OAIS as a reference model for repositories

an evaluation

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Author:	Julie Allinson, Digital Repositories Support, UKOLN, University of Bath
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Summary

This document has been prepared by the Digital Repositories Programme Support team to evaluate the potential of use the OAIS Reference Model across different types of repositories.

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Comments, corrections and feedback to j.allinson@ukoln.ac.uk

1. Introduction

The purpose of this document is to evaluate "whether OAIS is an appropriate reference model for use across the variety of repositories being developed within the JISC community" (Campbell 2005, p. 11). It follows on from discussions at the repositories strand of the JISC-CETIS Conference 2005 and the CETIS Metadata and Repositories SIG meeting held subsequently in March 2006.[1]. Forming part of the work of the Digital Repositories Programme Support team[2] to scope the need for repositories reference model(s), this document is a work in progress, to be further developed through consultation with the community and in future work. To enable community input, the document will be made available as an editable page on the Digital

1 JISC-CETIS Conference Repositories Strand, November 2005 http://www.e-framework.org/events/conference/programme/repositories/
Metadata and Digital Repositories SIG Meeting http://metadata.cetis.ac.uk/sig_meetings/HEAMar2006/
The SIG meeting identified the following potential areas for further work:

- More detailed analysis and evaluation of OAIS, including its terminology, functions, Information Model and mandatory responsibilities
- Evaluate any other candidate reference models, e.g. CORDRA
- Involve OAIS experts and representatives from the various stakeholder communities in this analysis work
- Identifying the relevant e-Framework 'bricks' to fulfil functions identified in the OAIS reference model
- Contributing to the e-Framework, keeping the e-Framework dynamic and possibly extracting some definitions of concepts from the OAIS (Fegen 2006)

2 The JISC Digital Repositories Programme is bringing together cross-domain projects to look at different aspects of digital repositories . The Digital Repositories Support team offer advice and support to projects and undertake various Programme-related activities. This evaluation relates to workpackage 2: "scope (a) reference model(s) for repositories, with reference to the e-Framework"
http://www.ukoln.ac.uk/repositories/digirep/index/Workplan_summary

Repositories Programme wiki[3].

The Reference Model for an Open Archival Information System (OAIS) has proved an extremely useful model in relation to 'archival systems'. This evaluation will consider the benefits and drawbacks of applying the OAIS across repositories in a more generic way, with reference to long-term preservation as outlined in the model, and, in addition, considering the model with reference to the other business requirements that a repository might fulfil. This evaluation is being carried out in the context of the JISC Digital Repositories Programme and will focus largely on repositories that serve the communities and domains covered by that Programme, although its conclusions should have wider relevance. It is not the intention of this evaluation to provide a detailed introduction to OAIS, but to draw on previous work in this area[4].

2. Background

Before evaluating OAIS, it is important to first establish for the purposes of this evaluation the scope of repositories and reference models. The main focus in this evaluation will be on 'institutional repositories' that serve the education sector although conclusions may be relevant to subject repositories and repositories in the cultural heritage domain for whom Long-Term preservation is not the core purpose. Clifford Lynch's much-quoted definition of a university-based institutional repository identifies a number of crucial concepts which will recur throughout the ensuing document:

> a set of services that a university offers to the members of its community for the management and dissemination of digital materials created by the institution and its community members. It is most essentially an organizational commitment to the stewardship of these digital materials, including long-term preservation where appropriate, as well as organization and access or distribution (2003, p. 1)

The notion of 'community' is deeply embedded in the OAIS model as is the importance of preservation for the stewardship of digital materials, working alongside access and dissemination functions. The idea of a repository as a co-ordinating set of services ties in well with the e-Framework for Education and Research which aims to provide a service-oriented factoring of services across education and research[5].

The OAIS and e-Framework definitions of a 'reference model' are mutually supportive. OAIS defines a reference model as:

> A framework for understanding significant relationships among the entities of some environment, and for the development of consistent standards or specifications supporting that environment. A reference model is based on a small number of unifying concepts and may be used as a basis for education and explaining standards to a non-specialist. (CCSDS 2002, p. 1-12)

The e-Framework for Education and Research takes this further, identifying various components that a reference Model should provide:

- An abstract task model of what has to be accomplished to meet the needs addressed, described in a way that is independent of how it is accomplished
- The description of the chosen means of implementing this model, including:
- The roles and activities that humans and computer systems are respectively to play in accomplishing this task.
- The workflow or processes involved.
- The use cases involved at one or more points in the process that form part of the computer system requirements at each point.

3 DigiRep http://www.ukoln.ac.uk/repositories/digirep/

4 Various summaries and overviews of the OAIS reference model provide digestible introductions. These include papers by Brian Lavoie (2004) and Alex Ball (2006), and a 2006 presentation by Michael Day (2006), amongst others.

5 e-Framework for Education and Research http://www.e-framework.org/ - "an initiative by the UK's Joint Information Systems Committee (JISC) and Australia's Department of Education, Science and Training (DEST) (the initial e-Framework Partners). The primary goal of the initiative is to facilitate technical interoperability within and across education and research through improved strategic planning and implementation processes".

- From the use cases are derived:
    - a specification of the service or services called on, together with links to the specifications and bindings used
    - a specification of how the various services are co-ordinated in those cases where they have to work together. (Oliver, Roberts and Blinco 2005, p. 8)

For repositories, a reference model offers a means of enabling better communication across different domains and communities, promoting interoperability, identifying requirements and assisting development. The potential relationship between OAIS and the e-Framework, and how this might be used for repositories, will be explored in later sections.

3. Evaluation of OAIS

OAIS, the Reference Model for an Open Archival Information System, was developed by the Consultative Committee for Space Data Systems (CCSDS) to provide a framework for the standardisation of long-term preservation within the space science community. OAIS was created with a view to its being widely applicable to long-term preservation in any context, primarily, but not exclusively, digital. The model exists at an abstract level, providing a conceptual framework for raising "fundamental questions regarding the long-term preservation of digital materials – questions that cut across domain-specific implementations" (Lavoie 2004, p. 2). Its usefulness in providing a common terminology and communication tool is immediately apparent. In the following sections, each aspect of the OAIS model will be considered in terms of its applicability and adaptability for variety of repositories, not only those where preservation is the main business requirement. The study will draw on existing work wherever possible[6].

3.1 Long-term preservation

Preserving digital data is a significant challenge for information curators. OAIS is very clear in its focus on Long-Term preservation. Many repositories, though, would not cite preservation as their primary function and might not immediately see the relevance of OAIS to them, equating long-term with an indefinite period. However in a well-managed repository there should be some consideration of preservation and the OAIS model is useful in ensuring preservation is not forgotten.

The Digital Preservation Coalition[7] tells us that digital preservation is "the series of managed activities necessary to ensure continued access to digital materials for as long as necessary" and OAIS says only that "Long Term *may* extend indefinitely" (CCSDS 2002, p. 1-1). This flexibility in defining length of term is a real benefit for repositories where preservation is not a core requirement.

Chris Rusbridge, in a recent paper for Ariadne attempts to rationalise some digital preservation fallacies and offers a loose definition of how long-term might be interpreted:

> It makes more sense for most of us to view digital preservation as a series of holding positions, or perhaps as a relay. Make your dispositions on the basis of the timescale you can foresee and for which you have funding. Preserve your objects to the best of your ability, and hand them on to your successor in good order at the end of your lap of the relay. In good order here means that the digital objects are intact, and that you have sufficient metadata and documentation to be able to demonstrate authenticity, provenance, and to give future users a good chance to access or use those digital objects. (2006)

It could be argued that many repositories haven't yet considered preservation for a number of reasons, such as the relative infancy of digital curation, the 'unkown' aspect of attempting to

6 The *Assessment of UKDA and TNA compliance with OAIS and METS standards* (Beedham, Missen, Palmer and Ruusalepp 2005) has undertaken a thorough evaluation of OAIS; its conclusions are regularly cited in this evaluation.

7 Digital Preservation Coalition http://www.dpconline.org/

identify the threats and losses that may occur into the future and the perceived dislocation between preservation activity and the more-pressing need to populate repositories with content. Indeed, OAIS itself accepts that "some of the Long Term Preservation activities may conflict with the goals of rapid production and dissemination of products to Consumers" (CCSDS 2002, p. 2-1). Yet most repositories, perhaps without realising it, are offering some level of preservation. They are storing and managing materials on behalf of others, they are committed to gathering metadata and they have agreements and policies to ensure a certain level of service. In addition, there is more to be gained from preserving materials in a repository than Long-Term preservation. For example, preservation can help demonstrate sustainability and viability, it can engender trust, embed preservation considerations into the workflow of authors, help maintain an institutional, or scholarly, archive of outputs and enhance open-access.

Preservation and access should not, indeed, cannot be separated despite the fact that "there is little consensus on the extent to which institutional repositories should be responsible for preservation" (Hockx-Yu 2006). How far, and for how long, repositories commit to preservation might be difficult to express in the current landscape, but as digital preservation becomes better understood and national preservation services develop[8], individual repositories will be better equipped to define their preservation position. OAIS draws attention to the important role of preservation for repositories, asking that it is considered alongside other functions and activities. What it does not do is demand a specific level of preservation, allowing repositories the scope to first assess the needs of their community and information.

3.2 Conforming to OAIS

Would conformance to the preservation aspects of the OAIS model be too onerous for 'typical' institutional repositories? How difficult is it for a repository to conform to the OAIS model? In answer, it is relatively easy, as OAIS requires a repository to adhere only to the following three aspects of the model:

- A conforming OAIS archive shall fulfil the responsibilities listed in 3.1
- A conforming OAIS archive implementation shall support the model of information described in 2.2
- A standard or other documents that claim to be conformant to the OAIS Reference Model shall use the terms and concepts defined in the OAIS Reference Model in the same manner (CCSDS 2002, p. 1-3)

The next three sections will evaluate each of these conformance areas in relation to institutional repositories, before considering the remaining aspects of the OAIS model. The first of these is a list of six mandatory responsibilities, as follows:

3.2.1 Mandatory responsibilities

The OAIS must:

- Negotiate for and accept appropriate information from information Producers.
- Obtain sufficient control of the information provided to the level needed to ensure Long-Term Preservation.
- Determine, either by itself or in conjunction with other parties, which communities should become the Designated Community and, therefore, should be able to understand the information provided.
- Ensure that the information to be preserved is **Independently Understandable** to the Designated Community. In other words, the community should be able to understand the information without needing the assistance of the experts who produced the information.
- Follow documented policies and procedures which ensure that the information is preserved against all reasonable contingencies, and which enable the information to be disseminated as authenticated

8 For example, through the PRONOM file format registry (http://www.nationalarchives.gov.uk/pronom/) or the preservation models currently being developed within the Sherpa DP (http://ahds.ac.uk/about/projects/sherpa-dp/i) and PRESERV (http://preserv.eprints.org/) projects.

copies of the original, or as traceable to the original.

- Make the preserved information available to the Designated Community. (CCSDS 2002, p. 3-1)

These responsibilities offer a small set of high-level goals, providing a loose framework for best practice and communication between repositories. These six responsibilities encompass many of the tasks that institutional repositories are already fulfilling. The first responsibility encompasses motivating and advocating deposit, encouraging engagement with the repository, identifying the scope of materials accepted and establishing a pre-ingest process. The second responsibility covers depositor agreements, setting policies and considering IPR issues. The third responsibility is where a repository ensures that it understands who it is providing services for, both the Producer and Consumer of its information. At this point stakeholder analysis, user requirements gathering and community liaison all play an important part. Responsibility four ensures that material can be accessed, used and understood by its community, either in terms of technology, language or subject matter. Responsibility five is where preservation is considered, asking that repositories have policies and procedures to ensure data is preserved and its route through the repository documented. The final responsibility simply asks that information is made accessible to the Designated Community.

These responsibilities, then, ask only that preservation has been planned for and a strategy identified. The remaining requirements cover aspects that any repository should be attending to in the course of service provision and, as such, could be used as a checklist for new repositories, as part of a larger development process.

3.2.2 Terms and concepts

OAIS clearly defines its terminology in section 1.7.2, endeavouring to “use terms that are not already overloaded with meaning” (CCSDS 2002, p. 1-7) and accepting that some mapping to community-specific terminology will be required. Already, OAIS terminology is gaining ground across a number of communities, with references to SIPs, AIPs and DIPs, and an appreciation of the 'Designated Community' becoming more widespread. Naturally difficulties will arise where new terms need to be learnt, applied and mapped and, where terminology is in current use with a different definition, there may be disagreements or misunderstandings. Throughout the OAIS document, examples largely focus on scientific data and may not be helpful to other domains. With increased usage of the model, more examples covering different types of content are beginning to surface[9].

3.2.2.1 Designated Community

The 'Designated Community' is central to the OAIS reference model and is defined as “An identified group of potential Consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities” (CCSDS 2002, p. 1-10). This useful concept is already implicit within many projects across the JISC Digital Repositories Programme that are gathering user requirements through online surveys, collecting scenarios and writing use cases, in order to better understand their Designated Community[10]. Understanding the dimensions and requirements of user communities is increasingly recognised as an essential part of repository design, both from a systems and a human perspective.

The 'Designated Community' acts as the point where the external environment and the OAIS model interact, it enables repositories to identify who they are providing for, their stakeholders and

9 For some examples, refer to *Assessment of UKDA and TNA compliance with OAIS and METS standards* (Beedham, Missen, Palmer and Ruusalepp 2005), 'An overview of the Reference Model for an Open Archival Information System (OAIS)' (Day 2006), 'Working with OAIS' (Micham 2006) and other presentations given at the DPC OAIS Briefing Day: http://www.dpconline.org/text/events/060404dpcbriefing.html

10 Projects include RepoMMan, CD-LOR, Versions and, Rights and Rewards. See http://www.ukoln.ac.uk/repositories/digirep/index/Projects for further information about projects. This issue was raised at the Second JISC Digital Repositories Programme in 2006, particularly in the e-Learning and Integrating infrastructure cluster group sessions: http://www.ukoln.ac.uk/repositories/digirep/index/Programme_meeting_2006-03-27.

users, to create policies about what they will offer and to frame their service-provision. This is extremely useful for repositories, yet, on the downside although OAIS makes a small concession towards the existence of multiple communities, it does imply a single knowable Designated Community. This is not always the case for institutional repositories and the effort required in identifying and understanding this community should not be underestimated.

3.2.2.2 OAIS Environment

The OAIS Environment can contain multiple communities made up of users, depositors and other stakeholders. In OAIS terms, the environment contains the Producer, Consumer and Management, where management "is the role played by those who set overall OAIS policy as one component in a broader policy domain" (CCSDS 2002, p. 2-2). This simple model provides a good foundation for mapping the external interactions with the repository and can include external systems that might act as Consumer or Producer, such as OAI harvesters. What it does not incorporate are attempts to map the relationships between Consumers and Producers, between the different communities and the stakeholders that do not fit within these three categories [11]. Also some work might need to be done to distinguish the primary Designated Community from other communities within the environment. Wider environmental issues, existing at a strategic, rather than functional level, can be difficult to incorporate within this model[12]. Perhaps these more complex issues are outside the remit of the abstract OAIS, and might be layered into a more fully developed reference model based on OAIS.

3.2.3 OAIS Information Model

The Information Model is another key aspect of OAIS, also required for conformance to OAIS. It provides a loose framework identifying the different blocks of data and metadata that make up the Information Package. In OAIS terminology the information package is made up of: content information, which comprises the data object (either digital or physical), together with its representation information (structural and semantic information to enable interpretation of the data object, used in conjunction with the external Knowledge Base of the Designated Community); and preservation description information (PDI), composed of reference, fixity, provenance and context information. Alongside these, a package description and packaging information complete the Information Package, which is in turn described by the descriptive information. OAIS defines three information packages handled by a repository: the Submission Information Package (SIP), the Archival Information Package (AIP) and the Dissemination Information Package (DIP). The SIP represents the data and metadata that comes from the Producer; the AIP is the data and metadata preserved by the repository and the DIP is the data and metadata that are sent to the Consumer on request.

What OAIS does not provide is any indication of how metadata schemas are applied or how each block of information breaks down, as noted by Beedham, Missen, Palmer and Ruusalepp: "in regard to the categorisations of metadata, they are extremely broad, functionally organised (as one would expect), and do not reflect the way metadata are packaged and used across particular archival practices" (2005, p.70). In addition, OAIS appears to suggest a fairly rigid flow between SIP, AIP and DIP, when in practice a repository might have different procedures.

For repositories, this may seem a daunting and unrealistic model for their information, but on closer examination it might not prove to be so complex, offering some useful terminology, concepts and points of consideration. For any practical use or implementation, this model must be accompanied by recommended metadata formats and mappings to metadata schemas. Forthcoming work to specify a Dublin Core application profile for eprints will help in identifying metadata for eprint

11 The CD-LOR project have used the concept of the Designated Community and further defining two levels of communities - "a core group of *end users* and the wider community of *stakeholders* " (Margaryan, Currier, Littlejohn and Nicol 2006).

12 The Digital Repositories Support team work on identifying themes has been loosely based on OAIS, coupled with the e-Framework definition of a reference model. By combining these two approaches it has been possible to incorporate the strategic, technical and process-orientated elements missing from OAIS: http://www.ukoln.ac.uk/repositories/digirep/index/Themes (work in progress).

repositories and schemas already exist for learning objects and electronic theses[13]. It is in the area of preservation metadata that institutional repositories have less awareness. Whilst some of the metadata created might be useful for preservation purposes this is less likely to be created explicitly for this purpose. The contents of the PDI blocks are open to interpretation, allowing repositories to specify a minimal set of information to capture largely for preservation purposes. Currently repositories might create and use such information for internal management of data, but do they export such information? Here again, guidance on use of specifications for preservation metadata, either at a simple minimal level or where appropriate at a level of detail suggested by the PREMIS data dictionary[14] could be used in conjunction with the model to aid implementation.

Overall, the OAIS Information Model demands simply that a repository accept the responsibility to provide sufficient information in order to make its data understandable to the Designated Community. In so doing, it does not ask that repositories structure their systems and metadata in any particular way, or adhere to specific standards, but suggests a loose framework to ensure that the necessary information is captured[15].

3.2.4 OAIS Functional Model

OAIS defines six functional entities[16], each with a set of sub-functions, further identifying how information flows between these. The following sections consider each main function with reference to institutional repositories. Adherence to the Functional Model is not required for conformance to OAIS, although the mandatory responsibilities would be fulfilled by functions defined here

3.2.4.1 Ingest

Ingest[17] is the function that accepts an information package from the Producer, checks and updates it, generates the version for storage and creates, or augments, the descriptive information. It is only during the Ingest stage that the repository and its Producer interact and it is at this stage that the information received is enhanced to ensure its usability by the Consumer. Leaving aside the generation of the AIP, the functions identified here are likely to map well to any repository procedure. Beedham, Missen, Palmer and Ruusalepp make two important observations about this stage. The first relates the lack of a model for the pre-ingest phase in OAIS:

> The OAIS reference model would serve the community better if it included this [pre-ingest] function rather than relying on the existence of a separate model (2005, p.34)

The pre-ingest function, as defined by Beedham, Missen, Palmer and Ruusalepp, includes contacts and negotiations between the Producer and repository (the preliminary phase), SIP design and submission agreement (formal definition phase), transfer of the SIP (transfer phase) and validation processing and Producer follow-up (validation phase). At this crucial point, where the information first flows into a repository, OAIS appears to provide little guidance, despite the fact that it is this information flowing in that drives the remaining functions. Conversely, it could be argued that these pre-ingest steps are indeed part of ingest, anticipated but not prescribed by OAIS.

The second issue relates to the Information Model, as discussed further in section 3.2.3. Where Beedham, Missen, Palmer and Ruusalepp disagree with OAIS is in the implication that a DIP is generated on-the-fly when requested by the Consumer. In practice, if generating a DIP at a later point, it might be found that information is lacking, information that, at a later stage, cannot be

13 Eprints Application Profile Working Group http://www.ukoln.ac.uk/repositories/digirep/index/Eprints_Application_Profile
UK LOM Core http://www.cetis.ac.uk/profiles/uklomcore
ETD-MS http://www.ndltd.org/standards/metadata/current.html

14 PREMIS http://www.loc.gov/standards/premis/

15 There is more detail to OAIS Information Model that has not been considered here, including some indication of how collections of information packages are modelled, and it should be noted that complex collections of information are a significant issue that need further analysis.

16 For a diagram showing the six functions, refer to OAIS section 4.1, figure 4-1, p. 4-1 (CCSDS 2002).

17 For a diagram of this function, refer to OAIS section 4.1.1.2, figure 4-2, p. 4-5 (CCSDS 2002).

recovered. The Sherpa DP project also presents a re-modelling of this information packaging process, whereby an AIP may be created at a later point by a dedicated preservation service. Secton 3.3 talks more about Sherpa DP and covers other options for adapting or re-modelling elements of OAIS.

3.2.4.2 Archival Storage

Archival Storage[18] offers the basic storage and backup of data, rather than the metadata, receiving it from the Ingest function and providing it to the Access function. Error checking, media replacement and disaster recovery are part of Archival Storage. For repositories this might be a file store with a structure and backup. Again, Beedham, Missen, Palmer and Ruusalepp note a potential discrepancy in limiting storage to AIPs, whereas in reality this function might conceivably be used to store SIPs and DIPs also. In addition, OAIS does not "address the need to provide preserved evidence of what it received" (McGovern, 2006) from the ingest function into the archival store; additional tracking or registry functionality may be needed.

3.2.4.3 Data Management

Data Management[19] is where the descriptive and system information are stored, most likely in a database. This function is also responsible for maintaining the database, performing queries sent by the Access function and generating reports. For repositories, this might be an open-source database, such as MySQL, and a series of scripts and configuration files. It might incorporate a web-accessible report generator, and other automated processes, as well as the effort of a database administrator to run specific queries and undertake any necessary development work.

Here Beedham, Missen, Palmer and Ruusalepp observe that where this functional entity looks simple, mapping it to real-life practice "results in an 'explosion' of mappings to all the different systems and processes that an archive performs" (2005, p.42). Repositories have much data to manage and this is clearly a hard-working function, perhaps not reflected in the model.

3.2.4.4 Administration

Administration[20] is the most complex function, incorporating a range of both technical and human processes encompassing audit, policy-making, strategy, customer service and many other management and administrative functions. Administration connects to every other function and also interfaces with the Producer, Consumer and Management. For any organisation or repository, this function will undoubtedly be the most difficult to understand and is likely to involve different staff across different departments depending on the size of repository and its role within the organisation or institution as a whole. For example, an Institutional Repository might be administered by a Librarian, liaising with various technical support staff with responsibilities for different systems tasks. It might have an advisory board, or management group, with representatives from across the institution and there may also be interactions with Academic Schools regarding material submission and with administrative departments for policy support.

Although OAIS provides a useful set of sub-functions for Administration, it could be argued that it provides too much detail about a set of discrete functions without providing an overview or indication of the full set of administrative functions a repository might need to fulfil. Indeed, Beedham, Missen, Palmer and Ruusalepp comment thus:

> Administration is a vital activity that every archive must perform. While there is nothing much to disagree with in the OAIS model, every institution will have it's own set of policies, procedures, requirements and responsibilities, which will inform the administration activities. OAIS, in this regard particularly, is only providing a very general functional subset of digital archive administration activities, where in other cases its Functional Model is more clearly complete. (2005, p. 49)

18 For a diagram of this function, refer to OAIS section 4.1.1.3, figure 4-4, p. 4-7 (CCSDS 2002).
19 For a diagram of this function, refer to OAIS section 4.1.1.4, figure 4-4, p. 4-9 (CCSDS 2002).
20 For a diagram of this function, refer to OAIS section 4.1.1.5, figure 4-5, p. 4-10 (CCSDS 2002).

Necessarily divergent practices and processes will exist in different repositories but, arguably, there are many areas insufficiently covered by OAIS here, including collection management, collections policy, freedom of information, data protection and access control. This echoes the limitations of the Environment identified in Section 3.2.2.2 where the complexity of interactions with external agencies or systems, or different parts of an organisation are not covered. This could be a danger for repositories that are using OAIS to guide and structure a new repository.

3.2.4.5 Preservation Planning

Logically part of the Administration function, Preservation Planning[21] has been drawn out into its own high-level functional entity because of the preservation focus of OAIS. Concerned with monitoring and setting policy, the Preservation Planning function does not carry out actual preservation activities, rather it is responsible for carrying out a technology watch function, monitoring changes in community requirements, recommending changes and updates, designing the information packages and developing preservation policies. Beedham, Missen, Palmer and Ruusalepp note that the function does not include any standards watch activity. For the UK Data Archive, the "formalised view" presented here was seen as restrictive:

> From the viewpoint of the UKDA this area of the OAIS standard can sometimes be overly bureaucratic and over-concerned with processes. Realistically organisations like UKDA have to be more pragmatic in their approach to decision making: decisions are often made out of necessity and are reactive rather than proactive and some decisions happen because of a need rather than being planned (Beedham, Missen, Palmer and Ruusalepp 2005, p.53)

For many repositories, the need for pragmatism and possible liaison with external preservation bodies are likely. Highlighting this particular planning function to the extent done by OAIS may not be appropriate for institutional repositories.

3.2.4.6 Access

The final function, Access[22], is where the repository interfaces with its Consumers, receiving queries and requests, delivering responses and connecting with the Data Management and Archival Storage functions to generate the DIP. It might be useful here to consider the two levels of communities identified by CD-LOR (Community Dimensions of Learning Object Repositories)[23] the user who simply wants materials, and the wider stakeholder community who might want a different set of information (Margaryan, Currier, Littlejohn and Nicol 2006). These users can be local or remote and might include interactions with external systems, such as OAI-harvesters or federated search services that rely on existing standards (e.g. OAI-PMH or SRU) and pre-defined metadata schemas (e.g. Dublin core or IEEE LOM).

Here again Beedham, Missen, Palmer and Ruusalepp (2005) cite DIP generation as a point of divergence, as DIPs may pre-exist and be retrieved, rather than delivered in this function. Other potential areas of contention include: the interface with the administration layer, where there is no apparent allowance for determining what information different users can and can't have access to; and the notion that a repository provides "a single user interface" (CCSDS 2002, p. 4-15) when in fact multiple points of access might exist for different Consumers.

For all repositories, Access is a necessary and existing function. The OAIS Access function provides a simple, abstract, model for the way a repository interacts with its Consumers. Points of contention do exist, though, and further analysis may be necessary of existing repository practice.

3.2.5 Other aspects of OAIS

The OAIS model does not end here, containing additional sections on 'Preservation perspectives'

21 For a diagram of this function, refer to OAIS section 4.1.1.6, figure 4-6, p. 4-12 (CCSDS 2002).
22 For a diagram of this function, refer to OAIS section 4.1.1.7, figure 4-7, p. 4-15 (CCSDS 2002).
23 CD-LOR http://www.ukoln.ac.uk/repositories/digirep/index/CDLOR/

and 'Interoperability'. OAIS Section 5, Preservation perspectives, outlines various practices used to preserve digital information and ensure continued access to that information. These include the data migration techniques of refreshment, replication, repackaging and transformation. In terms of this evaluation, it is not necessary to consider the detail of this section, but it is worth noting its existence as a source of further information about practical preservation.

Section 6, Archive interoperability, looks at the reasons for and types of cooperation between repositories. This section, although short, is important for repositories, covering key interoperability concepts and introducing the importance of using standards and specifications. OAIS introduces four categories of association: *Independent* (repositories motivated by local concerns), *Cooperating* (repositories using common standards but no shared functions), *Federated (repositories with a* Local Community and a Global community) and *Shared resources* (repositories that have entered into agreements with other archives to share resources).

This is one area where OAIS could be complemented separate implementation-specific detail, perhaps drawn from the e-Framework or other JISC activity in this area[24]. Section 4.1 talks in more detail about the e-Framework.

3.3 Adapting OAIS

OAIS is not an architectural model. It is an ontology, a terminology underlying a shared view, and, as such, provides a means of communication, ensuring that repositories are “on the same page” (Gladney 2002), whilst offering no practical implementation-specific detail. This conceptual nature is seen by many as a strength and, by being light on prescriptive statements, OAIS allows those implementing the model to apply their own layers of adaptation. Two JISC project that are currently exploring adaptive approaches to OAIS for repositories are Sherpa DP and PRESERV[25].

Sherpa DP has outlined a mechanism for enabling institutional repositories to engage a preservation service to undertake the Preservation Planning function and, where necessary to undertake some sub-functions of Ingest, Access, Archival Storage and Data Management. The SHERPA-DP OAIS report (Knight 2005a) aligns this disaggregation model against the OAIS, outlining any necessary re-modelling, whilst the 'Requirements for a Disaggregated Service' (Knight 2005b) takes the OAIS Mandatory responsibilities and draws out a more detailed set of requirements for both the preservation service and the institutional repository. PRESERV have identified 3 models for repository preservation: the Service provider model (an external preservation service is used), the Institutional model (the institution hosts a separate preservation database) and the Repository model (minimal preservation support is built into the single repository). Both projects offer a vision of how OAIS can be adapted to suit the needs of institutional repositories.

For institutional repositories, it is conceivable that the SIP, AIP and DIP are all the same, that a submitted package is ingested, stored and delivered in an unchanged state. There is nothing in OAIS to say that this should not happen, so long as the necessary information is captured at submission and the necessary planning for preservation has been made. There is a clear need for a repository to document its policy on how it manages information, to ensure that its flow of information is clear. The type of material being ingested, the size and scale of the repository, and its function will all impact on how different repositories handle information. There is also a convincing argument for archiving the SIP, as ingested, thereby maintaining the integrity of the original submission and enabling a Producer to get back exactly what they put it. Re-modelling the Information Package flow seems inevitable, when the model is applied to local requirements. This will have a knock on effect on some OAIS functions, for example 'generate DIP', or on elements of the workflow, yet remains within the framework set by OAIS.

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24 This includes forthcoming work on a UK search service for eprint repositories, work to specify a Dublin Core application profile for eprints, a project to establish an interim repository for repositories who have not yet established their own and work on specifying a common API for deposit (ingest). Projects currently ongoing in the Digital Repositories Programme relevant here include ASK, who are using the e-Framework to construct repository from the services therein, and PerX, who are creating a cross-search of engineering repositories.

25 SherpaDP (http://ahds.ac.uk/about/projects/sherpa-dp/i) and PRESERV (http://preserv.eprints.org/).

3.4 Measuring compliance

> The reference model, by implication, defines what a repository is, but does not enforce a strict definition or any mandatory elements. It is a map of the space, of its services and data, etc. rather than a compliance checklist ... it is not the intention of a reference model to exclude repositories. The definition is generic for this reason and changes in usage and landscape might necessarily alter this idea of sustainability and trust. (Fegen 2006)

There is ongoing work by RLG-NARA to produce a certification process for trusted repositories (RLG and NARA 2005), building on previous work by RLG and OCLC, which produced a report on the attributes and responsibilities of trusted digital repositories (RLG and OCLC 2002). Currently in draft form, it remains to be seen whether this kind of certification process will become widespread or of how this could benefit repositories and their users. For many repositories such a complex prescriptive process might be seen as a barrier, setting too high a bar and demanding too much time and funds. At the same time, repositories could gain from a functional audit that would accompany a certification exercise. Certification is not a recommendation of this report, although its potential value should not be discounted. Guidance, checklists and lightweight self-assessment activities could form a useful part of a repositories reference model, used in concert with OAIS.

3.5 Summary

From the above analysis it seems Institutional Repositories can use the OAIS to ensure good practice. Requirements for compliance to OAIS are low-level. To fulfil the mandatory responsibilities, a repository must define its long-term preservation commitment, as outlined in section 3.1, dedicate some time and effort to understand and document its processes, practices, functions, information, workflow and Designated Communities. Policies, guidelines and agreements should exist and these should demonstrate the sustainability and viability of the repositories' business model. Arguably, if repository developers and administrators are guided by a reference model, they are more likely to consider the right issues. By using OAIS as that reference model, awareness of long-term preservation is heightened and this could help embed preservation into the workflow, as well as demonstrating a commitment to long-term viability and sustainability and engendering trust. Such preservation considerations need not be over-emphasised and by allowing repositories to define their own preservation strategy, repositories are not tied into preserving into the infinite future, but can state their own preservation commitment. On the downside, the focus on Long-Term preservation could be viewed to sideline other, perhaps more central, business requirements and could act as a barrier, rather than an enabler, particularly if preservation activity might slow repository population or incur additional costs.

The detailed contents of OAIS provide support in relation to various potential problem areas, yet issues remain. OAIS offers a simple checklist of mandatory responsibilities with unbiased and neutral terminology and a model of the main interactions and functions inside and outside of the repository. Yet these apparently simple concepts are still contained within a lengthy document, which glosses over many areas that could prove much more complex in practice. For example, there is an apparent assumption that the OAIS-archive stands alone, when in reality it might be a small part of a very large organisation or information service. Comparing functions to current practice is no simple task and identifying issues that do not directly relate to the day-to-day functioning of a repository are challenging. Understanding the Designated Community, crucial to repositories, is also non trivial. The Information Model offers a loose framework into which existing domain-specific metadata schemas can be incorporated, but there is an issue over the seemingly rigid flow between the three information packages which may need adapting for repository-specific information needs.

One of the key strengths of OAIS is its abstract nature, allowing the model to be adapted for specific needs, such as repositories for different communities, functions or material types. Detailed implementation models could be layered beneath the high-level OAIS to provide additional context, guidance and examples, and to identify technical standards and specifications. Although prescriptive conformance is not desirable or achievable for most repositories, a set of lightweight

guidance documents and checklists, based around the shared vocabulary and concepts offered by the OAIS might be created to provide a flexible self-certification process. This could provide help and advice, whilst ensuring repositories have considered their full business model and preservation responsibilities, and that repositories develop along interoperable lines. What must be avoided is a situation where preservation-repositories and access-repositories are divided, arising from the misconception that OAIS is only applicable to preservation-oriented repositories. Where the dual functions of preservation and access are separated, for example in the methods proposed by Sherpa DP and Preserv, a documented relationship and workflow means that OAIS functions can be carried out by the most appropriate service.

4. Beyond OAIS

Returning to Oliver, Roberts and Blinco's definition quoted in section 2, OAIS indeed provides the "abstract task model" and provides some conceptual ideas for the "roles and activities that humans and computer systems are respectively to play" and the "workflow or processes involved". But it does not provide use cases or other requirements-gathering methods nor technical specifications of the services involved or of how these services might work together (2005, p. 8). For some of low-level detail, we can look to the e-Framework, but there is also a 'middle' layer, where contextualised guidance, documentation and modelling of the full range of business requirements that a repository might fulfil would reside. Some of this material already exists or is in development, for example the Digital Repositories Programme wiki is gathering scenarios and use cases[26] and a draft reference model for the discovery to delivery business requirement exists (Powell 2005a). This middle layer could be brought together in future work.

4.1 e-Framework for Education and Research

There is a natural relationship between e-Framework and OAIS as a repositories reference model. The aim of the e-Framework is "is to produce an evolving and sustainable, open standards based service oriented technical framework to support the education and research communities"[27]. The Framework identifies the available services which might be drawn upon by a reference model for implementation. Some work on identifying, and using, the services identified by Framework has been done by the ASK project[28]. The project is very positive about using frameworks and reference models for development: "The ideas behind frameworks, reference models, designs and artifacts are excellent and do support implementation projects" (Noble 2006), but cites the need for better communications and prototyping of missing services.

Frameworks, particularly technical frameworks, provide infrastructure for a practical implementation level. OAIS, on the other hand, is an abstract, conceptual model and the two should co-exist and complement. Identifying areas suitable for standards development is something that might fall out of working on a repositories reference model and this could usefully feed into e-Framework activity.

4.2 Deposit API

One area for standards development that has already been identified, and incorporated into the e-Framework, is the need to specify a common Deposit API. OAIS offers a number of statements that support forthcoming JISC-funded activity in this area:

- "standard(s) for the submission (ingest) methodology used by an archive;
- standard(s) for the submission (ingest) of digital data sources to the archive" (CCSDS 2002, p. 1-4)

26 http://www.ukoln.ac.uk/repositories/digirep/index/Scenarios_and_use_cases

27 http://www.e-framework.org/

28 ASK project http://www.ukoln.ac.uk/repositories/digirep/index/ASK - part of the Digital Repositories Programme

- "The Establish Standards and Policies function is responsible for establishing and maintaining the archive system standards and policies. ... The standards include format standards, documentation standards and the procedures to be followed during the Ingest process" (p. 4-11)
- "After the audit is completed, a *final ingest report* is prepared and provided to the Producer and the Negotiate Submission Agreement" (p. 4-12)
- "Producers may wish to have: a common SIP schema for submission to different archives" (p. 6-1)

Common deposit and exchange formats for SIPs and DIPs will make interoperability a more achievable goal.

4.3 Alternative reference models

There are other models and documents that could be considered as a potential reference model. These include CORDRA, the Digital Library Federation Framework and the IMS Digital Repositories v1.0 Final specification[29]. Evaluating these would be a useful follow-on exercise.

JISC has also funded a number of Reference Models projects and these could provide useful information and best practice about the development of reference models for repositories.[30]

5. Conclusions

OAIS was created to serve a specific community (space science) in carrying out a specific business requirement (long-term preservation), but this evaluation has demonstrated that its applicability goes beyond that. A heightened awareness of preservation has both direct and indirect benefits for repositories and compliance to the OAIS framework is relatively easy to achieve. In fact, there is nothing in the OAIS model that presents insurmountable difficulties for repositories. The conceptual and flexible nature of OAIS allows repositories to adapt and extend their own functional and informational models to take local practices into account whilst staying true to the OAIS model. In its current form, the length and apparent complexity of the OAIS document might prove a barrier to smaller repositories but a lightweight OAIS could be developed, offering a flexible, contextualised approach to applying the model across different types of repositories.

To adequately specify reference models for repositories further work is necessary and could include clarification or deeper analysis of some of the contentious areas plus activity to scope the 'middle layer', gathering existing information, developing a repository typology and ecology, analysis of the community and stakeholders and exploring the need for multiple contextualised models. Assessing the compliance of existing repositories could provide useful case studies. For the Information Model, metadata mappings and crosswalks, analysis of issues surrounding complex collections and content packaging and clarification of how repositories might generate and store the SIP, DIP and AIP, would be useful exercises. To extend a repositories reference model and include low-level technical implementation detail, it is necessary to establish a clearer vision of how OAIS and the e-Framework might interact and of what services would be used by different repositories in a service-oriented framework.

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29 See IMS 2003, Digital Library Federation (2005), Learning Systems Architecture Lab (2004)

30 The projects are: COVARM (Course Validation Reference Model Reference Model) http://covarm.tvu.ac.uk/covarm; XCRI (course information) http://www.elframework.org/projects/xcri; FREMA (e-assessment) http://www.frema.ecs.soton.ac.uk/; LADIE (Learning Activity Design) http://www.elframework.org/refmodels/ladie; EPLL (ePortfolio for Lifelong Learning) http://www.elframework.org/refmodels/epll

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