VERA: A Virtual Environment for Research in Archaeology

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Abstract

The VERA (Virtual Environment for Research in Archaeology) project[1] is based on a research excavation of part of the large Roman town at Silchester, which aims to trace the site's development from its origins before the Roman conquest to its abandonment in the fifth century A.D (Clarke 2007). The VERA project aims to investigate how archaeologists use Information Technology (IT) in the context of a field excavation, and also for post-excavation analysis. VERA is a two-year project funded by the JISC VRE 2 programme that involves researchers from the University of Reading, University College London, and York Archaeological Trust. The overall aim of the project is to assess and introduce new tools and technologies that can aid the archaeological processes of recording, manipulating and analysing data. The researchers involved in the project have a mix of skills, ranging from those related to archaeology, and computer science, though to ones involving usability and user assessment. This paper reports on the status of the research and development work undertaken in the project so far; this includes addressing various programming hurdles, on-site experiments and experiences, and the outcomes of usability and assessment studies.

Introduction

The Silchester site (http://www.silchester.reading.ac.uk/) is used as a research and training excavation that has been taking place for the last eleven years. The actual excavation takes place annually in July and August for about six-weeks each year and includes a variety of archaeologists ranging from very experienced ones through to novices. The annual excavation allows us to: study the use of advanced IT in an archaeological context; investigate the tasks carried out within an excavation; ascertain how and where technologies can be used to

[1] http://vera.rdg.ac.uk/

facilitate information flow within a dig; and inform the developers of the user portal how it may be adapted to allow the integrated use of the tools in the trench itself and for post dig analysis. To ensure that the software and tools developed within the VERA project are appropriate for the archaeologists that will use them we are engaging all the on-site team and the researchers who undertake post excavation analysis in the usability studies. One of the first such activities undertaken was a diary study that was used to gather information about the work patterns of different archaeological roles and the way that they are supported by both digital and analogue technologies.

Pre-VRE Archaeological Workflow

The archaeological workflow at Silchester has been developed and refined over the past eleven years as the research and training elements of the excavation have developed. An important part of the archaeological process is recording Contexts. A Context is the smallest identifiable unit into which the archaeological record can be divided and are usually the result of a physical action i.e. the cutting of a pit, the filling of a posthole or the creation of a floor surface. When a new Context has been identified, it is immediately given a unique number from the site register. Once numbered, a paper context card is taken and as much information as is known at that moment is filled in. Usually, the plan zone, context type, and parts of the description can be filled in upon discovery of the context but sometimes the other information is not known until much later. The context is then excavated and the card completed as more information is uncovered. The card will eventually contain sketches of the location and size of the context, plan numbers, coordinates, small find numbers and environmental sample numbers. Once completed, the context cards are filed in the area folder and then after the excavation all the information they contain is entered into the database. The recorded contexts provide the material to populate the research environment, they are stored in the Integrated Archaeological Data Base (IADB), which is an online database system for managing recording, analysis, archiving and online publication of archaeological finds, contexts and plans. In the past the entry of data on to the IADB has been undertaken manually. There are around 1000 contexts recorded each season, which means that manual input of the data and information is very time consuming.

How Archaeologists Currently Use Wiki and Blog Technologies

The VERA project uses both a Wiki and blog to facilitate the exchange of information about the project. The Wiki is for in house work, whilst the blog is available to the general public. There is no standard way of using Wiki or blog technologies in archaeology, and whether they are used on a project or not will usually depend on the practices of the commercial unit, or the preferences of the project manager. Wessex Archaeology (http://www.wessexarch.co.uk) use RSS feeds, Sharethis (http://www.sharethis.com) and podcasts to help their readers keep up to date with stories and news from the trenches. The Chester Amphitheatre Project, run by English Heritage and Chester City Council, has a blog (http://capweb.blogspot.com), which can be viewed by the public and is updated with photos of recent finds straight from the trench. They also use live streaming video to broadcast a section of the excavation as they happen. Archaeologists are increasingly using Wikis and blogs, and to a certain extent they are used to publicise the work being undertaken.

Usability Studies

As Lock has described, the goal of archaeological computing is to create a situation where “the information flows seamlessly from excavation, through post-excavation to publication and archive” (Lock 2003). The VERA project aims to identify how the use of IT can move

the workflow of excavation and post-excavation towards Lock's seamless flow of information. Alongside the fundamental aims of the project sits the issue of usability and appropriate design of IT. Numerous studies have demonstrated that the successful uptake of IT depends heavily on understanding users and that if new systems do not fit into existing procedures and routines, uptake of the new technology will be poor. "Publication after publication reaches the same conclusion: that technology is important but insufficient on its own for the success of ICT-enabled projects. Again and again technology projects fall down not because the hardware is unstable, but because different systems' architectures have been poorly scoped and designed. Without good change management and careful thought given to the people using the systems as well as the technology itself, ICT-enabled projects are unlikely to be successful…" (Jones 2005). In order to better understand the user group that the VERA project is serving, we have undertaken a diary study, one-to-one interviews and a workshop, which included user testing of the IADB.

Diary study

The data produced by modern excavations drives the demand for digital technologies, but although archaeologists have been relatively quick to embrace IT in some areas of research, its use to aid field archaeology has often met with resistance (Backhouse 2006). Whilst archaeologists routinely employ equipment such as Total Stations (http://tinyurl.com/wjzud) geophysical equipment, XRF (http://tinyurl.com/6q982l) and digital cameras (Lock 2003) these tend to operate peripherally to the main business of excavation, which continues to rely on pen and paper, pencil and permatrace (Backhouse 2006). The paper records produced on-site are then digitised so that they can be incorporated into the site database or final report, but frequently this occurs only after the excavation has finished. The 2007 field season at Silchester gave us the opportunity to study information flow on site.

The diary study was carried out by the UCL team, at the Silchester dig during the summer of 2007. Researchers from Reading also carried out a study into the use of digital hardware to support digging and data entry. The study aimed to gather information about the work patterns of different archaeological roles and the way that they are supported by both digital and analogue technologies. Diary studies enable researchers to understand how people usually work and can be used to identify areas that might be improved by the adoption of new working practices or technologies (O'Hare 1998). Diary studies have been used in the area of student use of IT, and to study the work of humanities scholars (Rimmer, forthcoming). However, this is the first time, that we are aware of, this method has been used to study field archaeology

Participants were asked to keep a detailed record of their work over a short period of time, recording the activities that they were undertaking, the technologies they were using and any comments they had on problems or the progress of their work. Participants also completed a questionnaire rating the technologies that they had used. A cross section of people representing different types of work and levels of experience were chosen. For example, we included inexperienced and experienced excavators; members of the finds team who process the discoveries made on site; those who produce plans of the site and visitor centre staff. Of the 70 people asked to participate, 33 returned completed questionnaires and diaries. Despite an explanation of the reasons for the study, some people felt the diaries were covert attempts to check how hard they were working. The participants who resented being studied naturally produced less detailed data than the willing participants. There was also some feeling amongst the students that they already had to complete too much paperwork, so anything that was optional was bound to take a lower priority. Very few of the participants (12%) had

previous experience of the digital technologies used on an archaeological site other than Silchester. Surprisingly, only 19% of the professional archaeologists claimed to have experience of using technologies on a site other than Silchester. This finding needs further investigation to find out how true a reflection it is of the archaeological profession.

There was some resistance to the use of new technologies on the excavation, especially on the part of the more experienced archaeologists. Some felt that the conditions were too hostile for computer hardware and worried about the potential cost of damaged equipment. *Participant 17* - "I think that a computerised version of our paper records is a good idea, but I feel that the environment that I work in doesn't really suit an electronic/computerised source. We work in muddy and wet conditions and expensive equipment may well be ruined." Supervisors were also concerned that new students found it challenging enough to learn about the archaeology without being confronted with unfamiliar technology.

During the 2007 excavation a Nokia N800 Internet Tablet[2] and digital pens were trialled for context recording. Before the field test it was anticipated that there might be problems using the Nokia N800 and the diary study confirms concerns about its field applications. *From the VERA blog* - "If we can't see the screen in direct sun light it could be a real deal breaker, this is definitely something we might have to hack around." *Participant 9* - "Failing to use Nokia handheld - WiFi not working and sunlight OTT. Suggest attach 1-2m parasol to Nokia?" The Nokia N800 was unsuited to outdoor use, as its screen could not be seen in bright sunshine and it obviously could not be used when it rained! Whilst the Nokia N800 struggled with the environmental conditions of the site, the digital pens fared much better. There were some issues in the way in that the digital pens record data (i.e. in a linear fashion), which is slightly at odds with the usual work flow patterns of archaeologists, who tend to record information as it becomes available but overall the digital pens were well liked by the people using them. The use of digital pens during the 2007 excavation season appeared to have had a positive affect on the speed that contexts were entered into the IADB. The process of archaeological thought and interpretation was obviously not affected, but the time taken to make the record available to the specialists and research team via the database from the original paper copy appears on first examination to have been reduced by a third. The 2008 season will provide a more detailed picture of this rate, as the initial problems with accuracy and software have now been solved.

The quality of the archive is of paramount importance for any further work and the diary study illustrated the importance of maintaining existing mechanisms for checking and controlling data. In the existing paper systems students are required to have their context cards, plans and sections checked by a supervisor and this system has worked effectively for numerous years. During the 2007 excavation the quality control applied to the paper record did not always operate with the same rigour for the digital entries and this created some anxiety for supervisors.

The reliability of the technologies used is of great importance, but perhaps never more so than in a field situation. Participants in the diary study expressed frustration at the site infrastructure, specifically the unreliability of computers and WiFi Internet access. Previous unsuccessful brushes with new technologies in the finds hut had left the team 'once bitten, twice shy' and there was a generally held belief that technology should only be used where it was necessary. Thus there was great support for digital cameras, but little enthusiasm for

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[2] https://vera.rdg.ac.uk/blog/?p=24

trialling any further technology. *Participant 17* – "A digital camera is essential for recording finds as often their original appearance can change as they dry out. Pen and paper - essential tool for finds". This allows for changes and withstands the dirt/mud/water that comes into the finds hut. It seems clear that the introduction of new technologies must be carefully managed and supported lest they alienate the very people they are supposed to be helping.

Interviews

As well as the core team of researchers the Silchester project utilises the skills of a large and geographically dispersed group of specialists who engage in various aspects of the project. Key to their interaction with the project is the IADB. One-to-one interviews were carried out to explore how the existing users currently organise their work and to discuss their experiences of working with the IADB.

The first part of the interview explored the background of the participant including their job and their experiences of working with technologies. The interviews then moved on to discuss the general working practices of the participant, e.g. data recording and processing, as well as publications. Here the focus was on software other than the IADB that participants worked with and their experiences of using it. The third part of the interview focused on the IADB and participants were asked to describe the tasks that they typically undertake with it. Where applicable, participants were asked to compare their experience of undertaking the same task outside of the IADB. The interviews concluded with participants being asked to what extent the IADB met their work needs and if there were any changes that would make their work easier.

Due to the specialised nature of each participant's work, individual needs of the IADB are wide-ranging. The VERA team are working to address individual user needs. The specialists involved with the Silchester project come from diverse backgrounds and have differing levels of technological expertise. Designing a user-friendly interface in such circumstances will always need to cater for the least technologically minded user. Many of the specialists use the IADB infrequently and there was a consensus that it needs to be as intuitive as possible so that it does not require a great investment of time for users to re-familiarise themselves with it.

The most common concern was that changes are made to the IADB with insufficient notice or explanation. This can be frustrating if familiar tools become unavailable and in the worst instances have resulted in the loss of data. Whilst users enjoy the developmental nature of the IADB and are keen that it continues to develop alongside their own needs there was a general agreement that imminent changes need to be better advertised. It has been agreed by the VERA team that there will be staged releases of IADB updates and some users felt that it would be useful to introduce feedback form to accompany updates to the system.

Some users have experienced difficulties when using the IADB search tools. This has already been partially rectified by simplifying the way in which the search tool works, but there is an underlying problem with the way in which keywords are entered into the IADB. At the moment the IADB allows users to type in free text if they do not wish to use any of the terms in the drop down menus. This leads to both typing errors and a general lack of standardisation, which in turn leads to a search not returning all the records that it should. Several users have expressed a preference to keep the free text facility because they believe that lists of terms will never be exhaustive, but it does seems that there needs to be some sort of trade-off to make the IADB fully cross searchable.

Data trails and knowing who inputs data is vitally important to several of the users who also need to be able to track changes. Whilst users accept that incorrect data needs to be corrected, many felt it was unacceptable that some users could delete entries wholesale. Users are happy for other users to add their own interpretations, but think that in some cases these should be entered as additions rather than written over existing entries. If a record is going to show multiple interpretations it is vitally important that the author of each section is obvious. It is also sensible that the most recent additions are displayed first.

Winter Workshop

The first VERA usability study was carried out at the 2007 VERA Winter Workshop at Reading (http://vera.rdg.ac.uk/events/winter_workshop.php). Participants were divided into two groups; a) those with no (or little) experience of using the IADB, designated 'novice users' and b) those who have experience of using the IADB in their work, designated 'experienced users'. Participants were given an hour to complete a number of tasks and if this time was found insufficient they were asked to ensure that answered the questions about their impressions of the IADB. The novice users were impressed by the way in which the IADB enables users to create links between different types of data and their initial impressions were that it would be a useful tool for managing large data sets. The matrices tool received several positive comments and participants liked its flexibility and its ability to incorporate data not traditionally found in a matrix. The IADB interface was found by some participants to be slightly confusing and although participants liked the familiarity of the windows it was felt that they could be better organised, perhaps by using some sort of tab system.

Overall the novice users were impressed by what they saw of the IADB. Although they received no introduction to the IADB participants felt that they could quite quickly get to grips with the system. It does seem that there is room for additional documentation and user manuals. Currently documents are designed to guide the specialists through using the IADB but none of the study participants found this. Support can also be found in the Wiki and although this was a popular idea with some of the participants there was a suggestion that more traditionally minded users would look instead for a help menu of some kind.

The terminology used in the IADB caused problems for novices, as it was not familiar to archaeologists. For example, the term "object" is used to refer a non-hierarchical data construct that allows users to group together any mix of Finds, Contexts, Sets, Groups, Phases or other Objects. For example, each Find or Context can belong to any number of Objects, making this a useful way of organising data within the IADB. The concern over terminology was also raised in the interviews with users, so is not unique to those unfamiliar with the IADB. This is another area where additional documentation might help.

The group of experienced users represented a wider sample than the one-to-one interviews as it also contained users of the IADB who are not directly associated with the Silchester project. This study echoed many of the issues that were raised in previous interviews and can be seen as providing a complementary picture. The impression from this study is a positive one, but it is clear that users are reliant on Mike Rains, the creator of the IADB, being available to offer help, support and to sort out any "glitches". The experienced users have a long history of using the IADB and value its flexibility, integration and accessibility. Whilst they are sometimes frustrated by system glitches and unannounced changes, a point reiterated in the interviews, users can see the advantages of being part of the development of the IADB. These users carry out a wide range of tasks with the IADB and it is used at (almost) all stages

of various projects. The links between different data types within the IADB is considered to be a strength, as it allows users to move easily between related data. The matrices tools received praise; it allows the diagrammatic representation of relationships between the site's data, and the plan browser. An area where there is room for further development is the use of the IADB as a tool for collection management. The experienced users would also like to see data entry speeded up and as mentioned earlier this is an area that VERA is working on. Whilst digital recording is one possible answer there are obvious issues surrounding data quality control. Several participants would like to see added functionality for working with spatial data/drawings and one of these would like to be able to work in 3D.

Usability Study Summary

Using various approaches, a diary study, one-to-one interviews, and a usability study, we have gathered a large amount of data relating to the use and potential of IT in archaeology. A theme that runs through all three studies is the importance of data quality and the transparency of data trails. Incorporating existing systems for data verification into any digital system is the first step towards Lock's ideal of a seamless flow of data. Another common theme is the ease of use of technologies as users are easily put off if technologies are perceived as 'not user friendly'. This hurdle can be overcome by providing easily accessible documentation or user support. Users of the IADB have become reliant on being able to receive personalised aid and whilst this helps to make the IADB very reflexive and user-driven, the mechanism is unlikely to be sustainable in the longer term. The reliability of technologies is also a key issue, users need to be assured that they will not be surprised by changes to software and also that hardware provided will be fit for purpose. Work is still ongoing to best understand the user needs of the archaeological community and future areas of work include a more detailed diary study during the Silchester 2008 field season, one-to-one interviews with IADB users outside of the Silchester project, and interviews with archaeologists using alternative data management systems.

Technical Programming Aspects

The technical programming development in VERA is based on enhancing the portal that was used during the JISC VRE 1 programme, known as OGHAM. This is based on the IADB, which consists of a MySQL backend, with a dynamic interface created using PHP, JavaScript, and AJAX. It was decided to embed the OGHAM portal within a standard portal framework using standard JSR-168 portlets, which ensures that from the user's perspective the interface barely changes, and also so that it can be reused within other standard portals. An examination of the original OGHAM source code showed that it was necessary to make a number changes, these included updating some global variables and adding extra code for security purposes so that the system would work with a more secure version of PHP. It had been previously decided that instead of adapting the OGHAM portal code to work within a JSR-168 portlet, we would consume the portal with a portlet using bridging technologies. This approach has a number of advantages, which includes not forking the original application code, and not having to support any code migrated into a portlet.

A common issue for current portal frameworks is how best to make use of existing Web-based software. There are a huge number of Web applications that are used extensively and have had considerable investment in their development; the problem is the majority were designed to act as stand-alone web-based applications and not be used within a restrictive portal framework. We have produced what we call the Recycle Bridge (RB) (http://vera.rdg.ac.uk/software), which was designed specifically for complex web-based

applications, with the main technical challenge being to elegantly combine the application's security with that of the portal so that it provides single sign on. To show that the Recycle Bridge works correctly we tested it by consuming both MediaWiki (http://www.mediawiki.org/]) that is used by Wikipedia, and WordPress (http://wordpress.org) that is used for blogging, into a portal framework. It should be noted that both these applications are used by hundreds of thousands of users and have been continuously developed over the last five years at considerable cost. As mentioned earlier, the only coding required to consume both these applications using the RB is the security binding; both MediaWiki and WordPress have APIs that can be used for this purpose.

Searching Across Multiple Archival Databases

The communities involved in archaeology and the preservation of ancient documents are increasingly using digital devices to record information about artefacts, and also store whatever is recorded within databases. While these advances in information recording and storage make individual projects more productive, the ability to search through multiple databases instances is limited by the fact that the projects predominately work alone and do not try to follow the prevailing standards, if available, in their project area. However, the ability to search through multiple databases does present significant advantages to these communities because the additional information that can be found in other databases can enhance the understanding of finds or artefacts and also provide further provenance or help match disparate entities together, that were not known to have a relationship before.

The XDB-Arch project (http://xdb.vera.rdg.ac.uk/) aims to create a generic and easy to use Web-based system that can be used by various communities to search through the existing distributed databases and potentially find matches between the artefacts or finds being studied. For example, it may be the case that an archaeologist has a piece of pottery with a particular stamp or graffiti mark on it; from their perspective it would be useful to gather more information about the stamp or graffiti, to help date the pottery, identify who made the it or verify where the it was produced. Similarly an historian trying to read a text might want to uncover the context of the text by treating the documents not as disembodied texts but as artefacts with an original archaeological or physical context. While a limited number of finds with any documentary interest have so far been recovered from the Silchester site, we hope that these links can demonstrate the potential of our approach.

The XDB-Arch prototype is collaboration between the School of Systems Engineering, at the University of Reading, and Centre for the Study of Ancient Documents at the University of Oxford. Reading is using the Integrated Archaeological Database (IADB), which stores archaeological data and information in a relational database, and Oxford is using an RDF data-store to holds images about ancient documents and manuscripts such as the Vindolanda site (http://vindolanda.csad.ox.ac.uk/).

The XDB-Arch Framework is shown in Figure 1. In order to make the system usable to non-technical users we have chosen to use the Contextual Query Language (CQL) (http://www.loc.gov/standards/sru/specs/cql.html), which is a formal language, based on the semantics of Z39.50 that is used for representing queries to information retrieval systems such as digital libraries, bibliographic catalogues and museum collections. We are using a service-oriented middleware known as Tycho (http://acet.rdg.ac.uk/projects/tycho/), which is REST-based, and provides an asynchronous messaging API, as well as a peer-to-peer-based registry. Every database linked to the system will run a Search Service, which is responsible for interacting with the local database and exposing a subset of it in a standard format. The

messaging API from Tycho allows data to be passed around the XDB-Arch Framework, from the client to the backend Search Services. The Tycho registry has a number of capabilities, not only can it be used to hold end-point address, where components register, find and bind to these at run-time, this allows Search Services to automatically discover each other.

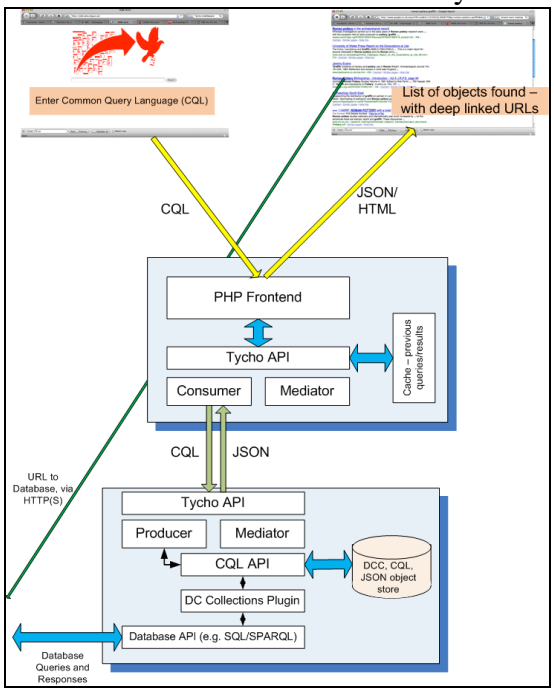

Figure 1: XDB-Arch Framework

When XDB-Arch starts up each Search Service automatically queries the local relational database or RDF data-store and populates a number of Dublin Core Collection (DCC) documents, which effectively aggregate information together about similar entities ("bags of entities"). To use the XDB-Arch system the user enters the web site, from here they can enter CQL manually with AJAX-based hints or via predefined pull-down boxes. The CQL is then injected into Tycho, which dispatches the query to the remote Search Services. Each Search Service queries its local DCC documents using CQL. If the DCC document shows that one of the databases contains relevant data/information, then pre-selected queries are initiated on the that database, and the response is returned directly to the user's web browser via Tycho. The response rendered in the user web browser is a combination of HTML and JavaScript Object Notation (JSON), which provides a basic description of the entity being searched for, plus a deep-linked URL. The deep-linked URL points back to the originating database, for instance at Reading this is the IADB and the user can then interact with it to find further information. This is similar to the way a conventional Internet search engine works, where search results provide a summary of information but ultimately point back to the original documents.

3D Visualisation of IADB Contexts

The VERA project is also creating the ability visualise the excavation site and view the finds and artefacts via a 3D-viewer. The archaeologists believe that such a capability will simplify their post excavation research. The first hurdle to overcome has been to introduce the "z" coordinate into all the context sheets held within the IABD. Currently, Only "small finds" and samples have the "z" coordinate, but there are calibration points within the IADB that will allow all the "z" be extrapolated and inserted in retrospect. The additional coordinate will also be useful because a GPS-based system that works off a known geographical location will be tested on-site this year, so that latitude, longitude and heights will be collected from the excavation during the 2008 season. We are currently also exploring the means of creating the

3D views, and we will export visualisation data that can be imported to the Cave Automatic Virtual Environment (CAVE) system located at Reading.

Summary and Conclusions

The VERA project is actively investigating how archaeologists use IT in the context of a field excavation, and also for post-excavation analysis. The project involves archaeologists; computer scientists and researchers involved in usability studies in the digital humanities. The cross disciplinary team are investigating and implementing mechanisms and tools that aid archaeologists in their field work, which is also helping them to streamline the processes they use to gather, analyse and later publish papers related to their activities.

To ensure that the software and tools developed within the project are appropriate for the archaeologists that will use them we are engaging all the on-site team and the researchers who undertake post excavation analysis in the usability studies. These studies have so far included a diary study, a workshop that was related to digital field recording and publication in archaeology, as well as interviews with individuals and groups involved with the IADB and Silchester project. These studies are providing significant information about not only how archaeologists work, but also feedback about how to improve the current tools and also hints about utilities that would help research in the future.

From a technical point of view new digital technologies are being investigated on-site and various changes are being made to the current VRE to ensure that it provides the interface, tools and utilities needed by the archaeologists. In addition, we are exploring easy to use mechanisms that will enable cross database searches of multiple archival systems and the means to provide 3D visualisation of the excavation and its associates finds and artefacts.

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