official acceptance testing (described in detail in Deliverable 13.5) are provided in Section 7.

The outcomes of WP13 (and of the whole project) have created a strong starting point to provide services within an integrated infrastructure. Section 8 outlines a possible set of actions moving forward.

1 Introduction

This document presents the final list of services designed and implemented for the ARIADNE infrastructure. The development and integration of services was the objective of Work Package 13 Developing Integrated Services (WP13).

WP13 is informed by the output of WP2 (mainly Task 2.1 *User needs and community building* and Task 2.2 *Special Interest Groups*), and parallels the data integration effort in WP12. Moreover, the services made available by the Portal developed in WP13 also incorporate those developed by WP14 (item-level integration), WP15 (Linked Data) and WP16 (NLP). WP13 has contributed to the provision of these latter services together with the ones specifically developed within the framework of WP13.

The main goal of ARIADNE is to bring together existing archaeological research data infrastructures, and integrate their data and services, thereby enabling researchers to access the datasets and take advantage of the resulting services at item and collection level. These services include functionalities that were already available, and are offered to communities who may not have had access to them. They also include new functionalities created *ad-hoc* by the partners on the basis of the requirements that were collected at the beginning of the project. The main modality of the implementation of these new functionalities was to provide web-based services, although other types of services (local tools, guidelines) were integrated as well.

This Deliverable is organised as follows: Section 2 gives a short description of the services that rely on the ARIADNE Catalogue. Section 3 offers an overview of the Services provided by the ARIADNE partners, which have been adapted and integrated in the Infrastructure. Section 4 presents the new Services developed specifically for the Infrastructure. Section 5 describes the ARIADNE preservation services. Section 6 presents some selected sample utilizations experimented by partners in the framework of the Transnational Access program, Section 7 describes the corrective actions undertaken to take into account the evaluation and suggestions of the ARIADNE users. Finally, Section 8 outlines the conclusions. This deliverable will refer, where necessary, to D13.1, which provides the design of the services, grouped by functional similarity. The implementation described here covers all the use cases proposed in the D13.1, taking into account the structure of the Infrastructure that is currently under final implementation.

2 Services provided within the ARIADNE Catalogue

The ARIADNE Catalogue is based on the ARIADNE Catalogue Data Model (ACDM), which was developed to describe the archaeological resources made available within the ARIADNE infrastructure to the researchers wishing to access and use them. The Catalogue has been made available as Linked Data, mapped to the CIDOC CRM for integration with item-level data, also expressed using the CIDOC CRM ontology. The resulting LD dataset is deployed in the Ariadne Linked Data Cloud, which is fully described in D15.3.

As shown in *Figure 1*, the central notion of the ACDM is the *ArchaeologicalResource* class, which has as instances the main resources described in the Catalogue. These resources are categorised as:

- *data resources*, representing the various types of data containers that can be discovered, accessed and possibly integrated within the ARIADNE infrastructure. Data resources are categorised in collections, datasets, databases and GIS;
- *services*, representing the services made available by the ARIADNE infrastructure;
- *language resources*, representing vocabularies, ontologies, metadata schemas, mappings (between language resources in general) and gazetteers that are available within the ARIADNE infrastructure.

Please refer to the specification of the ACDM (ARIADNE internal deliverable D12.2) for a detailed description.

The search and retrieval functionalities for all types of resources described in the Catalogue are currently under finalisation in the context of WP12.

The ACDM defines a rich structure to discover the large number of resources provided by the ARIADNE infrastructure, either by querying the Catalogue or by browsing the information space described within it. Given the size of that information space, it is expected that most queries will return a large result. For the same reasons, browsing the information space will be difficult. It was therefore paramount to create the discovery service with powerful visualisation functionality, allowing users to consume the query results and browse the ARIADNE information space in an easy and useful way.

To this end, a set of visualisation services (in addition to the basic search and retrieval functionalities) were made available within WP13 to explore query results and browse the ARIADNE information space. These services provide the front-end and back-end services implemented within WP12; therefore their implementation is the result of a tight collaboration between WP12 and WP13. These services had to cover the use cases 7.1 (Search and explore the registry), 7.2 (Preview data), 7.3 (Access data), 7.5 (Search and access the services registry), 7.6 (Prepare and register a new collection) and 7.7 (Enriching Visual Media Documents) described in D13.1

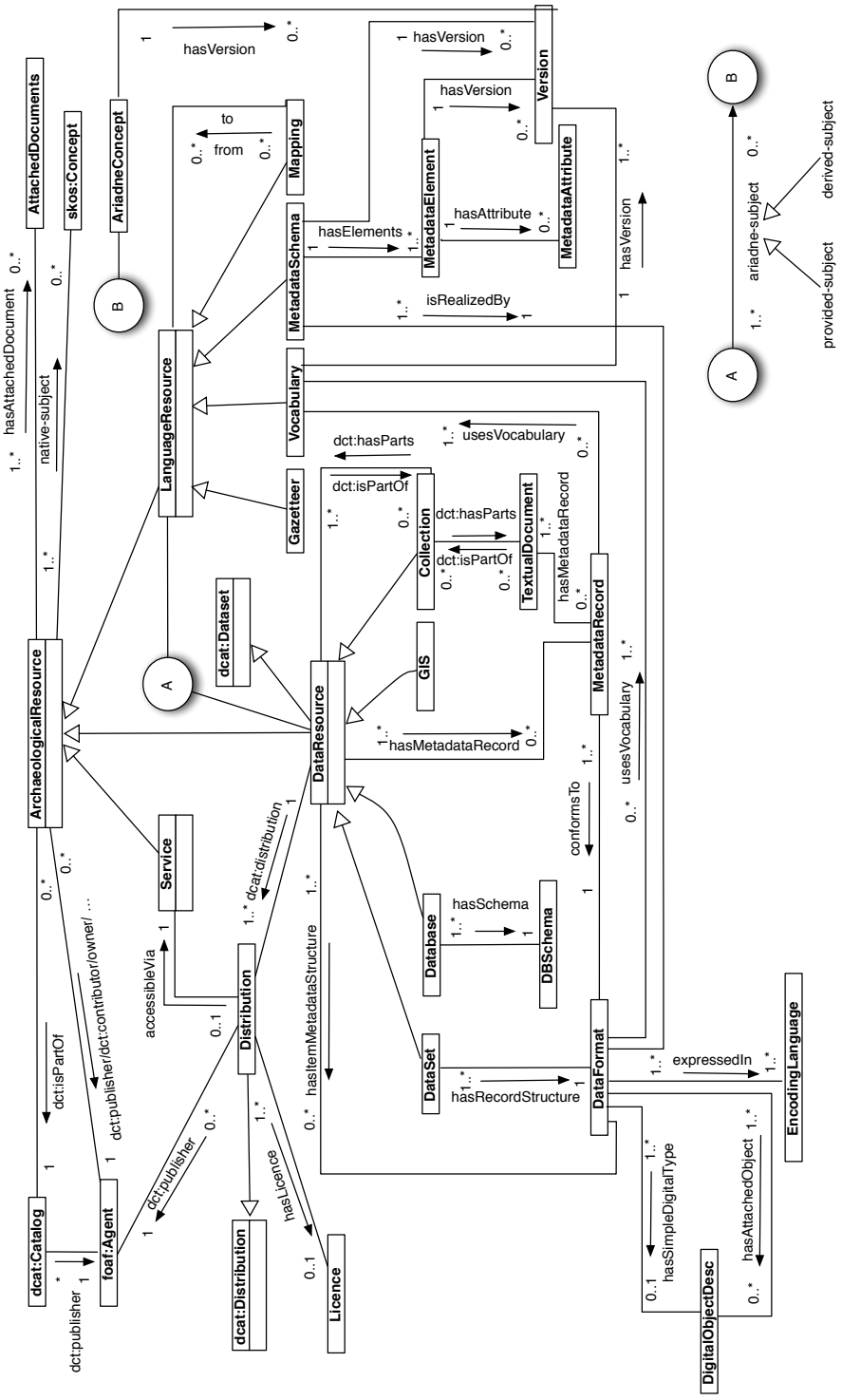

Figure 1: The UML Diagram describing the ACDM (extracted from the Specification document version 2.5.5

In addition to textual query results, two main visualisation services are available for discovering ARIADNE data resources:

- **Spatial display of query results:** because the data resources are associated with spatial data (expressed in terms of GPS coordinates, or postal address) it is possible to visualise the result of a query on a map (like the example shown in Figure 2).

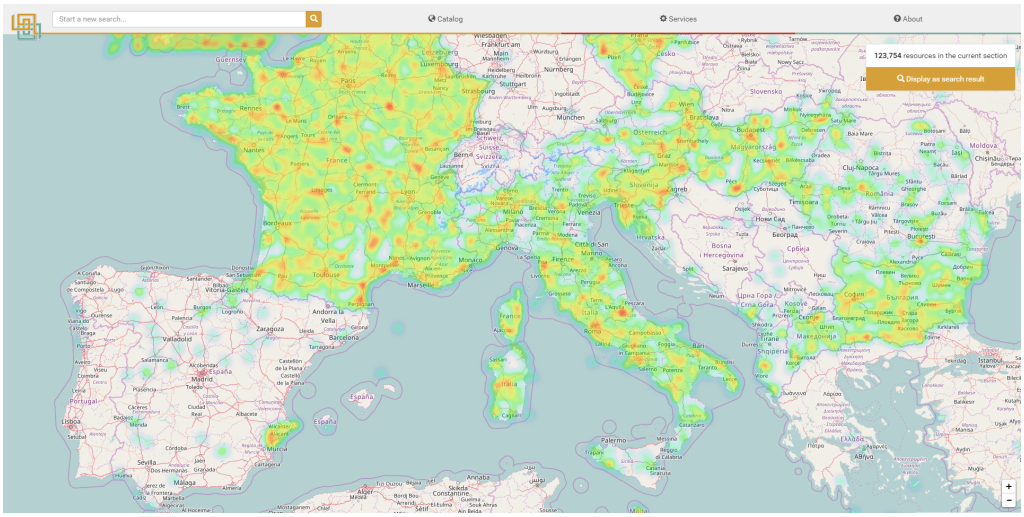

Figure 2: An example of spatial visualisation of a query result

- Timeline display of a query result: as temporal information (timeframe, generic period) is also available for any resource described in the Catalogue, results may be visualised graphically on a timeline as well, as shown in Figure 3. Again, the same type of visualisation can be obtained by browsing a certain region of the information space, for instance all resources available at an institution.

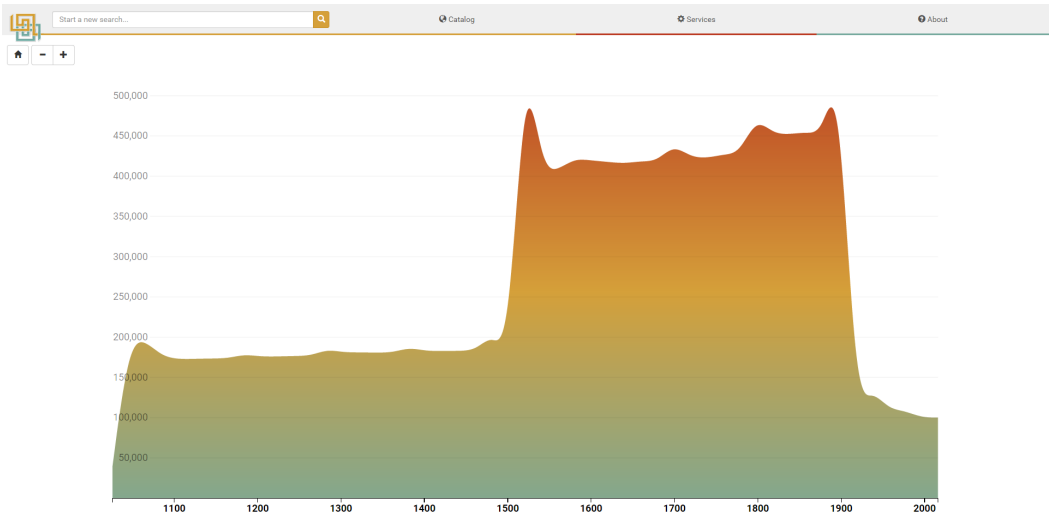

Figure 3: An example of timeline visualising several elements in a graphical way

The services above provide functionalities that are also outlined in several use cases in Deliverable 13.1. Both visualisation services are currently under finalisation within the context of the creation of the ARIADNE Portal and will be complete by the end of the project.

3 Services provided by ARIADNE Partners

The aim of the ARIADNE project is not only to integrate data from a variety of archaeological datasets, but to also deal with services that can operate on them.
The types of services taken into account were:

- Services already available, provided by the partners of the project;
- Services developed within the context of the project.

The decision to include services coming from external entities was left as an option to be implemented towards the end of the project.

Regarding the services already available, two surveys were conducted, during Year 1 and at the end of Year 3. The second survey was necessary following the finalisation of ACDM document, which better defined the typologies and description of services. Using the results of the surveys, the potential services were described following the ACDM scheme and grouped in different categories accordingly.

For the services developed within the context of the project, the outcomes of the Workshop "Ariadne infrastructure for Multimedia data: matching technologies and user needs" (which took place in Pisa at the end Year 1), showed there was a need to publish and visualise certain types of multimedia data (i.e. 3D models, re-lightable images, terrain models). It was therefore decided to develop and integrate a set of services devoted to these types of data within the ARIADNE portal.

3.1 Categories of service in the ACDM

The ACDM provides a general description of services. This was used to integrate them into the ARIADNE catalogue, and make them accessible via the ARIADNE portal.
Based on the evidence collected in Deliverable 13.2 (which provided an initial list of available services), services have been classified into the following categories, reflecting the way a service is accessed:

- *Institutional services:* these services are offered by an institution and must be negotiated via a personal interaction with representatives of that institution in order to be accessed.
- *Web services:* these are web accessible services with an API;
- *Stand-alone services*: these are tools to be downloaded and installed on one's machine.
- *Services for humans:* these web accessible services use a GUI only

In the following subsections, the services provided by partners and the services developed for the project are described in detail, following the classification above.

3.2 Services provided by partners

The services already available from partners can be broadly grouped in two categories: services for data deposit and services for language resources.
These two categories have been a hot topic since several years, so that a certain degree of standardization has been reached. This may be one of the reason why consolidated services fall into them.

In general, data deposit services are still provided as an institutional service, where a preliminary negotiation between the data provider and the institution is needed. The services for language resources are mainly provided as web services, directly accessible to users.

The rest of this section provides an overview of the services currently available, categorised following the ACDM model.

3.2.1 Institutional services

All the services under this category are related to data deposit and preservation. While ARIADNE introduced major improvements in the integration of data across Europe, in order for that data to be made feely and openly available, data providers must have terms of use and access in place with the copyright holders of that data. Because this licensing is in place, all the services described in this section can be searched and directly accessed through the ARIANDE portal. While many ARIADNE partners contributed data to the infrastructure, several partners have a specific remit to provide these kinds of services reliably and persistently.

University of York: Archaeology Data Service

Type of service: Data deposit and preservation service
Short Description: The Archaeology Data Service is the national digital data archive for archaeology the UK and a world-leading data management centre for archaeology and heritage sector. It was established in 1996 and now comprises some 15 staff. It is hosted by the Department of Archaeology in the University of York. It supports research, learning and teaching with free online high quality and dependable digital resources and preserves them in the long term. The ADS operates according to the OAIS model for digital archives and holds the Data Seal of Approval, the internationally recognised quality mark for trusted digital repositories. In 2012 the ADS was awarded the Digital Preservation Coalition's Decennial Award for the most outstanding contribution to digital preservation of the last decade. ADS-Easy provides an online costing tool and data deposit service.

Homepage: archaeologydataservice.ac.uk
First release: 1997
Provided by: Archaeology Data Service
Authentication: N/A

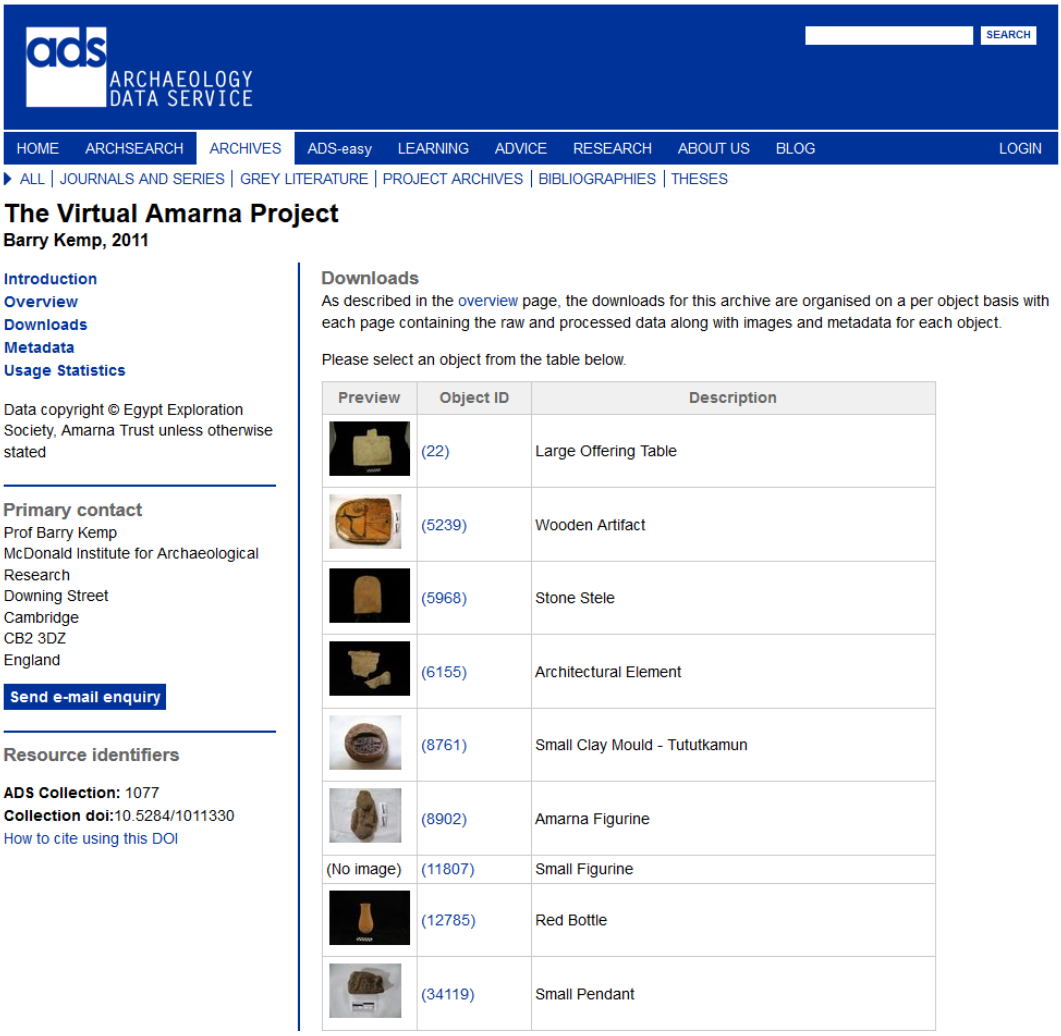

Figure 4: An example of a dataset hosted by the Archaeology Data Service

DANS: Data Archiving and Networked Services

Type of service: Data deposit and preservation service
Short Description: The e-depot for Dutch archaeology is accommodated at DANS, the national digital research data archive for the Netherlands. A wealth of digital archaeological excavation data such as maps, field drawings, photographs, tables and publications is accessible via EASY, DANS' online archiving (deposit, preservation and reuse) service. DANS operates according to the OAIS model for digital archives and holds the Data Seal of Approval, the internationally recognised quality mark for trusted digital repositories.

DANS was established in 2005, with predecessors dating back to 1964, and now comprises some 45 staff. DANS's activities focus on three core services: data archiving, data reuse, training and consultancy. Driven by data, DANS ensures the further improvement of sustained access to digital research data with its services and participation in (inter)national projects and networks. DANS is an institute of the Royal Netherlands Academy of Arts and Sciences (KNAW) and co-founded by the Netherlands Organization for Scientific Research (NW0).

Homepage: dans.knaw.nl
First release: 2005
Provided by: DANS
Authentication: N/A

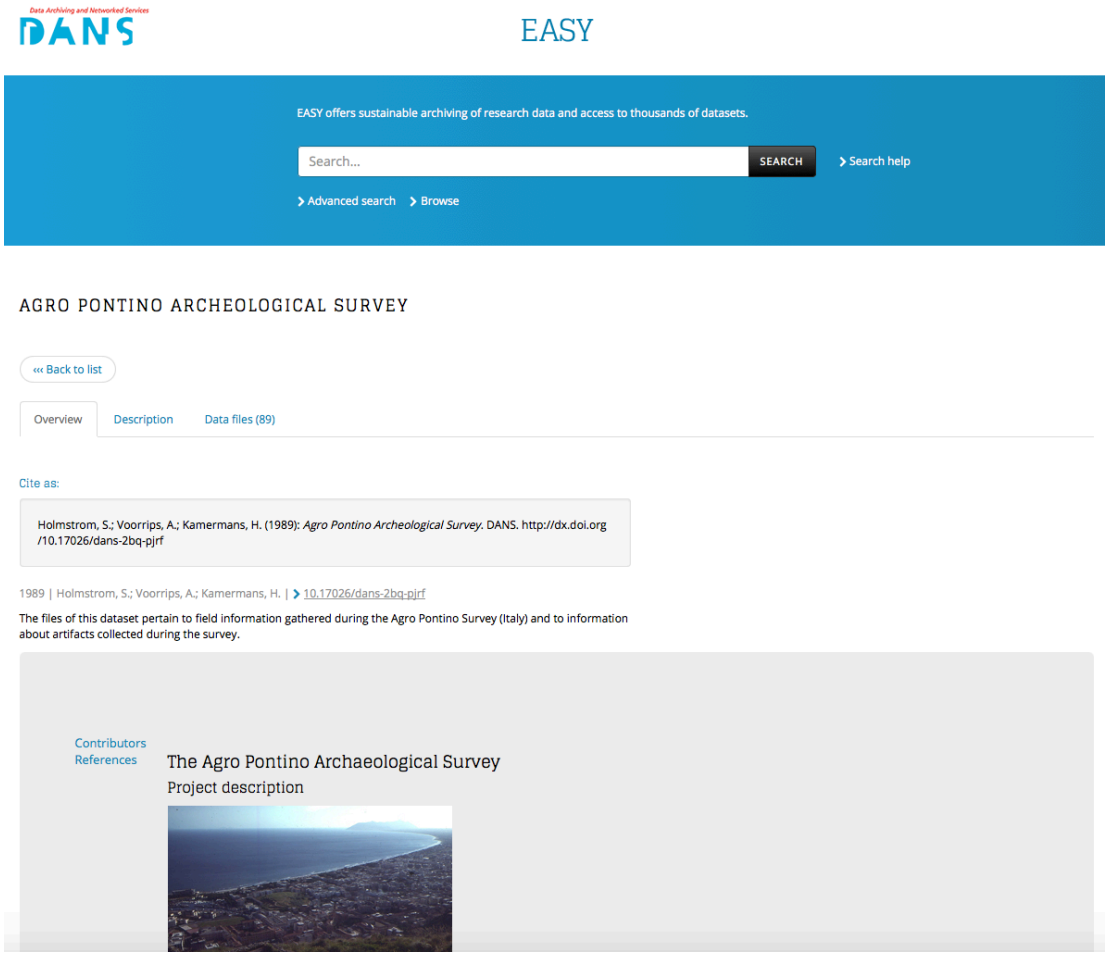

Figure 5: an example of a dataset hosted by DANS service

Arachne

Type of service: Data deposit and preservation service
Short Description: Arachne is the central Object database of the German Archaeological Institute (DAI) and the Archaeological Institute of the University of Cologne.

Arachne is intended to provide archaeologists and Classicists with a free internet research tool for quickly searching hundreds of thousands of records on objects and their attributes. This combines an ongoing process of digitizing traditional documentation (stored on media that are both threatened by decay and largely unexplored) with the production of new digital object and graphic data. Wherever possible, Arachne follows a paradigm of highly structured object-metadata which is mapped onto the CIDOC-CRM, to address machine-

readable metadata strategies of the Semantic Web. This “structured world” of Arachne requires large efforts in time and money and is therefore only possible for privileged areas of data. While there is an ever-increasing range of new, “born digital” data, in reality only a small effort-per-object ratio can be applied. It therefore requires a “low-threshold” processing structure which is located in the “unstructured world” of Arachne. All digital (graphic and textual) information is secure on a Tivoli Storage System (featuring long-term multiple redundancy) and distributed online through the Storage Area Network in Cologne via AFS.

Homepage: http://arachne.dainst.org
First Release: 1995
Provided by: DAI, Germany
Authentication: Not needed for downloading and browsing the data; data entry and import only for authenticated users

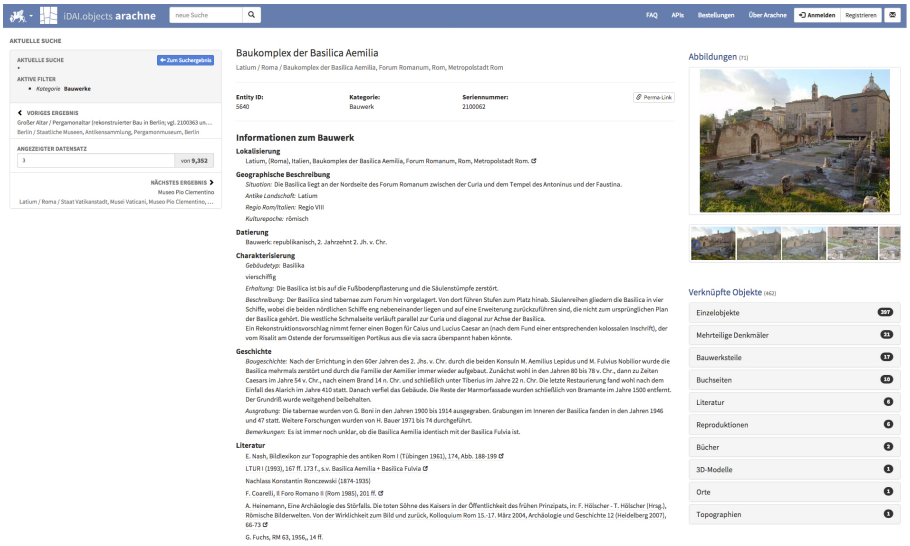

Figure 6: an example of a dataset in Arachne service

3.2.2 Web services

The web services category is most likely the easiest to integrate in the context of an infrastructure, as it usually does not need any local download or further contact with a service provider.

In the context of the ARIADNE services, the majority of options are related to language resources, since vocabulary matching is a strong necessity in the archaeological community. Nevertheless, dendrochronology and gazetteers are also represented.

The services developed within the context of ARIADNE fall in the category of Web services, which described in detail in Section 4.

iDAI.vocab

Type of service: German Thesaurus of Archaeological Concepts with support for multilingualism

Short Description: The new DAI Thesaurus of Archaeological Concepts was designed from the onset as a thesaurus of German words and phrases with significant multilingual support. The core of the thesaurus is a list of concepts related to the domain of archaeology (nouns, verbs, less frequently adjectives, but also complex phrases that point to a specific object, such as "carrarischer Marmor") all linked to corresponding translations in a wide spectrum of different languages. A minimal set of relations were established between the German terms (synonyms, direct hyper- and hyponyms), and the equivalent terms were grouped together; whenever it is possible, equivalent terms were also resolved by selecting one preferred concept. In addition, terms and concepts were connected by SKOS links to external thesauri, like the Arts & Architecture Thesaurus of the Getty Institution.

Homepage: http://archwort.dainst.org/thesaurus/de/vocab/index.php
First release: Jan 2014
Provided by: DAI, Germany

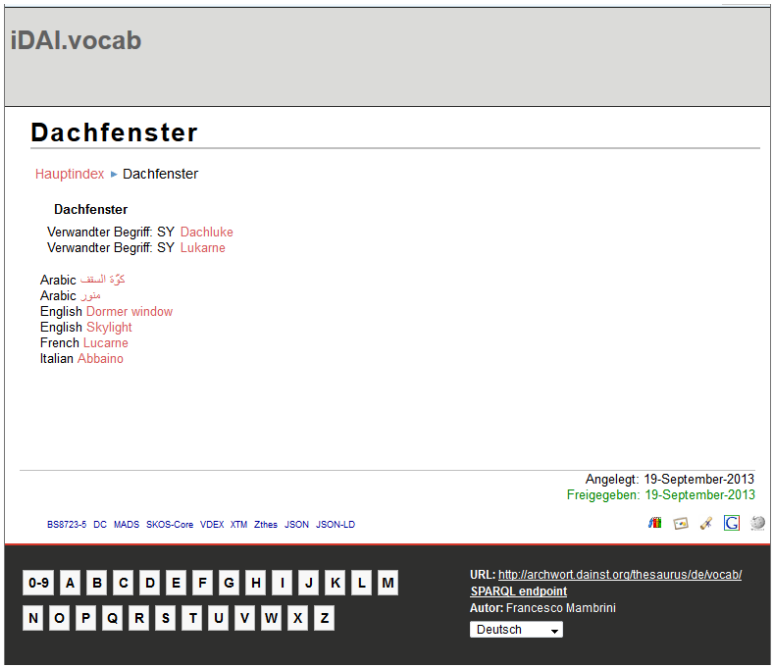

Figure 7: An example of a term in IDAI Vocabulary service

Linked Data Vocabularies for Cultural Heritage

Type of service: Service for language resources
Short Description: National cultural heritage thesauri and vocabularies have acted as

standards for use by both national organisations and local authority Historic Environment Records, but until now have lacked the persistent Linked Open Data (LOD) URIs that would allow them to act as vocabulary hubs for the Web of Data. The AHRC funded SENESCHAL project aimed to make these vocabularies available online as Semantic Web resources. The services consist of a series of REST URI calls with associated parameters. The returned data is a JSON structured string. The services all permit AJAX callbacks for use in browser based applications. Arguments may be present in any order. Argument names are not case sensitive, but any URI argument values are case sensitive. The source code for all SENESCHAL services is available as Open Source under a Creative Commons Attribution (CC-BY) license.

Homepage: http://www.heritagedata.org/blog/services/
Last Update: 2015
Provided by: University of South Wales

Figure 8: a snapshot of the Linked Data Vocabularies homepage

Vocabulary matching tool

Type of service: Vocabulary matching tool
Short Description: The Vocabulary Matching Tool was developed for aligning Linked Data vocabulary terms with Getty Art & Architecture Thesaurus concepts. The source code for the Vocabulary Matching Tool is also available for local download and installation (https://github.com/cbinding/VocabularyMatchingTool) - in which case it might then be classed as "stand-alone services" (tools to be downloaded and installed on one's machine).

Homepage: http://heritagedata.org/vocabularyMatchingTool/
Last Update: 2015

Provided by: University of South Wales

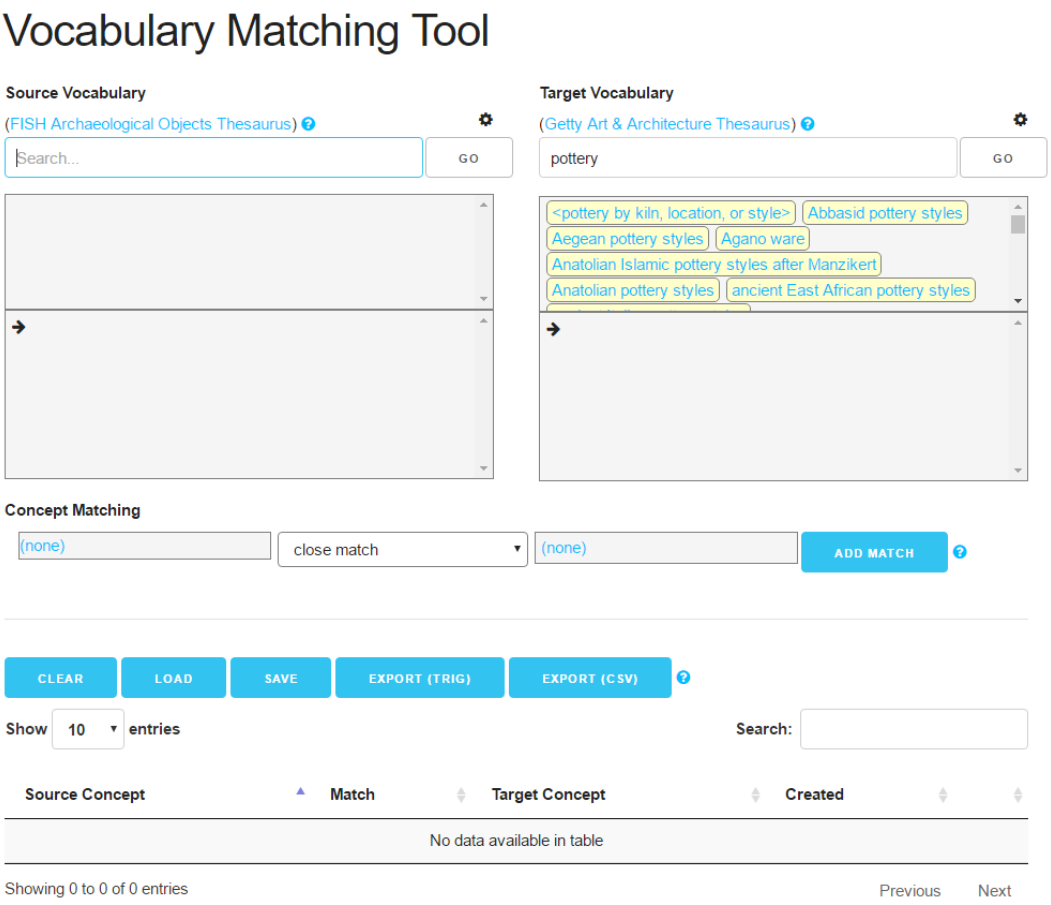

Figure 9: a snapshot of the vocabulary matching tool

Digital Collaboratory for Cultural Dendrochronology (DCCD)

Type of service: Service software tool to set up a digital repository for dendrochronological data
Short Description: To improve European integration of dendrochronological data, DANS has now made it possible for others to use the same software as the DCCD-repository of DANS, and use existing components to create their own dendrochronological archive that is also ARIADNE compatible. This open source software is available from the following GitHub repository: https://github.com/DANS-KNAW/dccd-webui

The DCCD software is an online digital archiving system for dendrochronological data. A recent version of this software (system) is deployed as 'Digital Collaboratory for Cultural Dendrochronology' (DCCD) at http://dendro.dans.knaw.nl.

Figure 10: the homepage of DCCD service

More information about the Digital Collaboratory for Cultural Dendrochronology (DCCD) project can be found here: http://vkc.library.uu.nl/vkc/dendrochronology.

The DCCD is the primary archaeological/historical tree-ring (meta)data network existing in Europe. It became operational in 2011. Within the DCCD Belgian, Danish, Dutch, German, Latvian, Polish, and Spanish laboratories have joined data in a manner that suits their shared and individual research agendas. In its present state the DCCD contains measurement series of different wood species derived from objects and sites dating between 6000 BC and present. All data sets are described with very detailed metadata according to the newly developed international dendrochronological data standard TRiDaS. The collection is derived by research from archaeological sites (including old landscapes), shipwrecks, historical architecture and mobile heritage (e.g. paintings, furniture).

Homepage: http://dendro.dans.knaw.nl/
Last Update: 2015
Provided by: DANS

iDAI.gazetteer

Type of service: Gazetteer
Short Description: The German Archaeological Institute together with the Cologne Digital Archaeology Laboratory is developing the iDAI.gazetteer - a web service connecting toponyms with coordinates. It was initially built as an authority file/controlled vocabulary for any geo-related information in information systems of the DAI. Furthermore it is meant to link these data with other worldwide gazetteer-systems.

Homepage: http://gazetteer.dainst.org/
Last Update: April 2015
Provided by: DAI, Germany

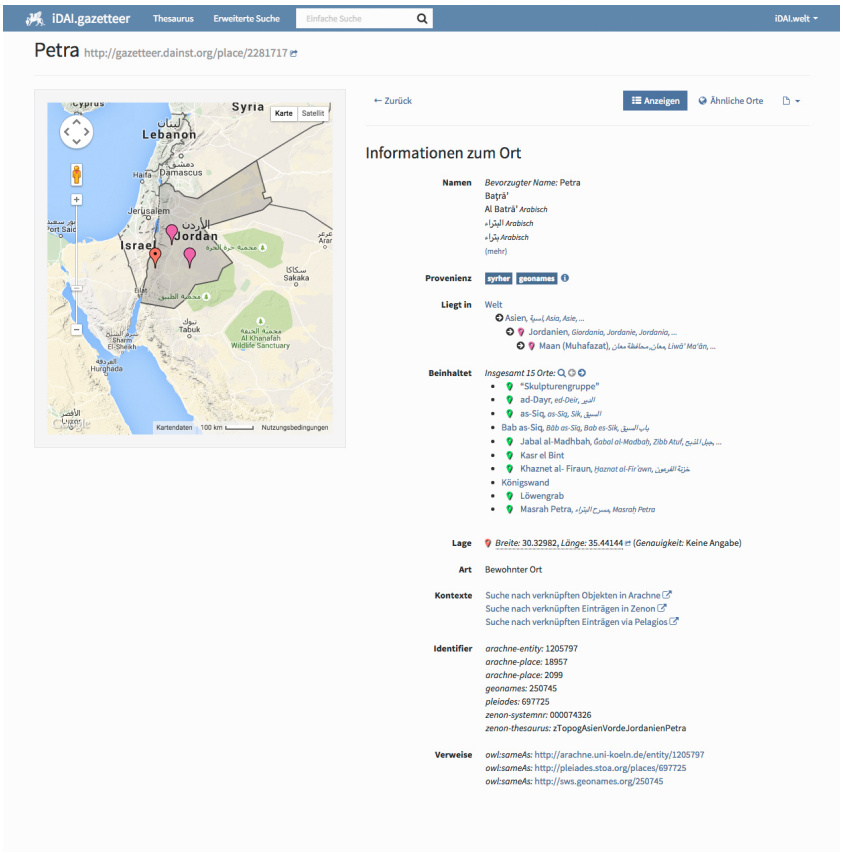

Figure 11: an example of a dataset in the iDAI gazetteer

3.2.3 Standalone services

Standalone services are essentially software tools that have been developed and made available to the community. While a full integration in the context of the portal is almost impossible, ARIADNE can provide direct access to download and install the tools, and a list of the functionalities that they provide.

One of the first tools implemented by partners inserted in the current implementation of the catalogue is MeshLab; several other tools (i.e. the ones collected by the DARIAH Italian initiative http://it.dariah.eu/sito/strumenti/) will be added soon.

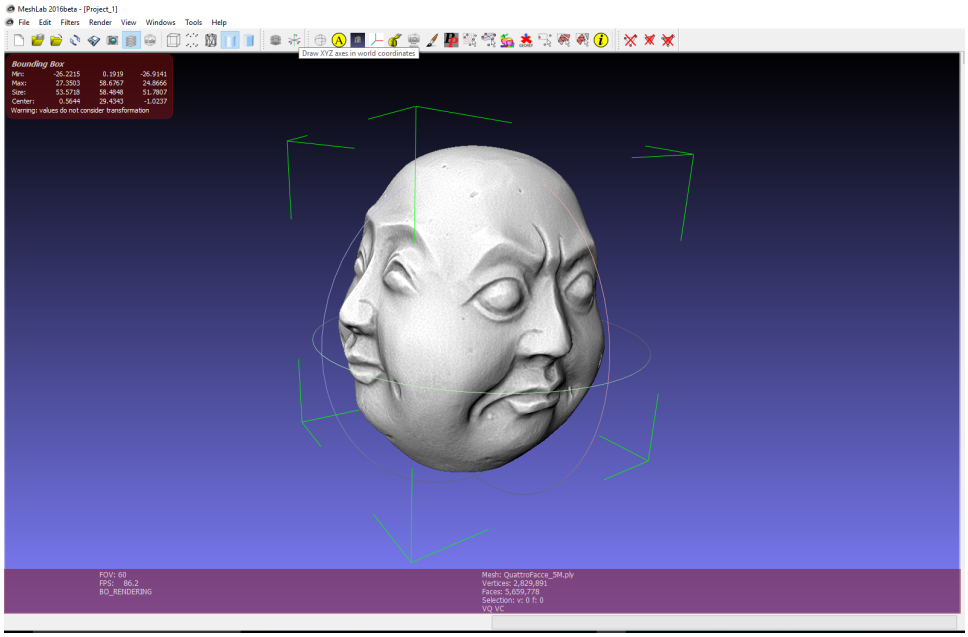

Figure 12: a screenshot of the latest version of MeshLab

MeshLab

Type of service: Mesh processing tool
Short Description: MeshLab is an advanced 3D mesh processing software system that is oriented to the management and processing of unstructured large meshes and provides a set of tools for editing, cleaning, healing, inspecting, rendering, and converting these types of meshes.

MeshLab is free and open-source, subject to GPL license, and is used as both a complete package and a library powering other software. This tool is widely used in the Cultural Heritage community not only for the processing and conversion of data, but also as a tool for the analysis and presentation of 3D data.

Homepage: http://www.meshlab.net/
Last Update: 2016
Provided by: ISTI-CNR

ADS Named Entity Recognition API

Type of service: Controlled vocabulary metadata creation tool
Short Description: Within ARIADNE, UoY ADS created a machine learning-based Natural Language Processing tool to help the archaeological domain better access the vast resource of unstructured digital data available to archaeologists in the form of text. This text typically exists in PDF, MS Word, or plain text files including unpublished fieldwork reports (also known as grey literature), digitised journal collections, and reports deposited within project archives.

To extract the possible metadata from these kinds of documents, a RESTful API was created with an NER module using a CRF classifier. Users submit a task and clients POST JSON to an API endpoint. When text is entered into the "input text area" entities are extracted from the text and suggested metadata is returned. Users can then assess the relevance of the extracted entities and confirm whether the metadata is correct. While originally envisioned as a Web application maintained by the ADS, it was decided that an API that was freely available and could be incorporated into other interfaces was more useful.

Homepage: http://ads.ac.uk/nlp/demo.jsf
Last Update: 2016
Provided by: UoY ADS

Figure 13: A screenshot of the NER API in use

4 Services developed within the ARIADNE project

While the goal of ARIADNE is essentially to create a common infrastructure of data and services, obtained mainly through integrating existing resources, a part of the effort of WP13 was also devoted to the development of new services.

The evolution of these services followed these main steps:

- Year 1 was devoted to the analysis of the types of data in archaeological collections for which the services provided by the community were considered to be inadequate. Visual media was found to be insufficiently supported in any of the considered communities.
- A first version of the services was developed during Year 1 and released at the end of Year 2.
- The services were tested by the ARIADNE community (but also by external users) and initial informal feedback was obtained.
- Year 3 was devoted to the improvement of features, and to testing (Task 13.3).
- In Year 4, two major updates were released, and the final results of the testing (Task 13.3) were collected.

In the following sections, a description of the services implemented during the ARIADNE project is provided.

4.1 ARIADNE Visual Media Service

Type of service: publication and presentation of complex media assets
Short Description: The ARIADNE Media Service aims to provide support for the easy publication and presentation of complex media assets on the Web. The idea is to build an automatic service able to transform any media file uploaded by ARIADNE archive managers into a format that will allow easy and efficient access and remote visualisation on the Web. The service is based on a simple web interface and supports three types of visual media: high-resolution images, RTI (Reflection Transformation Images, i.e. dynamically re-lightable images), and high-resolution 3D models.

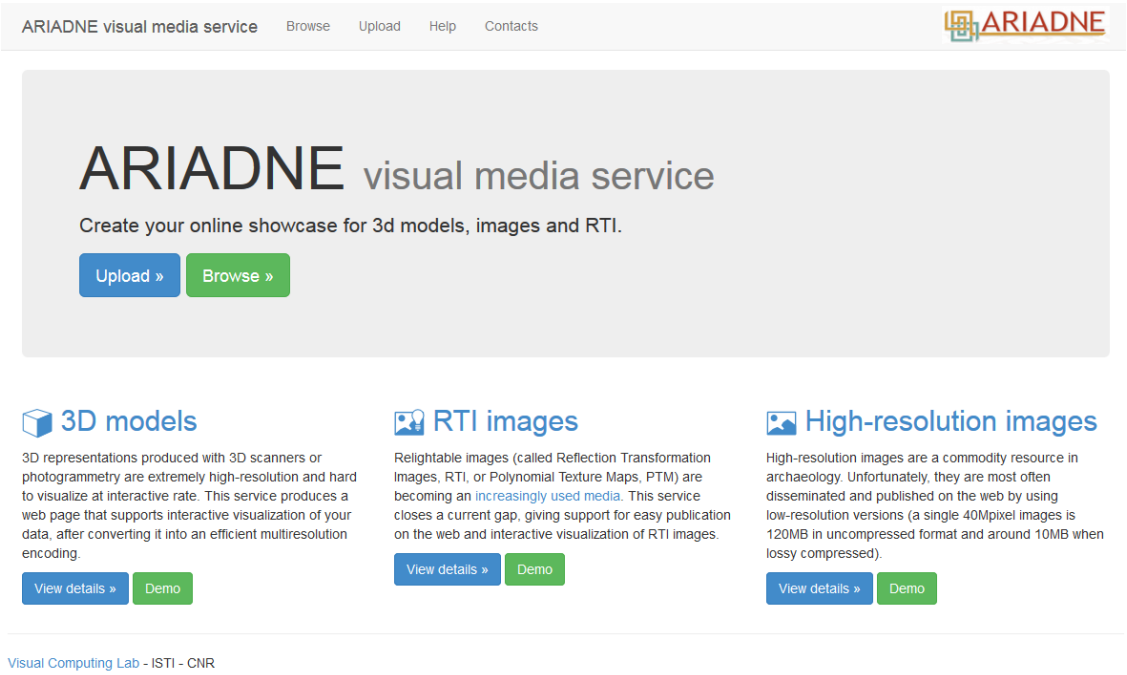

Figure 14: The Visual Media Service homepage

These types of media are not easy to display on the web, as entire files may need to be downloaded for them to be visualised, and dedicated software may need to be selected/installed. Moreover, the owner of high quality data may prefer not to give visitors the option to download them freely, in order to protect their ownership of the data.

After accessing the service, users will find a simple Web form that allows them to upload their data (3D model, hi-res image or RTI) and provide some basic information about the media. The service processes the input data in an automated way, and creates an online page. At the end of the processing step, the user receives an email containing a link to the visualisation page (hosted on the ARIADNE web-service and open to any external user) and to an admin page, where the associated data can be modified. It is also possible to download the page created (HTML code + processed 3D Model or image) in order to integrate the content on the user's local server or archive.

In the case of 3D models, the geometry is processed, converting a possible complex 3D model into a multi-resolution format (Nexus, http://vcg.isti.cnr.it/nexus). This multi-resolution structure can be streamed, and is used to create a visualisation webpage using a Web presentation tool (3DHOP, http://www.3dhop.net/) based on WebGL and developed by CNR-ISTI.

Analogously, high resolution images are also transformed into a multi-resolution format, supporting progressive streaming; the service transforms each image into a web-compliant format. Similarly to Google maps, the high-resolution image will be regularly divided into chunks, and a hierarchy of images at different resolutions is produced from these chunks; a

rendering webpage is then created where it will be possible to navigate the model in a WebGL frame.

Figure 15: an example of a visualisation page automatically generated by the Visual Media Service

RTI are managed similarly to hi-res images, even if the encoding for the Web streaming is more complex, and WebGL rendering also takes care of the input and calculation of the variable-lighting.

With this setup, even new users can easily create an efficient webpage to display complex 2D or 3D content. For more experienced users, these basic webpages may be the starting point for the development of more complex visualisations, or for the integration of visualisations inside existing websites, taking advantage of the features of the 3DHOP platform (www.3dhop.net). Finally, the data structures for remote visualisation (multi-resolution for 3D models, image pyramids for images and RTI web encoding) protect the original data, as a direct download of the multimedia file in a single plain format is not possible.

Homepage: http://visual.ariadne-infrastructure.eu/
First release: Jan. 2015
Last Update: October. 2016
Provided by: ISTI-CNR, Italy
Authentication: Not needed
Integration and other notes: This service is accessible directly from the ARIADNE portal.

Major Updates:

- February 2016: this update introduced a number of new features to the Visual Media Service, allowing further personalisation of the page. The user can now change the navigation paradigm and the style of the page. Moreover, new tools (i.e. for creating cut-through sections and for taking point-to-point measurements) were made

available, and they can be added to the visualisation page. The service was updated to the last version of 3dHop (www.3dhop.net), so that the basic visualisation pages may be used as a starting point for specialized visualisation.

- October 2016: this update was devoted to bug fixing, and the introduction of the support of Lidar Tiff format. The basic library was also updated to the latest version of 3DHop.

4.2 Landscape Factory

Type of service: generation and 3D visualisation of terrain datasets

Short Description: Landscape Services for ARIADNE are a set of responsive web services that include large terrain dataset generation, 3D landscape composing and 3D model processing, leveraging powerful open-source frameworks and toolkits such as GDAL, OSGjs, OpenSceneGraph and ownCloud.

The main components include: the cloud service, the terrain generation service, the terrain gallery and the front-end web component for interactive visualisation.

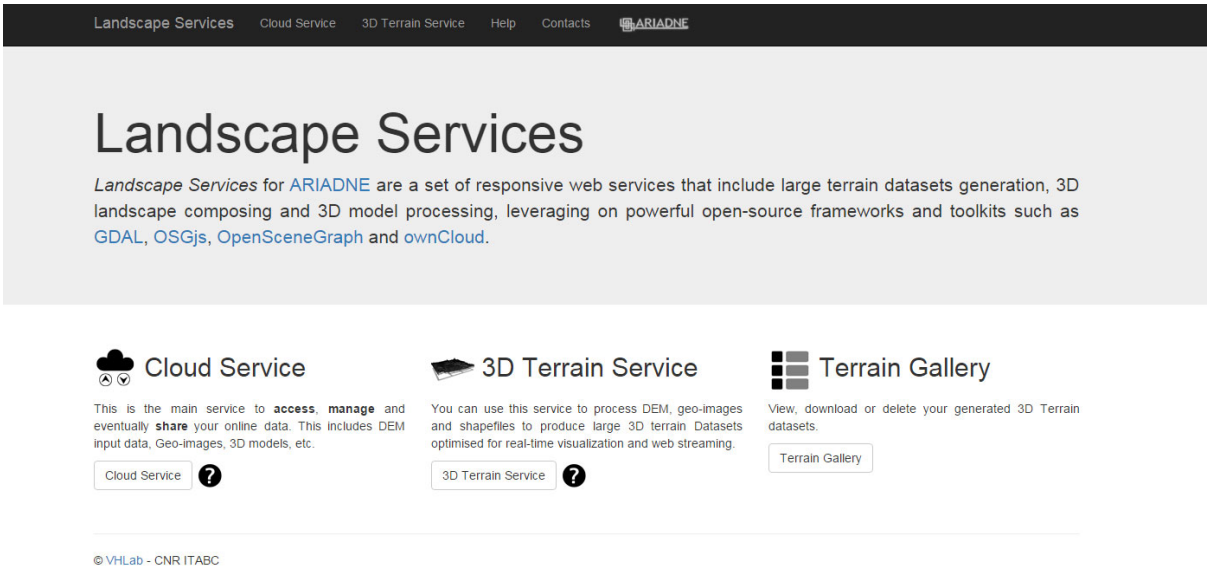

Figure 16: The Landscape Services main page

The *cloud service* aims to provide a way to access, manage and eventually share input (or output) data. This includes DEMs/DTMs, Geo-images, 3D models, etc. This is specifically designed for compact workflows or when dealing with massive amounts of data with special access policies. The service aims to not only provide a space to store data, but also to develop a collaborative environment online, where multiple users may work and modify data at the same time. For example, several users may work on the same landscape, enriching visualisation, integrating documents and more.

The *3D Terrain service* works in a similar way to the Visual Media Service, but it provides processing and visualisation for terrain datasets, which is a different type of 3D model. The service takes as input multiple DEM/DTM files, geo-images, shapefiles and ESRI *world files* (http://webhelp.esri.com/arcims/9.2/general/topics/author_world_files.htm) to georeference the final dataset. Advanced features are offered; including the ability to select specific areas of a generated dataset from a shapefile, set a vertical multiplier, switch to geocentric output mode, set resolution depth and much more. The output section provides several options, including:

- Common 3D formats for desktop segment (obj, 3ds, fbx, etc.), applied to landscape reconstruction workflow. Output includes optimised geometry and textures
- WebGL multi-resolution 3D visualisation for modern browsers. Published output includes multi-resolution compressed geometries and textures for efficient streaming.
- Preview visualisation by remote rendering of terrain dataset for devices not supporting WebGL. A set of interactive frames (images) is generated as output.

The WebGL Front-End provides efficient visualisation of generated 3D terrain datasets and options to embed the interactive frame into external pages, or search queries within the ARIADNE portal. The developed component also includes support for mobile browsers (responsive HTML5 interface), spherical panoramas, presentation of external XML metadata, points-of-view and several input peripherals, including mouse, keyboard, joypad and multi-touch devices (desktop, tablets and smartphones, Figure 17).

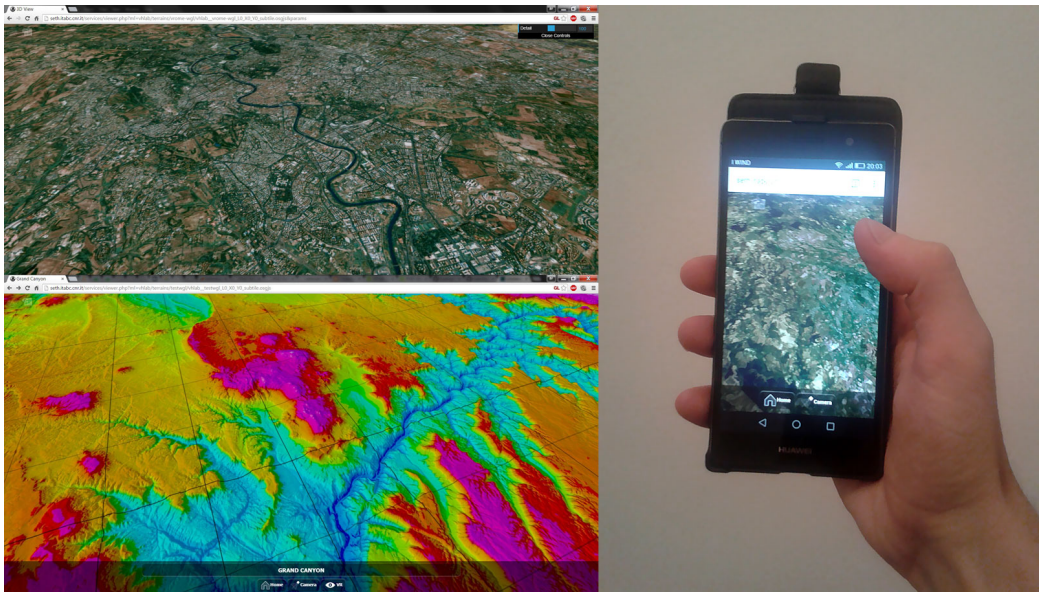

Figure 17: The interactive WebGL Front-End to visualize a multi-resolution 3D terrain DB on modern desktop browsers (left) and smartphones (right).

The *Terrain Gallery* allows users to display, edit and eventually delete generated terrain 3D datasets for a current logged user/research institution. Each listed item also offers links for

downloading full zip packages, which contain the chosen 3D format and textures for the datasets produced, links to the preview service, and links to the WebGL published page with embedded options for external integration.

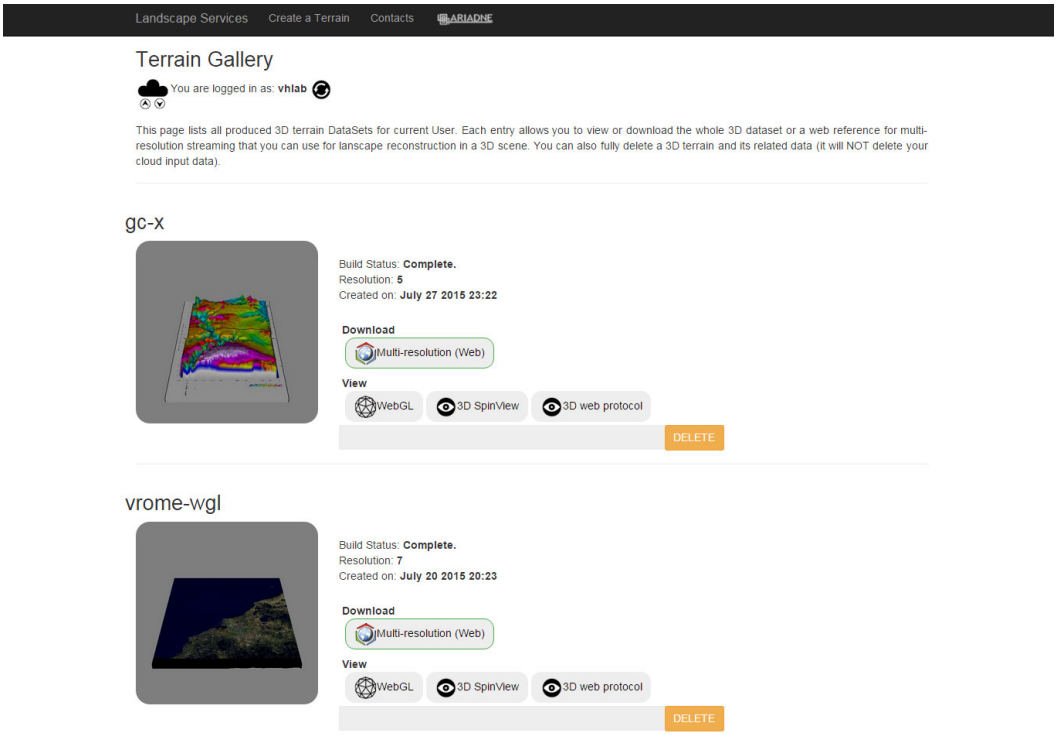

Figure 18: The Terrain Gallery listing produced terrain datasets for user "VHLab"

Homepage: http://seth.itabc.cnr.it/services/landscape/
First release: Jan 2015
Last Update: October 2016
Provided by: ITABC-CNR, Italy
Authentication: This service is accessible directly from the ARIADNE portal.

Major updates:

- January 2016: first support to 3D annotation, improved input form and support for panoramic data (panoramic images and video-streams), coordinate-system option in advanced input section.
- June 2016: several improvements to HTML5 3D annotation system, including built-in input form (javascript), import/export of 3D annotations (XML), improvements in scene presentation parameters import/export (PBR shading model, lights, fog, environment, etc.).
- October 2016: redesign of HELP and FAQ sections with tutorials and updated services description, improved service robustness on large dataset processing, video tutorials.

5 ARIADNE Preservation Services

ARIADNE aggregates, processes, enriches and presents over two million metadata records of archaeology-related information from partners all around Europe. An important part of the infrastructure is the ability to preserve this data centrally and thus provide:

- long-term preservation at the metadata and data level (binary datastreams and metadata records);
- preservation of the complete lifecycle of each digital object;
- preservation of all representations of each digital object (e.g. native format, ACDM, and other representations).

To facilitate this, a specialised service was developed as a plugin in the MORe aggregator which pushes the content into a dark archive. The overall architecture of this setup can be seen in Figure 19 below.

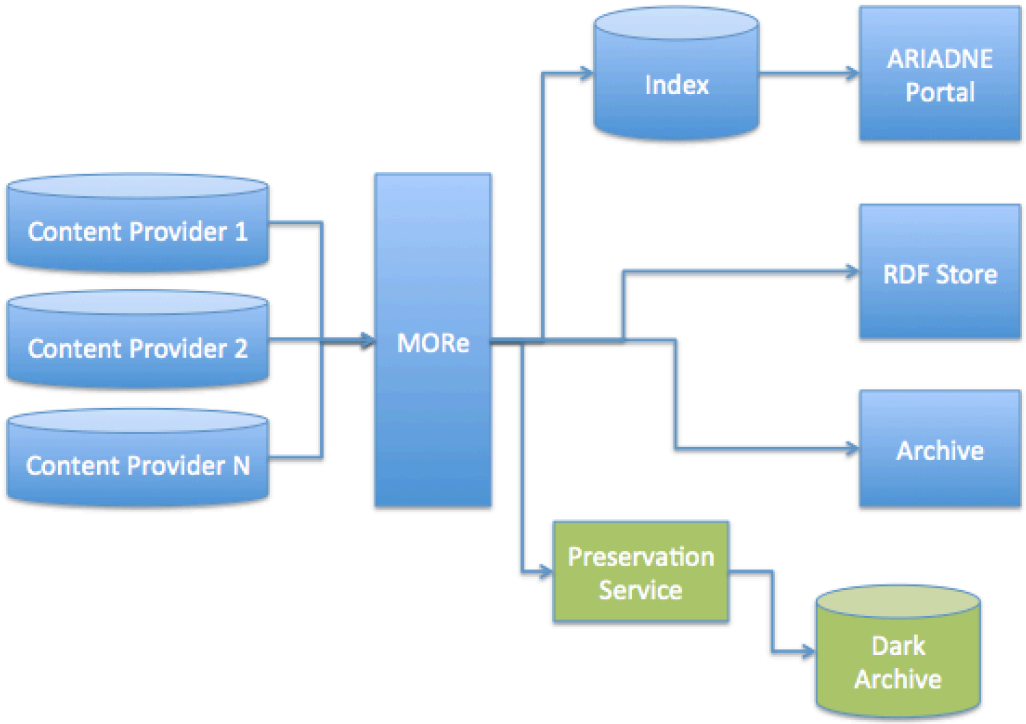

Figure 19: Overall setup of the preservation services

Within this architecture, metadata is aggregated from the content providers and through MORe into the primary index that powers the ARIADNE Portal. At the same time, data are sent to an RDF store and can be downloaded as an archive.

The primary role of the preservation service is to store data into a dark archive, and therefore maintains a registry of the native identifiers for all objects for every provider alongside the dark archive issued identifiers, so that it can extrapolate the identity of each incoming record and store it either as a new record, or as a new version of an existing one.

For the dark archive, Fedora-commons 4.x was chosen for its robust content model that is clearly suited for this purpose. In the new Fedora-commons 4.x content model, every item is represented as a container that contains the various data streams: Native metadata, ACDM metadata, etc.

The identity management service uses the following information in order to decide whether an incoming record is a new one or already exists:
[content provider id]-[item native id]

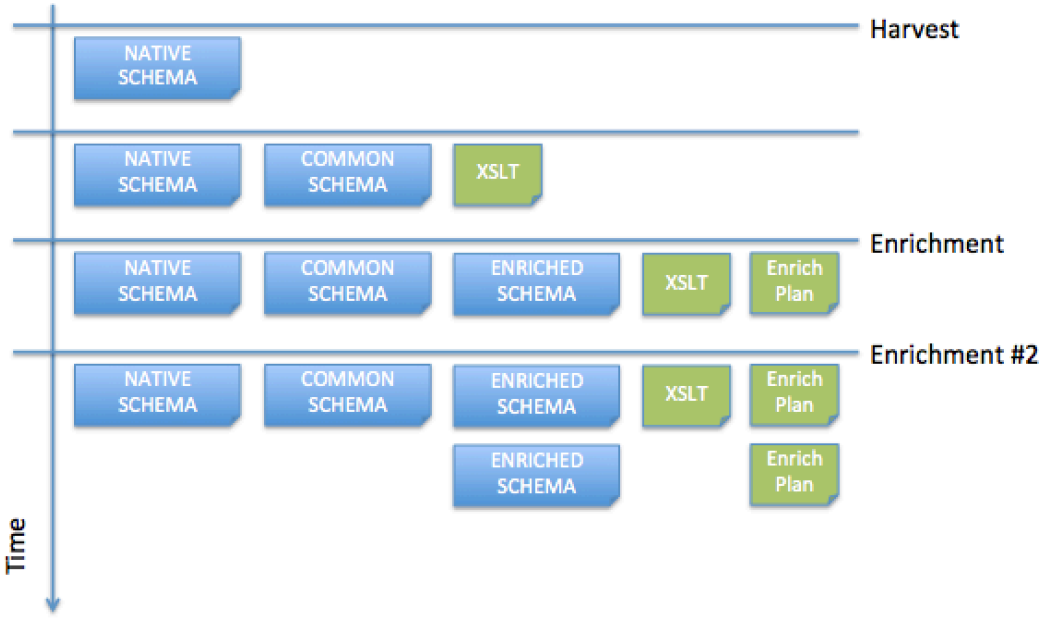

Figure 20: Digital object representations over time and during the aggregation-enrichment process

The aggregation process is a dynamic process that generates new data in the form of new representations of existing metadata records. An example of this process over time can be seen in Figure 20, where an incoming native schema is transformed into a common schema (in the case of ARIADNE : ACDM) and is then enriched using MORe's enrichment services, thus creating a new representation : ACDM enriched.

In short, this process creates the following information records:

1. Native schema
2. ACDM schema
3. Enriched ACDM schema
4. XSLT transformation from Native to ACDM
5. Enrichment plan from ACDM to Enriched ACDM

When the above information is pushed and stored into the dark archive, an accompanying PREMIS event log is generated that describes the above process. A high level overview of this process is shown in Figure 21 below.

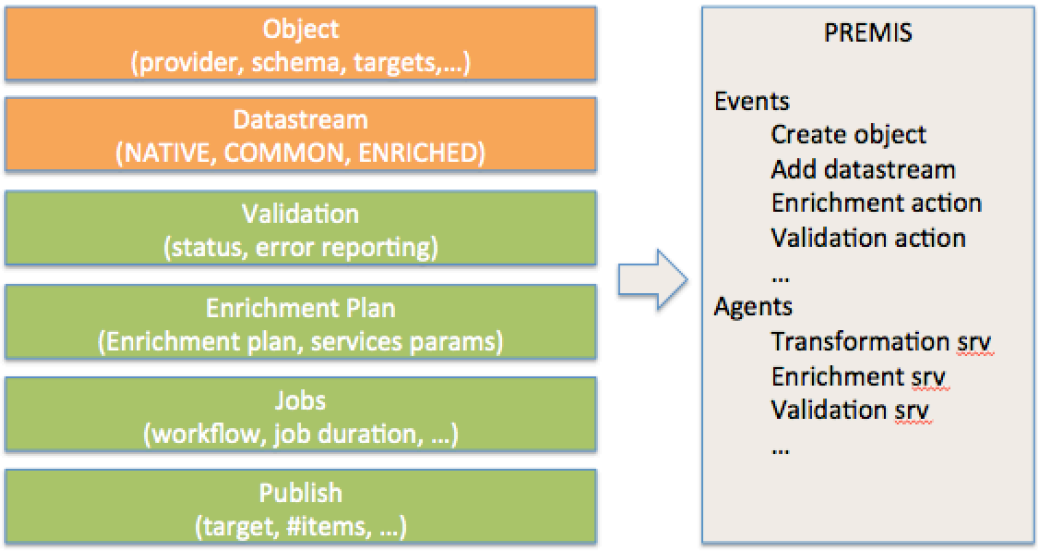

Figure 21: Dark archive content model and associated PREMIS metadata

The PREMIS log contains a complete list of events that describe all the actions/operations on the digital object. When all of these events are put together, the can tell the entire story of the digital object.

6 Selected sample utilisations in TNA

This section describes the dissemination and uses of the ARIADNE services as implemented in the Transnational Access program (TNA).

6.1 TNA on Mapping existing datasets to CIDOC-CRM (PIN, Prato, Italy)

During TNA activities concerning CIDOC CRM mapping, encoding and reusing of legacy data, PIN recommended the use of ARIADNE services to guarantee standardisation and interoperability of their converted data. In particular, the Vocabulary Matching Tool was used for standardise terminological resources and for stating correspondences with the Getty AAT Thesaurus. Both the iDAI vocab and the MiBACT RA Thesaurus (provided as ARIADNE services as well) were used as data input into the tool for mapping legacy concepts to Getty entities.

Resources coming from these vocabularies have then be used for type definitions during legacy archive mapping operations implemented with the 3M Mapping Tool provided by FORTH, for mapping and converting legacy datasets to CIDOC CRM. This work concerned a considerable part of the TNA activities and was useful for demonstrate the benefit of using standard technologies and data models.

6.2 TNA on Design of Archaeological Datasets (CNR, Pisa, Italy)

There is a tight connection between the TNA on the *Design of Archeological Datasets* and the *Ariadne Linked Data Cloud*. Although the latter is not one of the ARIADNE services, it plays a key role in establishing an integrated archaeological information space. The connection is twofold. On one hand, all the relevant standards for creating the ARIADNE LOD Cloud have been covered by the TNA, namely RDF, RDF schema and OWL. On the other hand, the CIDOC CRM ontology, which was employed as a conceptual backbone of the Ariadne LOD Cloud, was introduced in the section of the TNA devoted to archaeological metadata.

Various examples taken from the integration exercise carried out in order to obtain the data were used to explain the model and its usage for archaeological data integration.

6.3 TNA on 3D Documentation for Archaeology (CNR, Pisa, Italy)

The TNA on *3D Documentation of Fieldwork and Artefacts* aimed to provide training and assistance on the technologies and methodologies for 3D/2D data acquisition and dataset/repository management of archaeological findings. There were three iterations of the TNA, held in 2014, 2015 and 2016, which allowed CNR to host and support 26 visitors.
The scope of the TNA was to introduce to the visitors the technologies and methodologies for 3D/2D data acquisition and dataset/repository management of archaeological findings;

as well as providing practical, hands-on sessions to test and experiment with the technologies being presented.

Concerning the course lessons, the following were introduced: (a) the technologies for producing 2D and 3D documentation for archaeological purposes, considering both the small scale (artworks, finds) and the large scale (monuments, sites); and (b) the methodologies for providing visual access to the data gathered (considering both desktop and web-based visualisation).

One of the basic tools used in the training was Meshlab (Section 5.2.3.1), which was used for every step related to 3D data processing and presentation.

The Visual Media services provided by the ARIADNE platform were also an important part of the training experience. The capabilities of the services described are illustrated in subsections 4.1 and 4.2 of this document, presenting the Pro and Cons of these tools in detail. Together with a description of the basic components and technologies used to implement them (e.g. the 3DHOP open source platform developed by CNR, http://3dhop.net/).

6.4 TNA on Digital curation of archaeological knowledge (DCU – Athena Research Center, Athens, Greece)

The Digital Curation Unit within the ATHENA Research Center organised two TNA activities in the years 2015, 2016 on the topics of “Emerging digital practices in archaeological research” and "Digital curation of archaeological knowledge". Both TNA activities were structured as a week-long Summer School comprised of a Training Workshop and an Expert Forum. Both summer schools attracted thirteen TNA scholars and other archaeological researchers of all levels of experience, from postgraduate students to professors, engaging them with aspects of the ARIADNE digital infrastructure based on their individual research projects and challenges of using digital methods, resources and tools.

The first TNA activity was organised in Athens between 29 June and 3 July 2015 on “Emerging digital practices in archaeological research”, aiming to enable researchers and professionals in archaeology to engage with cutting edge and emerging digital practices within archaeological research. The practices ranged from new methods to capture, organise and curate archaeological resources and data to new approaches of archaeological interpretation and dissemination, mediated by digital infrastructures. During the lecture of this summer school entitled “Discovering archaeological datasets and resources through registries and repository service” the ACDM model was presented to the participants as well as the main functionalities of the ARIADNE registry system.

The second TNA activity, organised in collaboration with the Faculty of Information of the University of Toronto and the Department of Informatics of the Athens University of Economics and Business, was a week-long Summer School on the topic of "Digital curation of archaeological knowledge", conducted in Athens between 13 and 17 June 2016. During

the session entitled “Managing legacy archaeological data and resources through registries and repository services” the ARIADNE registry, which forms part of the ARIADNE research infrastructure, was presented in the context of the affordances it offers to archaeologists and stewards of archaeological information to appraise, ingest, curate and access information on archaeological datasets, metadata models (schemas), controlled vocabularies and other resources of interest. Moreover the challenges and utility of data management and knowledge enrichment services were introduced. This was necessary to ensure the usefulness of such an infrastructure to address the problem of data discovery in archaeology, as archaeological research seeks increasingly to leverage the potential benefits of data integration and linking across heterogeneous collections. The school also introduced complementary technologies for the effective resource discovery of online archaeological resources and metadata through a variety of data management, knowledge enrichment, geodata and semantic linking services. This was obtained through the example of MORe 2.0, a curation-enabled metadata and digital object repository infrastructure used for metadata aggregation, semantic enrichment and online delivery of heterogeneous archaeological and cultural heritage objects from multiple collections across Europe.

7 Corrective actions undertaken after services evaluation

This section describes the corrective actions undertaken by partners, taking into account the evaluation and suggestions of the ARIADNE users. This testing is generally reported within D13.5 *Final Testing Report.*

7.1 Acceptance testing: methodology used and results (by INRAP)

The evaluation has been implemented in two complementary directions:

- Using predefined testing scenarios during specific training workshop with selected testers;
- Using open evaluation questionnaires, both with power testers.

The evaluation cycle followed several steps.
Preliminary tasks:

- Creation of the group of evaluators
- Preparation of the evaluation scheme and reports
- Evaluation
- Analysis of results;
- Production of structured and commented feedback to the implementation team (if necessary), and implementation of the requested changes and production of a revised version of the service/tool

The task leader had periodic contacts with services developers, concerning bugs and issues raised by the testers.

The aim of the questionnaire related to a specific service was to determine whether the service met the expectations of the users.

The useful data gathered was primarily:

- Answers to precise questions about usability of the services
- Open comments about the service (usability, requests for improvements)
- Notes given to the service (similar to what would be found in the AppStore)
- Quantitative data about usage (e.g. number of downloads of an application, number of clicks, number of files uploaded, etc.)

The questionnaire answers clearly show the service was rated highly by the evaluators and, overall, that the performances have met the needs of users. It shows some deficiencies in services (such as the lack of measuring optimised instruments, the lack of links between the different services and inability to download the majority of the elements present in services).

Feedback is extremely positive on the general services (average 4.01/5.00) and the developers' punctual interventions to fix the bugs found by testers have certainly helped to

evaluate the services as best as possible. Several testers have used the optional answers to suggest improvements to the facilities.

For a complete evaluation data analysis see deliverable D13.5 "Final services testing report".

7.2 Modifications and bug fixing to the ARIADNE Portal and Services

The suggestion and evaluation reported by the INRAP team, both during the setup and execution of the testing phase and at its end, have been carefully evaluated by all partners contributing to service design and implementation.

All important and critical bugs or suggestion for improvements were taken into account and incorporated (bug fixes and some modifications of GUI and internal algorithms) in the final year of the project.

8 Conclusions

This deliverable presented the final state of integration and implementation of services developed in the context of the ARIADNE infrastructure. We have presented in detail the organisation, the features and the design of all the services which form the ARIADNE infrastructure.

The results of the user testing, as briefly reported here and described in more details in deliverable D13.5, has been very successful and also helped the service developers to refine and improve the services.

8.1 Afterthoughts on the ACDM

Going back to the initial phases of the project and taking into account all the development and the related testing results, the solution of mapping ACDM into CRM, an ISO standard widely used within Cultural Heritage, has proved to be an appropriate technical decision, making the ARIADNE Catalogue more interoperable.

This interoperability has been exploited in the context of the ARIADNE LOD experiment on the integration of the catalog-level data with the item-level data, for instance in the coin demonstrator.

8.2 Long term preservation services

ARIADNE aggregates, processes, enriches and presents over two million metadata records of archaeology-related information from partners all around Europe. An important part of the infrastructure should be the ability to preserve this data centrally and thus provide (i) long-term preservation at the metadata and data level (binary datastreams and metadata records), (ii) the ability to preserve the complete lifecycle of each digital object and (c) the ability to preserve all representations of each digital object).

The primary role of the preservation service is to store data into a dark archive. For that reason, a specialised service has been developed as a plugin in the MORe aggregator which pushes the content into a dark archive. Currently the content that is preserved consists of the following information records: (i) records following the native schema of the providers, (ii) records that are compliant with ACDM schema, (iii) enriched records that follow the ACDM schema, (iv) the XSLT that transforms records from Native to ACDM schema and (v) the enrichment plan of ACDM records that produces the Enriched ACDM records. When the above information is pushed and stored in the dark archive, an accompanying PREMIS event log is generated that contains a complete list of events that describe all the actions / operations on the digital objects.

The long term preservation aspect has been only partially faced. Given its importance in the context of any infrastructure, it will be necessary to extend the current service in order to account for it.

9 References

ARIADNE Description of Work"- DoW
ARIADNE deliverable D2.1 "First report on Users' Needs" http://ariadne-infrastructure.eu/Resources/D2.1-First-report-on-users-needs
ARIADNE deliverable D12.1 "Use Requirements" http://ariadne-infrastructure.eu/Resources/D12.1-Use-Requirements
ARIADNE Deliverable D13.1 "Service Design" http://ariadne-infrastructure.eu/Resources/D13.1-Service-Design
Specification of the ARIADNE Catalogue Data Model v. 2.5.5 http://ariadne-support.dcu.gr/
ARIADNE website: www.ariadne-infrastructure.eu