BS ISO 14721:2025

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Space Data System Practices — Reference model for an open archival information system (OAIS)

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National foreword

This British Standard is the UK implementation of ISO 14721:2025. It supersedes BS ISO 14721:2012, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2025

ISBN 978 0 539 27845 3

ICS 35.240.30; 49.140

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2025.

Amendments/corrigenda issued since publication

Date	Text affected

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International Standard

ISO 14721

Third edition
2025-03

Space Data System Practices — Reference model for an open archival information system (OAIS)

Pratiques des systèmes de données spatiales — Modèle de référence pour un système ouvert d'archivage d'information (SOAI)

Reference number
ISO 14721:2025(en)

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Foreword

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This document was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 650.0-M-3, December 2024) and drafted in accordance with its editorial rules. It was assigned to Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems* and adopted under the "fast-track procedure".

This third edition cancels and replaces the second edition (ISO 14721:2012), which has been technically revised.

The main changes are as follows:

— Changes from the current issue are too numerous to permit meaningful markup.

— This issue has additions to, and clarifications of, concepts and terminology, for example:

  — The relationship between Preservation Description Information (PDI) and Content Data Object has been clarified, emphasizing that, as has been stated since the original version of OAIS, any Information Object may serve as Content Information.

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— The concept of Preservation Objectives has been introduced to allow "Independently Understandable" to be more consistently testable.

— Consistency with the Producer-Archive Interface Specification (PAIS) (CCSDS 651.1-B-1) has been improved.

— Diagram conventions have been clarified.

— Some definitions in the Glossary have been clarified.

— Consistency between the diagrams of the Functional Entities and supporting text has been improved.

— A Preservation Watch function has been added to the Preservation Planning Functional Entity.

— The definition of the Information Package has been updated for consistency.

— Additional preservation techniques have been described explicitly in addition to Migration.

— Additional types of Archive interaction have been added, including primary-supporting Archives.

— Annex A is marked as Informative. It had previously erroneously been marked as Normative.

— Annex B from the previous issue described the relationship of OAIS to other standards; but its contents were continually out of date as those other standards develop along different directions and timelines as compared to OAIS development. Also, subsection 1.5 from the previous issue, which provided a roadmap to related Standards which could be developed was removed since a number of those standards are now available. Both have been replaced by pointers in annex B to informative documents on the CCSDS web site which can be updated more rapidly.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this document is to define the CCSDS and International Organization for Standardization (ISO) Reference Model for an **Open Archival Information System** (OAIS). An OAIS is an Archive system consisting of hardware, software, information, and policy-based processes and procedures put in place and operated by an organization and its staff. The organization has accepted the responsibility to preserve information and make it available for a **Designated Community**. The organization may be part of a larger organization. The system meets a set of mandatory responsibilities that allow an OAIS Archive to be distinguished from other uses of the term 'archive'. The set of mandatory responsibilities an OAIS Archive must perform are defined in 3.2. The term 'Open' in OAIS is used to imply that this Recommended Practice, as well as future related Recommended Practices and standards, are developed in open forums, and it does not imply that access to the Archive is unrestricted. The information being maintained has been deemed to need **Long Term Preservation**, even if the OAIS itself is not permanent. **Long Term** is long enough to be concerned with the impacts of changing technologies, as well as support for new media and data formats, or with a changing **Knowledge Base** of the Designated Community or changes within the Designated Community or its definition. Long Term may extend indefinitely. In this **Reference Model** there is a particular focus on digital information, both as the primary forms of information held and as supporting information for both digitally and physically preserved materials. Therefore, the model accommodates information that is inherently non-digital (e.g., a physical sample), but the modelling and preservation of such information is not addressed in detail. This Reference Model:

- provides a framework for the understanding and increased awareness of archival concepts needed for Long Term digital information preservation and access;
- provides the concepts needed by non-archival organizations to be effective participants in the preservation process;
- provides a framework, including terminology and concepts, for describing and comparing architectures and operations of existing and future Archives;
- provides a framework for describing and comparing different Long Term Preservation strategies and techniques;
- provides a basis for comparing the data models of digital information preserved by Archives and for discussing how the data models and the underlying information may change over time;
- provides a framework that may be expanded by other efforts to cover Long Term Preservation of information that is NOT in digital form (e.g., physical media and physical samples);
- expands consensus on the elements and processes for Long Term digital information preservation and access, and promotes a larger market which vendors can support;
- guides the identification and production of OAIS-related standards.

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The reference model addresses a full range of archival information preservation functions including ingest, archival storage, data management, access, and dissemination. It also addresses the migration of digital information to new media and forms, the information models used to represent the information, the role of software in information preservation, and the exchange of digital information among Archives. It identifies both internal and external interfaces to the Archive functions, and it identifies a number of high-level services at these interfaces. It provides various illustrative examples and some 'best practice' recommendations. It defines a minimal set of responsibilities for an Archive to be called an OAIS, and it also defines a maximal Archive to provide a broad set of useful terms and concepts.

1.2 APPLICABILITY

The OAIS model in this document may be applicable to any Archive. It is specifically applicable to organizations, which may themselves be part of larger organizations, with the responsibility of making information available for the Long Term (as defined in 1.6.2). This includes organizations with other responsibilities, such as receiving, processing and distribution in response to programmatic needs.

Organizations may require their information, from the start, to be re-processable to enable the results created by others to be reproduced, interoperable with other information, and re-used in new ways. Such organizations will find this document relevant because of the requirement that, to be preserved, the information must be understandable and usable.

This model is also of interest to those organizations and individuals who create information that may need Long Term Preservation and those that may need to acquire information from such Archives.

The model, including the functional and information modelling concepts, is relevant to the comparison and design of facilities which hold information, on a temporary basis, for two reasons:

- When taking into consideration the rapid pace of technology changes or possible changes in a Designated Community, there is the likelihood that facilities, thought to be holding information on a temporary basis, will in fact find that some or much of their information holdings will need Long Term Preservation attention.
- Although some facilities holding information may themselves be temporary, some or all of their information may need to be preserved indefinitely. Such facilities need to be active participants in the Long Term Preservation effort.

Standards developers are expected to use this model in conjunction with related standards and community documents as a basis for further standardization in this area. Many related standards are possible and some have already been developed. Annex B includes links to websites containing references to a selection of related standards.

This reference model does not specify a design or an implementation. Actual implementations may group or break out functionality differently.

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1.3 RATIONALE

A tremendous growth in computational power, and in networking bandwidth and connectivity, has resulted in an explosion in the number of organizations making digital information available. Transactions among all types of organizations are being conducted using digital forms that are taking the place of more traditional media such as paper.

Preserving information in digital forms is much more difficult than preserving information in forms such as paper and film. This is not only a problem for traditional archives, but also for many organizations that have never thought of themselves as performing an archival function. Along with the many advantages in terms of, for example, searchability and replication, the spread of digital technology in every field brings certain disadvantages. The rapid obsolescence of digital technologies creates considerable technical dangers, particularly a much greater risk than in the past of losing the possibility of restoring, rendering or interpreting the information. Ways of avoiding or reducing these dangers will be detailed throughout this Recommended Practice. Nevertheless, it would be unwise to consider the problem from a solely technical standpoint. There are also organizational, legal, industrial, scientific and cultural issues to be considered. To ignore the problems raised by preserving information in digital forms would lead inevitably to the loss of this information. In addition, information is more and more easily altered or faked. Ways to be more sure of the authenticity of information, by knowing its provenance and being sure that it has not been altered, will help to counter these threats

It is expected that this reference model, by establishing minimum requirements for an OAIS Archive along with a set of archival concepts, will provide a common framework from which to view archival challenges, particularly as they relate to digital information. This should enable more organizations to understand the issues and take the proper steps to ensure Long Term information preservation. It should also provide a basis for more standardization and, therefore, a larger market that vendors can support in meeting archival requirements.

1.4 CONFORMANCE

A conforming OAIS Archive implementation shall support, and be able to map to the components of, the model of information described in 2.3 and 4.3, which provides more formal definitions of the model using UML. The OAIS Reference Model does not define or require any particular method of implementation of these concepts.

A conforming OAIS Archive shall fulfil the responsibilities listed in 3.2. Subsection 3.3 provides examples of the mechanisms that may be used to discharge the responsibilities identified in 3.2. These mechanisms are not required for conformance.

A conformant OAIS Archive may provide additional services that are beyond those required of an OAIS.

This reference model does not specify a design or an implementation. Actual implementations may group or break out functionality differently.

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It is assumed that implementers will use this reference model as a guide while developing a specific implementation to provide identified services and content. This document does not assume or endorse any specific computing platform, system environment, system design paradigm, system development methodology, database management system, database design paradigm, data definition language, command language, system interface, user interface, technology, or media required for implementation.

The OAIS Reference Model is designed as a conceptual framework in which to discuss and compare Archives. As such, it attempts to address all the major activities of an information-preserving Archive in order to define a consistent and useful set of terms and concepts. A standard or other document that claims to be conformant to the OAIS Reference Model shall use the terms and concepts defined in the OAIS Reference Model in the same manner. Subsection 1.6.2 defines OAIS terminology and is normative.

To summarize, to be conformant with OAIS, an Archive must support the basic terminology specified in section 1.6.2, must be able to map its practices to the OAIS Information Model, which is defined at very high level in 2.3 and in more detail in 4.3, and must also fulfill the Mandatory Responsibilities specified in 3.2.

1.5 DOCUMENT STRUCTURE

1.5.1 HOW TO READ THIS DOCUMENT

All readers should read the Purpose and Scope (1.1), Applicability (1.2), and Conformance (1.4) subsections to obtain a view on the objectives and applicability of the document.

Those who want just an overview of the major concepts should also read OAIS Concepts (section 2) and OAIS Responsibilities (section 3).

Those who will implement OAIS Archives or administer them should read the entire document.

1.5.2 ORGANIZATION BY SECTION

Section 1 provides purpose, scope, applicability, and definitions sections typical of many standards. It also provides rationale for the effort and conformance requirements.

Section 2 provides a high-level overview of the major concepts involved in an OAIS Archive. It provides a view of the environment of an OAIS Archive and the roles played by those who interact with it. It discusses what is meant by ‘information’ and what is necessary to preserve it for the Long Term. It contains key information concepts relevant to OAIS-conforming implementations.

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Section 3 describes the responsibilities required of an OAIS. Subsection 3.2 defines mandatory responsibilities an OAIS Archive must discharge in preserving its information, and 3.3 provides clarifying material of the types of activities that may be needed in many Archives to discharge these responsibilities.

Section 4 provides model views needed for a detailed understanding of an OAIS Archive. It breaks down the OAIS into a number of informative abstract functional entities and it describes some abstract high-level services provided at the interfaces of these entities. It also provides normative information models using Unified Modeling Language (UML) class diagrams.

Section 5 provides some perspectives on the issues of information preservation. It also provides some perspectives on the issues of preserving access services to digital information using software porting, wrapping, and emulation of hardware.

Section 6 is an introduction to the various alternatives for Archive-to-Archive associations to provide increased or more cost-effective services.

The annexes B-F are not part of the Recommended Practice and are provided for the convenience of the reader:

- annex A provides a composite diagram of the detailed functional entities described in 4.2;
- annex B contains pointers to external documents which relates parts of this reference model to other standards work and provides a guide for development of related standards;
- annex C provides a brief tutorial on the Unified Modeling Language class diagrams (UML);
- annex D provides a list of informative references;
- annex E provides a layered model of information;
- annex F provides an overview of security considerations.

1.5.3 DIAGRAM CONVENTIONS

Except where indicated otherwise, diagrams show entities such as people or organizations as round cornered long rectangles, functions as rectangles with round corners and functional entities as rectangles with cut corners, with information between them as arrows, and special information objects as ellipses as illustrated in figure 1-1.

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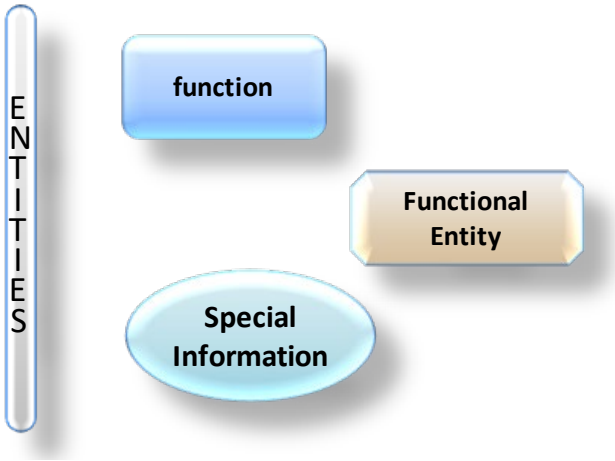

Figure 1-1: Examples of Diagram Conventions

To serve as visual clues, consistent colors have been adopted for each Functional Entity and its component Functions; however, the diagrams do not depend upon these colors to be usable.

1.5.4 TYPOGRAPHICAL CONVENTIONS

There are many terms which are used in this reference model and which need to have well-defined meanings. These terms are defined in 1.6.2. When first used in the text, they are shown in bold and are capitalized. Subsequent use employs capitalization only. Because of their extensive use in this document, the defined terms ‘data’ and ‘information’ will not always be capitalized unless they are part of another defined term. The defined term ‘archive’ will not be capitalized unless it is used as the equivalent of an ‘OAIS Archive’.

Many diagrams are included throughout this reference model, primarily in sections 4 and 6. In text discussing the diagrams, block names are capitalized and flows are italicized.

1.5.5 NOMENCLATURE

1.5.5.1 Normative Text

The following conventions apply for the normative specifications in this Recommended Practice:

a) the words ‘shall’ and ‘must’ imply a binding and verifiable specification;

b) the word ‘should’ implies an optional, but desirable, specification;

c) the word ‘may’ implies an optional specification;

d) the words ‘is’, ‘are’, and ‘will’ imply statements of fact.

NOTE – These conventions do not imply constraints on diction in non-normative text.

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1.6 DEFINITIONS

1.6.1 ACRONYMS AND ABBREVIATIONS

AIC	Archival Information Collection
AIP	Archival Information Package
AIU	Archival Information Unit
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee for Space Data Systems
CD-ROM	Compact Disk-Read Only Memory
CDO	Content Data Object
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CSV	Comma Separated Value
DBMS	Data Base Management System
DIP	Dissemination Information Package
DRM	Digital Rights Management
FITS	Flexible Image Transport System
FTP	File Transfer Protocol
HFMS	Hierarchical File Management System
HTTP	HyperText Transfer Protocol.
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISBN	International Standard Book Number
ISO	International Organization for Standardization
MPEG	Moving Picture Experts Group
OAIS	Open Archival Information System
PDF	Portable Document Format

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PDI	Preservation Description Information
QA	Quality Assurance
RFC	Request For Comment
SIP	Submission Information Package
TCP/IP	Transmission Control Protocol/Internet Protocol
UML	Unified Modeling Language
USB	Universal Serial Bus
VHS	Video Home System
WWW	World Wide Web
XFDU	XML Formatted Data Unit
XML	eXtensible Markup Language

1.6.2 TERMINOLOGY

This subsection is normative.

There are many terms which are used in this reference model and which need to have well-defined meanings. These terms are defined in this subsection. When first used in the text, they are shown in bold and are capitalized. Subsequent use employs capitalization only.

In other CCSDS documents the terms such as 'service' and 'object' have different definitions from those used here. Where confusion may arise then the terms from this document may be prefixed with 'OAIS'.

As this reference model is applicable to all disciplines and organizations that do, or expect to, preserve and provide information in digital form, these terms cannot match all of those familiar to any particular discipline (e.g., traditional archives, digital libraries, science data centers). Rather, the approach taken is to use terms that are not already overloaded with meaning so as to reduce conveying unintended meanings. Therefore, it is expected that all disciplines and organizations will find that they need to map some of their more familiar terms to those of the OAIS Reference Model. This should not be difficult and is viewed as a contribution, rather than a deterrent, to the success of the reference model. For example, archival science focuses on preservation of the 'record'. This term is not used in the OAIS Reference Model, but one mapping might approximately equate it with 'Content Information within an Archival Information Package' (see definitions below, as well as 2.3 and 4.3 for context).

Access Aid: A software program or document that allows Consumers to locate, analyze, order or retrieve information from an OAIS.

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Access Collection: A collection of AIPs that is defined by a Collection Description but for which there is no Packaging Information for the collection in Archival Storage.

Access Functional Entity: The OAIS functional entity that provides the services and functions that support Consumers in determining the existence, description, location and availability of information stored in the OAIS, and allowing Consumers to request and receive information products.

Access Rights Information: The information that identifies the access restrictions pertaining to the Content Data Object, including the legal framework, licensing terms, and access control. It contains the access and distribution conditions stated within the Submission Agreement, related to both preservation (by the OAIS) and final usage (by the Consumer). It also includes the specifications for the application of rights enforcement measures.

Access Software: A type of software that presents part of or all of the information content of an Information Object in forms understandable to or usable by humans or their proxy systems.

Ad-hoc Order: A request that is generated by a Consumer for information the OAIS has indicated is currently available.

Administration Functional Entity: The OAIS functional entity that provides the services and functions needed to control the operation of the other OAIS functional entities on a day-to-day basis.

AIP Edition: An AIP whose Content Information or Preservation Description Information has been subject to an upgrade or improvement which was not required for preservation. An AIP edition is not considered to be the result of a Migration.

AIP Version: An AIP resulting from changing the Content Information or Preservation Description Information of a source AIP, in order to preserve the information. An AIP Version is considered to be the result of a Migration.

Archival Information Collection (AIC): An Archival Information Package whose Content Information is an aggregation of other Archival Information Packages.; its PDI must include a description of the collection criteria and process.

NOTE – At a minimum all OAISes can be viewed as having at least one AIC which contains all the AIPs held by the OAIS.

Archival Information Package (AIP): An Information Package, consisting of the Content Information and the associated Preservation Description Information (PDI), which is preserved within an OAIS.

Archival Information Unit (AIU): An Archival Information Package where the Content Information does not include any other Archival Information Packages. An AIU can consist of multiple digital objects, for example, multiple files.

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Archival Storage Functional Entity: The OAIS functional entity that provides the services and functions used for the storage and retrieval of Archival Information Packages.

Archive: An organization that intends to preserve information for access and use by a Designated Community.

Associated Description: The information describing the content of an Information Package from the point of view of a particular Access Aid.

Authenticity: The degree to which a person (or system) regards an object as what it is purported to be. Authenticity is judged on the basis of evidence.

Collection Description: A type of Package Description that is specialized to provide information about an Archival Information Collection (or an Access Collection) for use by Access Aids.

Common Services: The supporting services such as inter-process communication, name services, temporary storage allocation, exception handling, security, and directory services necessary to support the OAIS.

Consumer: The role played by those persons, or client systems, who interact with OAIS services to find preserved information of interest and to access that information in whatever level of detail is allowed. In addition to the normally expected entities outside the OAIS, this can also include other OAISes, as well as internal OAIS persons or systems.

Content Data Object: The Data Object, that together with associated Representation Information, comprises the Content Information.

Content Information: A set of information that is the original target of preservation. It is an Information Object composed of its Content Data Object and its Representation Information.

Context Information: The information that documents the relationships of the Content Data Object to its environment. This includes why the Content Data Object was created and how it relates to other Content Data Objects.

Co-operating Archives: Those Archives that have Designated Communities with related interests. They may order and ingest data from each other. At a minimum, Co-operating Archives must agree to support at least one common Submission Information Package (SIP) and Dissemination Information Package (DIP) for inter-Archive requests.

Data: A reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing.

NOTE – Examples of data include a sequence of bits, a table of numbers, the characters on a page, the recording of sounds made by a person speaking, or a moon rock specimen.

Data Dictionary: A formal repository of terms used to describe data.

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Data Dissemination Session: A delivery of media or a single telecommunications session that provides Data to a Consumer. The Data Dissemination Session format/contents is based on a data transfer specification negotiated between the OAIS and the Consumer in the Order Agreement. This specification identifies the logical constructs used by the OAIS and how they are represented on each media delivery or in the telecommunication session.

Data Management Data: The data created and stored in Data Management persistent storage that refer to operation of an Archive.

NOTE – Examples of Data Management Data are accounting data for Consumer billing and authorization, policy data, Event Based Order (subscription) data for repeating requests, preservation process history data, and statistical data for generating reports to Archive management.

Data Management Functional Entity: The OAIS functional entity that provides the services and functions for populating, maintaining, and accessing both Descriptive Information which identifies and documents Archive holdings and administrative data used to manage the Archive.

Data Object: Either a Physical Object or a Digital Object.

Data Submission Session: A delivery of media or a single telecommunications session that provides Data to an OAIS. The Data Submission Session format/contents is based on a data transfer specification negotiated between the OAIS and the Producer in the Submission Agreement. This specification identifies the logical constructs used by the Producer and how they are represented on each media delivery or in the telecommunication session.

Derived AIP: An AIP generated by extracting or aggregating information from one or more source AIPs.

Descriptive Information: An Information Object which is a set of information, consisting primarily of Package Descriptions, which is provided to Data Management to support the finding, ordering, and retrieving of OAIS information holdings by Consumers.

Designated Community: An identified group of potential Consumers who should be able to understand a particular set of information in ways exemplified by the Preservation Objectives. The Designated Community may be composed of multiple user communities. A Designated Community is defined by the Archive and this definition may change over time.

Digital Migration: The transfer of digital information, while intending to preserve it, within the OAIS. It is distinguished from transfers in general by three attributes:

- a focus on the preservation of the full information content that needs preservation;
- a perspective that the new archival implementation of the information is a replacement for the old; and

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– an understanding that full control and responsibility over all aspects of the transfer resides with the OAIS.

Digital Object: An object composed of a set of bit sequences.

Dissemination Information Package (DIP): An Information Package, derived from one or more AIPs, and sent by Archives to the Consumer in response to a request to the OAIS.

Event Based Order: A request that is generated by a Consumer for information that is to be delivered periodically on the basis of some event or events.

Federated Archives: A group of Archives that has agreed to provide access to their holdings via one or more common Finding Aids.

Finding Aid: A type of Access Aid that allows a user to search for and identify Archival Information Packages of interest.

Fixity Information: The information which documents the mechanisms that ensure that the Content Data Object has not been altered in an undocumented manner.

Global Community: An extended Consumer community, in the context of Federated Archives, that accesses the holdings of several Archives via one or more common Finding Aids.

Independently Understandable: A characteristic of information that is sufficiently complete to allow it to be understood by the Designated Community, as exemplified by the associated Preservation Objectives, without having to resort to special resources not widely available, including named individuals.

Information: Any type of knowledge that can be exchanged. In an exchange, it is represented by data.

NOTE – An example of Information is a string of bits (the data) accompanied by a description of how to interpret the string of bits as numbers representing temperature observations measured in degrees Celsius (the Representation Information).

Information Object: A Data Object together with its Representation Information.

Information Package: A logical container composed of optional Information Object(s). Associated with this Information Package is Packaging Information used to delimit and identify the Information Object and optional Package Description information used to facilitate searches for the Information Object.

Information Property: A part of the information content of a Content Information object that is highlighted for a particular purpose.

Information Property Description: The description of the Information Property.

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Ingest Functional Entity: The OAIS functional entity that provides the services and functions to accept Submission Information Packages from Producers (or from internal elements under Administration control), including quality assurance and prepare Archival Information Packages for storage, and ensures that Archival Information Packages and their supporting Descriptive Information become established within the OAIS.

Knowledge Base: A set of information, incorporated by a person or their proxy system that allows that person or their proxy system to understand the received information.

Local Community: The community which would be served by the Archive outside of the context of Federated Archives.

Long Term: A period of time long enough for there to be concern about the impacts of changing technologies, including support for new media and data formats, and of a changing Designated Community or changes to the Designated Community's Knowledge Base, on the information being held in an OAIS. This period extends into the indefinite future.

Long Term Preservation: The act of maintaining information, Independently Understandable by a Designated Community, and with evidence supporting its Authenticity, over the Long Term.

Management: The role played by those who set overall OAIS policy as one component in a broader policy domain, for example as part of a larger organization.

Member Description: An Associated Description that describes a member of a collection.

Metadata: Data about other data.

Non-Reversible Transformation: A Transformation which cannot be guaranteed to be a Reversible Transformation.

Open Archival Information System (OAIS): An Archive system consisting of hardware, software, information, and policy-based processes and procedures put in place and operated by an organization and its staff. The organization has accepted the responsibility to preserve information and make it available for a Designated Community. The organization may be part of a larger organization. The system meets a set of mandatory responsibilities that allows an OAIS Archive to be distinguished from other uses of the term 'archive'. The term 'Open' in OAIS is used to imply that this Recommended Practice and future related Recommended Practices and standards are developed in open forums, and it does not imply that access to the Archive is unrestricted.

NOTE – The set of mandatory responsibilities an OAIS Archive must perform are defined in 3.2.

Order Agreement: An agreement between the Archive and the Consumer in which the physical details of the delivery, such as media type and format of Data, are specified.

Ordering Aid: A type of Access Aid that assists the Consumer to discover AIPs of interest and their cost. It may allow requests for transformation of the information.

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Other Representation Information: A type of Representation Information which cannot easily be classified as Structure Representation Information or Semantic Representation Information. It is a type of Information Object.

NOTE – For example, software, algorithms, encryption, written instructions and many other things may be needed to understand the Content Data Object in ways exemplified by the Preservation Objectives, all of which therefore would be, by definition, Representation Information, yet would not obviously be either Structure Representation Information or Semantic Representation. Information defining how the Structure Representation Information and the Semantic Representation Information relate to each other, or software needed to process a database file would also be regarded as Other Representation Information.

Overview Description: A specialization of the Collection Description that describes the collection as a whole.

Package Description: The information intended for use by Access Aids. It is a type of Information Object.

Packaging Information: The information that describes how the components of an Information Package are logically or physically bound together and how to identify and extract the components. It is a type of Information Object.

Physical Object: An object (such as a moon rock, bio-specimen, microscope slide) with physically observable properties that represent information that is considered suitable for being adequately documented for preservation, distribution, and independent usage.

Preservation Description Information (PDI): The information, which along with Representation Information, is necessary for adequate preservation of the Content Data Object and which can be categorized as Provenance Information, Context Information, Reference Information, Fixity Information, and Access Rights Information. It is a type of Information Object.

NOTE – Defining PDI (as well as its components: Provenance Information, Context Information, Reference Information, Fixity Information, and Access Rights Information) as relevant to the Content Data Object does not mean that those concerns are any less important for other data objects or at other levels, for example, it is important to apply reference, fixity, provenance, context and access rights to Representation Information, or to any other information the Archive is preserving. Definition of these terms as relevant to the Content Data Object is simply to ease discussion of these concepts at the Content Data Object level.

Preservation Objective: A specific achievable aim which can be carried out using the Information Object.

Preservation Planning Functional Entity: The OAIS functional entity which provides the services and functions for monitoring the environment of the OAIS and which provides recommendations and preservation plans to ensure that the information stored in the OAIS

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remains accessible to, understandable by, and sufficiently usable by, the Designated Community over the Long Term.

Producer: The role played by those persons or client systems that provide the information to be preserved. This can include internal or external OAIS persons or systems.

Provenance Information: The information that documents the history of the Content Data Object. This information tells the origin or source of the Content Data Object, any changes that may have taken place since it was originated, and who has had custody of it since it was originated. The Archive is responsible for creating and preserving Provenance Information from the point of Ingest; however, earlier Provenance Information should be provided by the Producer. Provenance Information adds to the evidence to support Authenticity.

Reference Information: The information that is used as an identifier for the Content Data Object. It also includes identifiers that allow outside systems to refer unambiguously to a particular Content Data Object.

NOTE – An example of Reference Information is an ISBN.

Reference Model: 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.

Refreshment: A Digital Migration where the effect is to replace a media instance with a copy that is sufficiently exact that all Archival Storage hardware and software continues to run as before.

Repackaging: A Digital Migration in which there is an alteration in the Packaging Information of the AIP.

Replication: A Digital Migration where there is no change to the Packaging Information, the Content Information, and the PDI. The bits used to represent these Information Objects are preserved in the transfer to the same or new media-type instance.

Representation Information: The information that maps a Data Object into more meaningful concepts so that the Data Object may be understood in ways exemplified by Preservation Objectives. It is a type of Information Object.

NOTE – An example of Representation Information for a bit sequence which is a FITS file might consist of the FITS standard which defines the format plus a dictionary which defines the meaning in the file of keywords which are not part of the standard. This would then allow the information in the FITS file to be used by a computer program to display the image which may be contained in the FITS file, together with the associated coordinate system so that a human can identify objects of interest, for example stars or galaxies. Alternatively, the computer program may identify such objects automatically.

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Representation Information Network: The set of Representation Information that fully describes the meaning of a Data Object. Representation Information in digital forms needs additional Representation Information so its digital forms can be understood over the Long Term. It is a type of Information Object.

Representation Information Rendering Software: A type of software that displays a Representation Information object in forms understandable to humans.

Retrieval Aid: An application that allows authorized users to retrieve the Content Information and PDI described by the Package Description.

Reversible Transformation: A Transformation in which the new representation defines a set (or a subset) of resulting entities that are equivalent to the resulting entities defined by the original representation. This means that there is a one-to-one mapping back to the original representation and its set of base entities.

Search Session: A session initiated by the Consumer with the Archive during which the Consumer will use the Archive Finding Aids to identify and investigate potential holdings of interest.

Semantic Representation Information: The Representation Information that further describes the meaning of the Data Object, and its parts or elements, beyond that provided by the Structure Representation Information.

NOTE – For example, Semantic Representation Information may describe the meaning of columns, and perhaps particular values seen in the columns of a spreadsheet.

Structure Representation Information: The Representation Information that imparts information about the arrangement of and the organization of the parts or elements of the Data Object.

NOTE – For example, Structure Representation Information maps bit streams to common computer types such as characters, numbers, and pixels and aggregations of those types such as character strings and arrays.

Submission Agreement: The agreement reached between an OAIS and the Producer that specifies the intended formats and content descriptions, and any other arrangements needed (such as delivery or transmission protocols), for the Data Submission Sessions. Such specifications establish the intended deliverables from the Producer and how they are represented on each delivery through physical media or in a telecommunication dialogue.

Submission Information Package (SIP): An Information Package that is delivered by the Producer to the OAIS for use in the construction or update of one or more AIPs and/or the associated Descriptive Information.

Succession Plan: The plan of how and when the management, ownership and/or control of the OAIS holdings will be transferred to a subsequent OAIS in order to ensure the continued effective preservation of those holdings.

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Transformation: A Digital Migration in which there is an alteration to the Content Information or PDI of an Archival Information Package.

NOTE – An example of a Transformation is changing ASCII codes to Unicode in a text document being preserved.

Transformational Information Property: An Information Property the preservation of the value of which is regarded as being necessary but not sufficient to verify that any Non-Reversible Transformation has adequately preserved information content. This could be important as contributing to evidence about Authenticity. Such an Information Property is dependent upon specific Representation Information, including Semantic Representation Information, to denote how it is encoded and what it means.

NOTE – The term 'significant property', which has various definitions in the literature, is sometimes used in a way that is consistent with it being a Transformational Information Property.

Unit Description: A type of Package Description that is specialized to provide information about an Archival Information Unit for use by Access Aids.

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2 OAIS CONCEPTS

2.1 GENERAL

The purpose of this section is to motivate and describe several key high-level OAIS concepts. A more complete view, and a formal modeling of these concepts, is given in section 4.

The term 'archive' has come to be used to refer to a wide variety of storage and preservation functions and systems. Traditional archives are understood as facilities or organizations which preserve records, originally generated by or for a government organization, institution, or corporation, for access by public or private communities. The Archive accomplishes this task by taking custody of the records, ensuring that they are understandable to the accessing community, and managing them so as to preserve their information content and evidence of their Authenticity. Historically, these records have been in such forms as books, papers, maps, photographs, and film, which can be read directly by humans, or read with the aid of simple optical magnification and scanning aids. The major focus for preserving this information has been to ensure that they are on media with Long Term stability and that access to this media is carefully controlled.

The explosive growth of information in digital forms has posed a severe challenge not only for traditional archives and their information providers, but also for many other organizations in the government, commercial and non-profit sectors. These organizations are finding, or will find, that they need to take on the information preservation functions typically associated with traditional archives because digital information is easily lost or corrupted. The pace of technology evolution is causing some hardware and software systems to become obsolete in a matter of a few years, and these changes can put severe pressure on the ability of the related data structures or formats to continue effective representation of the full information desired. Because much of the supporting information necessary to preserve this information is more easily available or only available at the time when the original information is produced, these organizations need to be active participants in the Long Term Preservation effort, and they need to follow the principles espoused in this OAIS Reference Model to ensure that the information can be preserved for the Long Term. Participation in these efforts will minimize the lifecycle costs and enable effective Long Term Preservation of the information.

The explosion of computer processing power and digital media has resulted in many systems where the Producer role and the Archive role are the responsibility of the same entity. These systems should subscribe to the goals of Long Term Preservation discussed in this document. The designers and architects of such systems should realize that some of the Long Term Preservation activities may conflict with the goal of rapid production and dissemination of products to Consumers. The designers and architects of such systems should document the solutions that have been reached.

A major purpose of this Reference Model is to facilitate a much wider understanding of what is required to preserve and access information for the Long Term. To avoid confusion with simple 'bit storage' functions, the Reference Model defines an Open Archival Information System (OAIS) which performs a Long Term information preservation and access function. An

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OAIS Archive is one that intends to preserve information for access and use by a **Designated Community**, and it meets the requirements given in section 3. It includes Archives that have to keep up with steady input streams of information as well as those that experience primarily aperiodic inputs. It includes Archives that provide a wide variety of sophisticated access services as well as those that support only the simplest types of requests. For the remainder of this document, the term Archive and OAIS are equivalent and understood to refer to an OAIS Archive, unless the context makes it clear otherwise (e.g., traditional archives).

The OAIS model recognizes the already highly distributed nature of digital information holdings and the need for local implementations of effective policies and procedures supporting information preservation. This allows, in principle, a wide variety of organizational arrangements, including various roles for traditional archives, in achieving this preservation. It is expected that organizations attempting to preserve information will find that using OAIS terms and concepts will assist them in achieving their information preservation goals.

2.2 OAIS ENVIRONMENT

The simple model shown in figure 2-1 depicts the environment surrounding an OAIS.

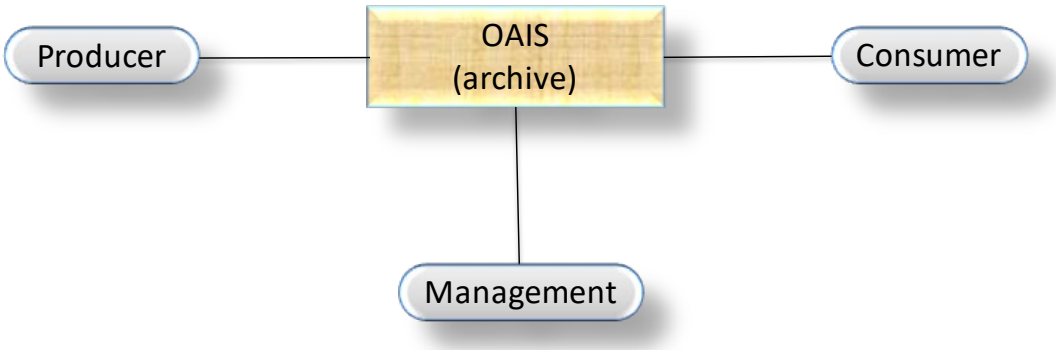

Figure 2-1: Environment Model of an OAIS

Outside the OAIS are **Producers**, **Consumers**, and **Management**.

- Producer is the role played by those persons, or client systems, which provide the information to be preserved.
- Management is the role played by those who set overall OAIS policy as one component in a broader policy domain, for example as part of a larger organization. In other words, Management control of the OAIS is only one of Management's responsibilities. Management is not involved in day-to-day Archive operations. The responsibility of managing the OAIS on a day-to-day basis is included within the OAIS in an Administrative Functional Entity that will be described in 4.2.
- Consumer is the role played by those persons, or client systems, that interact with OAIS services to find and acquire preserved information of interest. A special class of

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Consumers is the Designated Community. The Designated Community is the set of Consumers who should be able to understand the preserved information. A given individual or system may act in the role of both a Consumer and a Producer.

Other OAIS Archives are not shown explicitly. Such Archives may establish agreements among themselves consistent with Management and OAIS needs. Other Archives may interact with a particular Archive for a variety of reasons and with varying degrees of formalism for any prearranged agreements. One OAIS may take the role of Producer to another OAIS; an example is when the responsibility for preserving a type of information is to be moved to this other Archive. One OAIS may take the role of Consumer to another OAIS; an example is when the first OAIS decides to rely on the other OAIS for a type of information it seldom needs and chooses not to preserve locally. Such reliance should have some formal basis that includes the requirement for communication between the Archives of any policy changes that might affect this reliance. The range of possible interactions between OAIS Archives is discussed in section 6, Archive Interoperability.

2.3 OAIS INFORMATION

2.3.1 OVERVIEW

Only this subsection of this introductory section is normative.

2.3.2 INFORMATION DEFINITION

A clear definition of information is central to the ability of an OAIS to preserve it. While formal modeling of information is provided in section 4, some key concepts are provided in this subsection.

A person, or system, can be said to have a Knowledge Base, which allows that person or system to understand received information. For example, a person who has a Knowledge Base that includes an understanding of written English will be able to read, and understand, an English text.

Information is defined as any type of knowledge that can be exchanged, and this information is always expressed (i.e., represented) by some type of data in an exchange. For example, the information in a hardcopy book is typically expressed by the observable characters (the data) which, when they are combined with a knowledge of the language used (the Knowledge Base), are converted to more meaningful information. If the recipient does not already include English in its Knowledge Base, then the English text (the data) needs to be accompanied by English dictionary and grammar information (i.e., **Representation Information**) in a form that is understandable using the recipient's Knowledge Base.

An OAIS is responsible for defining the Designated Community, and its associated Knowledge Base, for whom the information is being preserved by the Archive. The definition of the Designated Community and its associated Knowledge Base may be subject to agreement with funders and other stakeholders. They will likely provide input into those

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definitions and may have agreements with the OAIS regarding those definitions. The Knowledge Base of the Designated Community will probably change over time and the definition of the Designated Community itself may change over time.

Similarly, the information stored within a digital file is expressed by the bits (the data) it contains which, when they are combined with the Representation Information for those bits, are converted to more meaningful information as long as the Representation Information is understandable using the recipient's Knowledge Base. For example, assume the bits represent an ASCII table of numbers giving the coordinates of a location on the Earth measured in degrees latitude and longitude. The Representation Information will typically include the definition of ASCII together with descriptions of the format of the numbers and their locations in the file, their definitions as latitude and longitude, and the definition of their units as degrees. It may also include additional meaning that is assigned to the table. Another example of Representation Information for a bit sequence which is a FITS file might consist of the FITS standard which defines the format plus a dictionary which defines the meaning of keywords in the file which are not part of the standard. In general, it can be said that 'Data interpreted using its Representation Information yields Information', and this is shown schematically in figure 2-2.

Figure 2-2: Obtaining Information from Data

In order for this **Information Object** to be successfully preserved, it is critical for an OAIS to identify clearly and to understand clearly the **Data Object** and its associated Representation Information. For digital information, this means the OAIS must clearly identify the bits and the Representation Information that applies to those bits. This required transparency to the bit level is a distinguishing feature of digital information preservation, and it runs counter to object-oriented concepts which try to hide these implementation issues. This presents a significant challenge to the preservation of digital information.

As a further complication, the recursive nature of Representation Information, which typically is composed of its own data and its own Representation Information, typically leads to a network of Representation Information objects. Since a key purpose of an OAIS is to preserve information for a Designated Community, the OAIS must understand the Knowledge Base of its Designated Community to understand the minimum Representation Information that must be maintained. The OAIS should then decide between maintaining the minimum Representation Information needed for its Designated Community and maintaining a larger amount of Representation Information that may allow understanding by a larger Consumer community with a less specialized Knowledge Base, which would be the equivalent of extending the definition of the Designated Community. Over time, evolution of the Designated Community's Knowledge Base may require updates to the Representation Information to ensure continued understanding.

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An OAIS needs to ensure that it has Long Term access to all the relevant Representation Information. A choice must be made whether the OAIS collects all the relevant Representation Information itself or references the existence of the Representation Information in another trusted or partner OAIS Archive. That choice is an implementation and organization decision.

As a practical matter, software, some of which may itself be Representation Information, is used to access the Information Object, and it will incorporate some understanding of the network of Representation Information objects involved. However, this software should not be used as rationale for avoiding identifying and gathering readily understandable Representation Information that defines the Information Object, because it is harder to preserve working software than to preserve information in digital or hardcopy forms.

The OAIS Reference Model emphasizes the preservation of information content. As digital technology develops, multimedia technology and the dependency on complex interplay between the data and presentation technologies will lead some organizations to require that the look and feel of the original presentation of the information be preserved. This type of preservation requirement may necessitate that the software programs and interfaces used to access the data be preserved. This problem may be further complicated by the proprietary nature of some of the software. Various techniques for preserving the look and feel of information access are the subject of research and prototyping. These techniques, which include hardware level emulation, emulation of various common service APIs, and the development of virtual machines, are being investigated for the preservation of the original bit stream and software across technology. Though the OAIS reference model does not focus on these techniques, it should provide an architectural basis for the prototyping and comparison of these techniques. A more detailed discussion of the issues involved in the preservation of look and feel of information access can be found in 5.3 of this document.

2.3.3 INFORMATION PACKAGE DEFINITION

The definition of an Information Object is applicable to all the information types discussed in this and the following subsections. In other words, they all have associated Representation Information, although this is usually not shown explicitly.

Every submission of information to an OAIS by a Producer, and every dissemination of information to a Consumer, occurs as one or more discrete transmissions. Therefore, it is convenient to define the concept of an **Information Package**.

An Information Package is a logical container composed of optional **Information Object(s).** Associated with this Information Package is Packaging Information that describes how the components of an Information Package are logically or physically bound together and how to identify and extract the components.

These Information Package relationships are shown schematically in figure 2-3.

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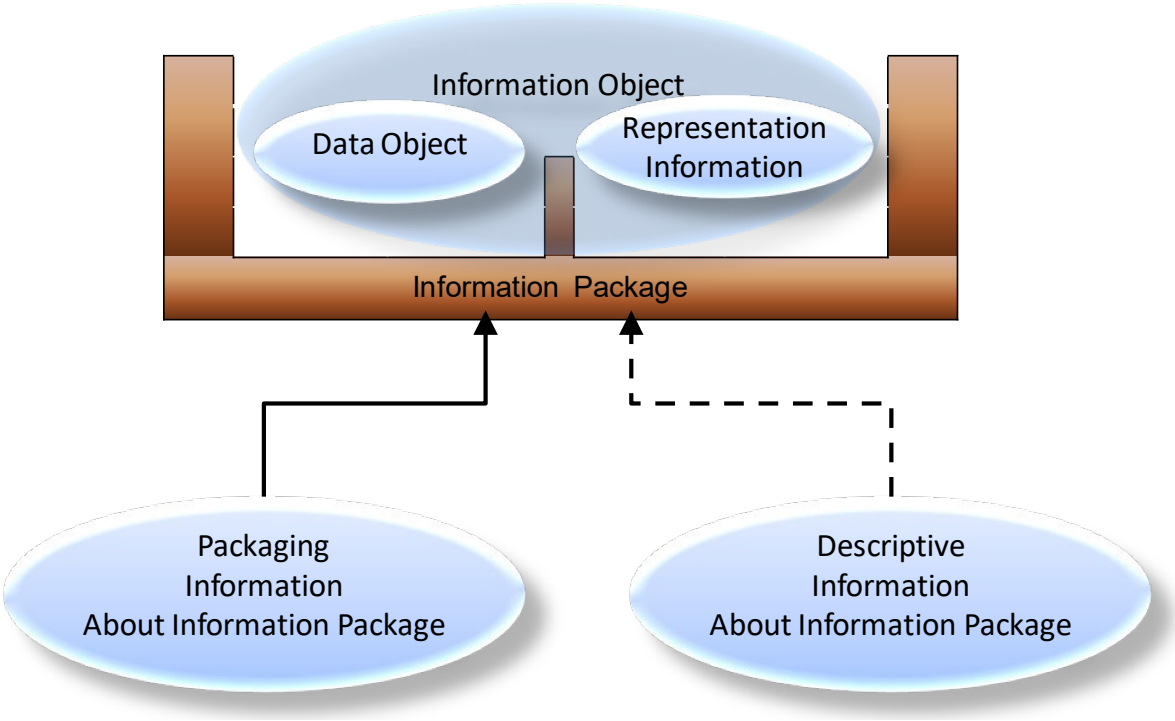

Figure 2-3: Information Package Concepts and Relationships

The Information Object is a Data Object plus associated Representation Information which is needed to make the Data Object understandable. For example, the Data Object may be an image that is provided as the bit content of one file. Other files would contain Representation Information.

The Packaging Information is that information which describes how the components of an Information Package are logically or physically bound together and how to identify and extract the components.

The Information Object in the package may have various components. Of particular significance is the case in which the Information Object is made up of **Content Information**, which is the original target of preservation, plus its related **Preservation Description Information** (PDI). Only after the Content Data Object has been clearly defined can an assessment of the Preservation Description Information be made. The Preservation Description Information applies to the Content Data Object and is needed to preserve the Content Data Object, to ensure it is clearly identified, and to understand the environment in which the Content Data Object was created. The Preservation Description Information is divided into five types of preserving information called Provenance Information, Context Information, Reference Information, Fixity Information and **Access Rights Information**. Briefly, they are the following:

- Provenance Information describes the source of the Content Data Object, who has had custody of it since its origination, and its history (including processing history).
- Context Information describes how the Content Data Object relates to other information outside the Information Package. For example, it would describe why the

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Content Information was produced, and it may include a description of how it relates to another Content Information object that is available.

– Reference Information provides one or more identifiers, or systems of identifiers, by which the Content Data Object may be uniquely identified. Examples include an ISBN for a book, or a set of attributes that distinguish one instance of Content Data Object from another.

– Fixity Information documents the mechanisms that ensure that the Content Data Object has not been subject to undocumented alteration. Examples include Cyclic Redundancy Check (CRC) codes, checksums, or message digests. The mechanisms are not excluded from being used for other objects but the mechanisms used for Content Data Objects are of particular interest.

– Access Rights Information provide the terms of access, including preservation, distribution, and usage of the Content Data Object. For example, it would contain the statements to grant the OAIS permissions for preservation operations, licensing offers (for distribution), specifications for rights enforcement measures, as well as access control specifications.

For example, if the Information Object consists of Content Information and PDI which are identified as being the content of specific files, then the Packaging Information would include the information about the file system(s) used, as well as the names and directory information (paths) of the files containing the Content Information and the PDI. Another example of packaging is an XFDU (reference [D8]) where the Packaging Information would be the elements and their tags of the individual components of the XFDU instance following the definition of the XFDU packaging method.

The Descriptive Information is that information which is used to discover which package has the Data Object of interest. Depending on the setting, this may be no more than a descriptive title of the Information Package that appears in some message, or it may be a full set of attributes that are searchable in a catalog service.

2.3.4 INFORMATION PACKAGE VARIANTS

It is necessary to distinguish between an Information Package that is preserved by an OAIS and the Information Packages that are submitted to, or disseminated from, an OAIS. These variant packages are needed to reflect the reality that some submissions to an OAIS will have insufficient Representation Information or PDI to meet OAIS preservation requirements. In addition, these may be organized very differently from the way the OAIS organizes the information it is preserving. Finally, the OAIS may provide to Consumers information that does not include all the Representation Information or all the PDI with the associated Data Object being disseminated. These variants are referred to as the **Submission Information Package** (SIP), the **Archival Information Package** (AIP), and the **Dissemination Information Package** (DIP).

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The Submission Information Package (SIP) is that package that is sent to an OAIS by a Producer. Its form and detailed content are typically negotiated between the Producer and the OAIS. Most SIPs will have some Content Information and some PDI.

The relationships between SIPs and AIPs can be complex; as well as a simple one-to-one relationship in which one SIP produces one AIP, other possibilities include: one AIP being produced from multiple SIPs produced at different times by one Producer or by many Producers; one SIP resulting in a number of AIPs; and many SIPs from one or more sources being unbundled and recombined in different ways to produce many AIPs. Even in the first case, the OAIS may have to perform a number of transformations on the SIP. The Packaging Information will always be present in some form.

Within the OAIS one or more SIPs are transformed into one or more Archival Information Packages (AIPs) for preservation. The AIP, which the Archive must use to preserve its Content Information, must have a set of Representation Information, adequate for the Designated Community, and PDI for the associated Content Data Object. The AIP may also contain a collection of other AIPs, and this is discussed and modeled in section 4. The Packaging Information of the AIP will conform to OAIS internal standards, and it may vary as it is managed by the OAIS.

In response to a request, the OAIS provides one or more Dissemination Information Packages (DIPs) to a Consumer. The DIP(s) are derived from one or more AIPs. For dissemination purposes, the DIP's Packaging Information will need to be created such that the Consumer can clearly identify and extract the information that was requested.

2.4 PRESERVATION OBJECTIVES

Long Term Preservation is defined as the act of maintaining information, Independently Understandable by a Designated Community, and with evidence supporting its Authenticity, over the Long Term.

To be **Independently Understandable** the information must be sufficiently complete to allow it to be understood by the Designated Community, as exemplified by the associated Preservation Objectives, without having to resort to special resources not widely available, including named individuals.

Preservation Objectives are intended to allow the repository to make it possible to test whether the information actually is Independently Understandable by members of the Designated Community now and into the future, in particular having adequate Representation Information. In order to facilitate this each Preservation Objective should be:

– Specific—The objective should be well defined and clear to anyone with the assumed Knowledge Base.

– Actionable—The objective should be achievable currently and into the future.

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– Measurable—It should be possible to know whether or not the objective has been attained at a given point in time.

Examples of Preservation Objectives include:

– The ability to render documents, images, videos or sounds in a way which is sufficiently similar to the original. This could be checked by verifying that, for example, the document is readable or the image is viewable. An analysis of the colors could also be compared. A spectral analysis could be performed on the sounds and compared with that of the original.

– The ability to process a dataset and generate the data products expected. This could be checked by comparing with something generated earlier, for example on Ingest.

– The ability to understand a dataset and use it in analysis tools to generate results, for example the density of electrons in the upper atmosphere or the structure of a molecule, given certain measurements. These could be compared with results generated earlier.

– The ability to re-perform an artistic performance. This could be compared with a recording of a previous performance.

Checks on the success of the preservation activity should include confirmation that these aims have been fulfilled. Clearly information needed to make comparisons, as in the examples above, would be expected to be created earlier, perhaps on Ingest, and would need to accompany the information being preserved.

An OAIS must define Preservation Objectives. The definition of the Preservation Objectives may be subject to agreement with funders and other stakeholders. They will likely provide input into those definitions and may have agreements with the OAIS regarding those definitions. The definition of the Designated Community and its Knowledge Base will probably change over time and therefore the definition of the Preservation Objectives may change over time. In this case, funders and other stakeholders would again be consulted.

2.5 SUPPLEMENTARY INFORMATION HELD BY THE ARCHIVE

The archive will need to preserve many pieces of information besides the AIPs. The following lists show items mentioned in this document, but the archive may preserve other items.

As long as the objects are being preserved by the archive the following should also be preserved:

- Definition of the Designated Communities;
- Preservation Objectives;
- Transformational Information Properties (checks of the values of these may be part of Provenance Information).

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For as long as any specific AIP structure is in use:

- Packaging Information for the AIPs;
- Relationship between Editions and Versions of AIPs.

Other information may be useful while the various services are in use:

- Finding, Ordering, and Retrieval Aids;
- Packaging Information for SIPs, DIPs.

2.6 OAIS HIGH-LEVEL EXTERNAL INTERACTIONS

2.6.1 OVERVIEW

The following subsections present a high-level view of the interaction between the entities identified in the OAIS environment. Figure 2-4 is a data flow diagram that represents the operational OAIS Archive external data flows. This diagram concentrates on the flow of information among Producers, Consumers and the OAIS and does not include flows that involve Management. These flows are dealt with further in section 4.

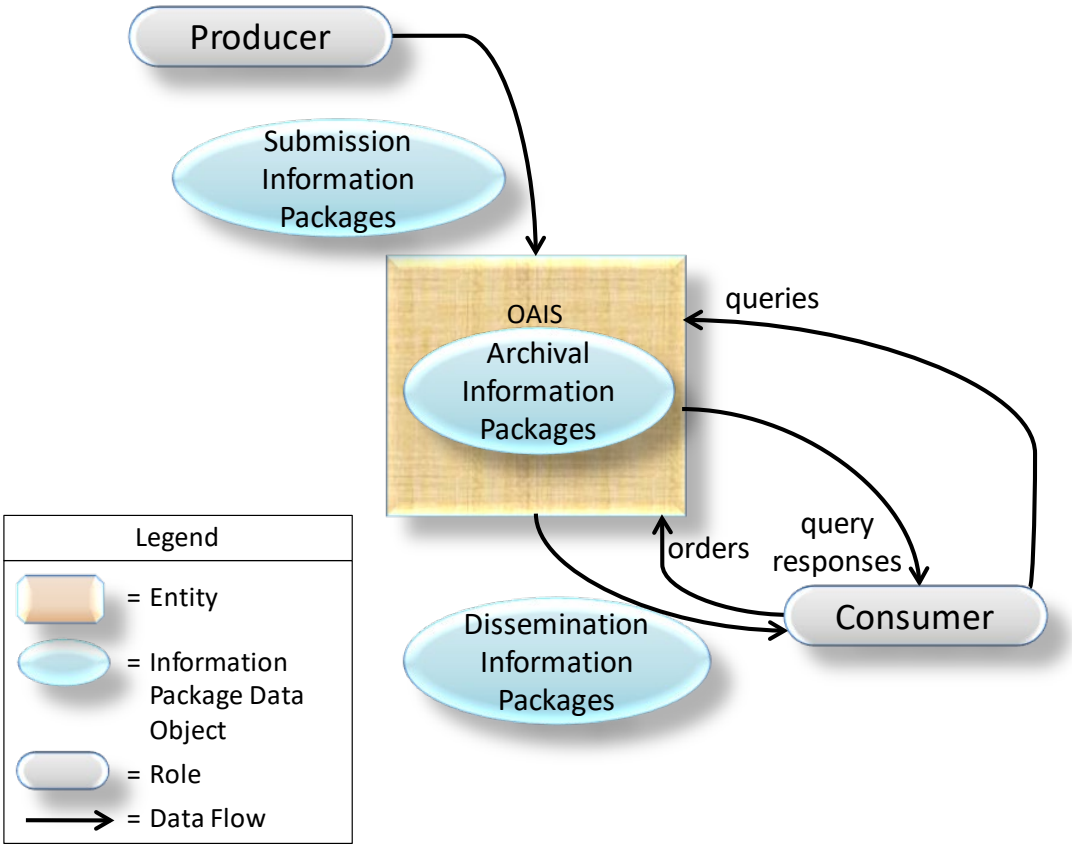

Figure 2-4: OAIS Archive External Data

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2.6.2 MANAGEMENT INTERACTION

Management provides the OAIS with its charter and scope. The charter may be developed by the Archive, but it is important that Management formally endorse Archive activities. The scope determines the breadth of both the Producer and Consumer groups served by the Archive.

Some examples of typical interactions between the OAIS and Management include:

- Management is often the primary source of funding for an OAIS and therefore should agree the budget for the Archive's activities and may provide guidelines for resource utilization (personnel, equipment, facilities).
- Management will generally conduct some regular review process to evaluate the OAIS performance and progress toward Long Term goals, and assess the risks to which the OAIS and its holdings are exposed.
- Management determines, or at least endorses, pricing policies, as applicable, for OAIS services.
- Management participates in conflict resolution involving Producers, Consumers and OAIS internal administration.

Effective Management should also provide support for the OAIS by establishing procedures that assure OAIS utilization within its sphere of influence. For example, management policies could require that all funded activities within its sphere of influence submit data products to the Archive and also adhere to Archive standards and procedures.

2.6.3 PRODUCER INTERACTION

The first contact between the OAIS and the Producer is a request that the OAIS preserve the data products created by the Producer. This contact may be initiated by the OAIS, the Producer or Management. The Producer establishes a **Submission Agreement** with the OAIS, which among other things identifies the SIPs to be submitted and the schedule of **Data Submission Session**s. Some Submission Agreements will reflect a mandatory requirement to provide information to the OAIS, while others will reflect a voluntary offering of information and others may reflect any payments which may be involved. Even in the case such as web harvesting where a component of the OAIS itself acts as the Producer, the OAIS should have policies specifying the file formats and the general subject matter the OAIS will accept and those policies will in effect be the Submission Agreement for this data.

The Submission Agreement should make it clear whether the Content Information contains links to other information. If there are such links then the Submission Agreement should make it clear whether that referenced information is included in the SIP. For example, a document submitted may contain hyperlinks to web pages or documents, and a decision should be taken as to how these are to be treated by the Archive.

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The Submission Agreement will normally include a detailed description of the Submission Information Package(s) (SIP). The description formally defines the digital information objects to be transferred by an information Producer to an Archive and how these objects are packed in the form of Submission Information Packages (SIPs). This supports effective transfer and validation of SIP data. This formal definition is a negotiated agreement between the data Producer and the Archive that facilitates production of agreed data by the Producer and validation of received data by the Archive. It does not address the actual transfer of a SIP nor how the Archive does validation upon the received SIP. The extent of such validation will depend on the level of validation required by the Submission Agreement.

Within the Submission Agreement, one or more Data Submission Sessions are specified. There may be significant time gaps between the Data Submission Sessions. A Data Submission Session will contain one or more SIPs delivered as a set of media or via a single telecommunications session. The Data Submission Session content is based on a data model negotiated between the OAIS and the Producer in the Submission Agreement. This data model identifies the logical components of the SIP (e.g., the Content Data Objects, Representation Information, PDI, Packaging Information, and Descriptive Information) that are to be provided and how (and whether) they are represented in each Data Submission Session. All data deliveries within a Submission Agreement are recognized as belonging to that Submission Agreement and will generally have a consistent data model, which is specified in the Submission Agreement. The Producer should provide as much Preservation Description Information as possible and also as much Representation Information as possible to support, where applicable, the Preservation Objectives. Other information to support testing the achievement of Preservation Objectives, and Transformational Information Properties, should also be provided if available.

For example, a Data Submission Session may consist of a set of Content Information corresponding to a set of observations, which are carried by a set of files on a transfer medium. The Preservation Description Information is in this example split between two other files. All of these files need Representation Information which must be provided in some way. The transfer media and its directory/file structure and an understanding of the directory/file structure are the Packaging Information, which provides encapsulation and identification of the Content Information and PDI in the Data Submission Session. The Submission Agreement indicates how the Representation Information for each file is to be provided, how the transfer media is to be recognized, how the Packaging Information will be used to identify and encapsulate the SIP Content Information and PDI, and how frequently Data Submission Sessions (e.g., one per month for two years) will occur. It also gives other needed information such as access restrictions to the data and enforcement requirements.

Each SIP in a Data Submission Session is expected to meet minimum OAIS requirements for completeness as specified in the Submission Agreement. However, in some cases multiple SIPs may need to be received before an acceptable AIP can be formed and fully ingested within the OAIS. In other cases, a single SIP may contain data to be included in many AIPs. A Submission Agreement also includes, or references, the procedures and protocols by which an OAIS will either verify the arrival and completeness of a Data Submission Session with the Producer or question the Producer on the contents of the Data Submission Session.

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2.6.4 CONSUMER INTERACTION

There are many types of interactions between the Consumer and the OAIS. These interactions include questions to a help desk, requests for literature, catalog searches, orders and order status requests. The ordering process is of special interest to the OAIS Reference Model, since it deals with the flow of Archive holdings between the OAIS and the Consumer.

The Consumer establishes an **Order Agreement** with the OAIS for information. This information may currently exist in the Archive or be expected to be ingested in the future. The Order Agreement may span any length of time, and under it one or more **Data Dissemination Sessions** may take place. A Data Dissemination Session may involve the transfer of a set of media or a single telecommunications session. The Order Agreement identifies one or more AIPs of interest, how those AIPs are to be transformed and mapped into Dissemination Information Packages (DIPs) and how those DIPs will be packaged in a Data Dissemination Session. The Order Agreement will also specify other needed information such as delivery information (e.g., name or mailing address), rights information (e.g., usage restrictions, authorized Consumers, or license fees) and any pricing agreements as applicable. The Consumers must also be informed of restrictions, if any, arising from the Access Rights Information associated with the Information and must agree to abide by those restrictions. Such restrictions could include, for example, limitations on commercial use by the Consumer or attributions which must accompany results derived from the Information.

Unless the Order Agreement is very straightforward, the Order Agreement will likely detail a dissemination information schema. The dissemination information schema formally defines the digital information objects to be transferred by an Archive to a Consumer and how these objects are packed in the form of Dissemination Information Packages (DIPs). This supports effective transfer and validation of DIP data. This formal definition is a negotiated agreement between the data Consumer and the Archive that facilitates production of agreed data by the Archive. It does not address the actual transfer of a DIP.

There are two common order types initiated by Consumers: The **Event Based Order** and the **Ad-hoc Order**.

In the case of an Ad-hoc Order, the Consumer establishes an Order Agreement with the OAIS for information available from the Archive. If the Consumer does not know *a priori* what specific holdings of the OAIS are of interest, the Consumer will establish a **Search Session** with the OAIS. During this Search Session, the Consumer will use the OAIS **Finding Aids** that operate on **Descriptive Information,** or in some cases on the AIPs themselves, to identify and investigate potential holdings of interest. This may be accomplished by the submission of queries and the return of query responses, for example, result sets, to the Consumer. This searching process tends to be iterative, with a Consumer first identifying broad criteria and then refining these criteria based on previous search results. Once the Consumer identifies the OAIS AIPs containing information of interest, the Consumer may enter into an Order Agreement with the OAIS that documents the identifiers of the AIPs the Consumer wishes to acquire, what information from the AIPs the Consumer wishes to acquire and how the DIPs will be transmitted to the Consumer in one or more Data

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Dissemination Sessions. If the AIPs are available, an Ad-hoc Order will be placed. However, if the AIPs desired are not yet available, an Event Based Order may be placed.

In the case of an Event Based Order, the Consumer establishes an Order Agreement with the OAIS for information expected to be received on the basis of some triggering event. This event may be periodic, such as a monthly distribution of any AIPs ingested by the OAIS from a specific Producer, or it may be a unique event such as the ingestion, or creation, of a specific AIP. The Order Agreement will also specify other needed information such as the trigger event for new Data Dissemination Sessions and the criteria for selecting the OAIS holdings to be included in each new Data Dissemination Session.

In some cases, a possibly informal, unwritten, Order Agreement will be used and a separate formal, written, Order Agreement may not be generated. In such cases an OAIS will for example have a general pricing policy which could include free products. An OAIS may in some cases only deliver copies of just the Content Data Object or of full AIPs or it may allow for easy selection of the portion of the content needed through on-line forms. An OAIS may deliver its products through direct downloads of content or it may maintain a database of consumer delivery options. The process of generating a virtual Order Agreement could be as simple as the user filling out an online order form, clicking to accept the terms and conditions and clicking the submit button.

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3 OAIS RESPONSIBILITIES

3.1 OVERVIEW

Subsection 3.2 is normative and identifies the minimum responsibilities that shall be discharged by an OAIS. Subsection 3.3 gives some examples of mechanisms to discharge these responsibilities, although not all of these will be applicable to all OAISes. The rest of this section is non-normative.

Annex F discusses security considerations which may apply to 3.2.

3.2 MANDATORY RESPONSIBILITIES

This subsection is normative and establishes mandatory responsibilities that an organization must discharge in order to operate an OAIS Archive.

The OAIS shall:

- 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 entities should become the Designated Community, that is, the communities that should be able to understand the information provided. Definition of the Designated Community includes a determination of their Knowledge Base.
- Ensure that the information to be preserved is Independently Understandable to the Designated Community. In particular, the Designated Community should be able to understand the information without needing special resources such as 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, including the demise of the Archive, ensuring that it is never deleted unless allowed as part of an approved strategy. There should be no ad-hoc deletions.
- Make the preserved information available to the Designated Community and enable the information to be disseminated as copies of, or as traceable to, the original submitted Content Information with evidence supporting its Authenticity.

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3.3 EXAMPLE MECHANISMS FOR DISCHARGING RESPONSIBILITIES

3.3.1 OVERVIEW

This subsection provides example mechanisms for discharging the responsibilities of 3.2. Not all of these mechanisms will be applicable to all OAISes.

3.3.2 NEGOTIATES FOR AND ACCEPTS INFORMATION

An organization operating an OAIS should have established some criteria that aid in determining the types of information that it is willing to, or it is required to, accept. These criteria may include, among others, subject matter, information source, degree of uniqueness or originality, and the nature of the techniques used to represent the information (e.g., physical media, digital media, and format). The information may, in general, be submitted using a wide variety of common and not-so-common forms, such as books, documents, maps, data sets, and physical objects using a variety of communication paths including networks, mail, and special delivery.

The OAIS should negotiate with the Producer to ensure it acquires appropriate Content Information and associated PDI for its mission and the Designated Community. Considerable iteration may be required to agree on the right information to be submitted, and to get it into forms acceptable to the OAIS. For example, this may include digitizing audio or video material, or scanning text.

Negotiation can embrace a range of possible actions. It may sometimes be unnecessary to generate a totally new Submission Agreement because the Producer and OAIS can rely on a previously negotiated Submission Agreement template and simply apply it to the actual content of this submission. It may be carried out for each SIP, for each Producer, or for a class of Producers. It may involve extensive human contact or machine-machine negotiations, such as that which takes place between a web crawler and a web server when deciding what, if any, content the server will permit the crawler to have (the web server acting as a Producer, the web crawler as part of an OAIS).

The OAIS should extract, or otherwise obtain, sufficient Descriptive Information to assist the Designated Community in finding the Content Information of interest. It also should ensure that the information meets all OAIS internal standards.

3.3.3 OBTAINS SUFFICIENT CONTROL FOR LONG TERM PRESERVATION

It is important for the OAIS to recognize differences exist between ownership, custody or possession of Content Information and ownership of intellectual property rights over this information. If the OAIS has created the information and is the legal owner of the Content Information, the OAIS may already possess the rights to do what is required to preserve the information and make it available. If instead the OAIS is acquiring the Content Information or PDI from any other Producer or entity, the OAIS should ensure that there is a legally valid

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transfer agreement that either transfers ownership or the intellectual property rights of the item to the OAIS, or clearly specifies the rights granted to the OAIS or others and describes any limitations imposed by the rights holder(s). If only limited rights are transferred, the OAIS will need to determine if the limited rights are sufficient for Long Term Preservation. The OAIS should ensure that its subsequent actions to preserve the information and make it available conform to these rights and limitations. When the OAIS does not acquire the intellectual property rights, the agreement should specify what involvement the rights holder(s) will have in preservation, management or release of the information. In most cases, it will be preferable for the OAIS to negotiate an agreement that specifies the rights holder(s) requirements and authorizes the OAIS to act in accordance with those requirements without active involvement of the rights holder(s) in individual cases.

The OAIS must assume sufficient control over the Content Information and Preservation Description Information so that it is able to preserve it for the Long Term. There is no issue with the AIP's Packaging Information because, by definition, this is under internal OAIS control. The problems of assuming sufficient control of the Content Information and Preservation Description Information, when they are largely digital, are addressed in three related categories, as follows:

- copyright implications, intellectual property and other legal restrictions on use;
- authority to modify Content Information;
- agreements with external organizations.

Copyright implications, intellectual property and other legal restrictions on use: An Archive must honor all applicable legal restrictions. Issues often arise when an OAIS acquires materials that are subject to legal restrictions or materials for which the intellectual property rights are held by a third party. An OAIS should understand the intellectual property rights concepts, such as copyrights, patents and any other applicable laws (e.g., data protection) prior to accepting restricted materials into the OAIS. It can establish guidelines for ingestion of information and rules for dissemination and duplication of the information when necessary. It is beyond the scope of this document to provide details of national and international copyright laws related to such restrictions.

Authority to modify Content Information: Although the Fixity Information within the Preservation Description Information of an AIP ensures that the Content Data Objects-related bits have not been altered, there will come a time when Content Data Objects bits are not in a form that is convenient for the Consumers from the Designated Community. The OAIS needs the authority to migrate the Content Data Objects to new representation forms. When an OAIS acquires materials that are subject to legal restrictions or materials for which the intellectual property rights are held by a third party, it may need to seek additional permission to make such changes. If the information is copyrighted, the OAIS should already have negotiated permission to make the changes needed to meet its mission. Ideally, when this situation arises, both the original AIPs and new AIPs will be retained. Digital Migration issues are addressed more fully in 5.2.

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Agreements with external organizations: An OAIS may establish a variety of agreements with other organizations to assist in carrying out its mission. For example, it may establish an agreement with another OAIS so that it does not have to preserve all the common Representation Information objects related to its Content Data Objects. Agreements with other organizations should be monitored to be sure they are being followed and remain useful.

3.3.4 DETERMINES DESIGNATED COMMUNITY

The submission, or planned submission, of Content Information and associated PDI requires a determination as to who the expected Consumers, or Designated Community, of this information will be. This is necessary in order to determine if the information, as represented, will be understandable to that community. For example, an Archive may decide that certain Content Information should be understandable to the general public and, therefore, this becomes the Designated Community.

For some scientific information, the Designated Community of Consumers might be described as those with a first-year graduate level education in a related scientific discipline. This is a more difficult case as it is less clear what degree of specialized scientific terminology might actually be acceptable. The Producers of such specialized information are often familiar with a narrowly recognized set of terminology, so it is especially critical to clearly define the Designated Community for that information and to make the effort to ensure that this community can understand the information.

The possible changes to the definition of the Designated Community also need consideration. Information originally intended for a narrowly defined community may need to be made more widely understandable at some future date. For example, information originally intended to be understandable to a particular scientific community may need to be made understandable to the general public. This is likely to mean adding explanations in support of the Representation Information and the Preservation Description Information, and it can become increasingly difficult to obtain this information over time. Selecting a broader definition of the Designated Community (e.g., general public) when the information is first proposed for Long Term Preservation can reduce this concern and also improve the likelihood that the information will be understandable to all in the original community.

3.3.5 ENSURES INFORMATION IS INDEPENDENTLY UNDERSTANDABLE

The degree to which Content Information and its associated PDI conveys information to a Designated Community is, in general, quite subjective. Nevertheless, it is essential that an Archive make this determination in order to maximize information preservation. Therefore, as described in detail in 2.4, Preservation Objectives allow a more objective determination to be made. .Digital Content Information and PDI need adequate Representation Information to be Independently Understandable to the Designated Community. Typically, there are multiple Representation Information objects involved, and this is discussed in 4.3.

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For example, consider Content Information from a digital set of observations of rainfall, temperature, pressure, wind velocities, and other parameters measured all over the world for a year. This type of information is very extensive and is not usually in a form intended for direct human browsing or reading; but it is in a form appropriate to searching and manipulation by application software. Such content may only be understandable to the original Producers, unless there is adequate documentation of the meaning of the various fields and their inter-relationships, and how the values relate back to the original instrumentation that made the observations. In such specialized fields extra effort is needed to ensure that the Content Information and the Preservation Description Information are understandable to a Designated Community. If the Archive does not have this level of expertise in-house, it may have outside community representatives review the information for Long Term understandability. Otherwise some of the information may be understandable to only a few specialists and be lost when they are no longer available.

Even when a set of information has been determined to be understandable, as exemplified by the associated Preservation Objectives, to a particular Designated Community, over time the Knowledge Base of this community may evolve to the point that important aspects of the information may no longer be readily understandable. At this point it may be necessary for the OAIS to enhance the associated Representation Information so that it is again readily understandable to the Designated Community.

The Designated Community should be monitored to be sure the Content Information is still understandable to them. The Designated Community may lose its familiarity with some terminology, and the definition of the community may be broadened to include other members with different backgrounds. For example, a periodic review with participants representing the Designated Community could assist in this process.

As another example, a manuscript's Content Information may be written in English and therefore its content may be generally understandable to a wide audience. However, unless the purpose for which it was created is clearly documented, much of its meaning may be lost. This 'purpose' information is part of its Context Information and must be provided in the Preservation Description Information.

Software is needed for efficient access to digital Content Information. However, maintaining Content Information-specific software over the Long Term has not yet been proven cost effective because of the narrow application of such software. The danger of information loss is great when such software is relied upon for information preservation and understanding because it may cease to function under only small changes to the hardware and software environment. This may not be recognized unless there is a vigorous, ongoing, testing and validation program. A related approach is to employ an emulator that maintains a consistent environment for a range of application specific software. A major concern with this approach is the need to upgrade and maintain the emulator over time while ensuring it runs all the application specific software with fidelity, and to do this cost-effectively.

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