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IODE Quality Management Framework for National Oceanographic Data Centres

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1. INTRODUCTION

The International Oceanographic Data and Information Exchange (IODE) (*http://www.iode.org*) programme of the Intergovernmental Oceanographic Commission (IOC) of UNESCO (*http://www.ioc-unesco.org*) maintains a global network of National Oceanographic Data Centres (NODC) and Ocean Biogeographic Information System (OBIS) nodes responsible for the collection, quality control, archive, and online publication of many millions of ocean observations which are made available to Member States. In addition it coordinates a network of marine information (library) managers.

To facilitate the exchange and dissemination of oceanographic data and services, the IODE has developed the Ocean Data Portal (ODP) and manages the OBIS portal to provide seamless access to the data collections across the IODE network for data discovery, access and retrieval.

The IODE Committee has long held the view that there is a need for a quality management framework to ensure that NODCs are established and operate according to defined principles, including adherence to agreed standards and the requirements of the IOC Oceanographic Data Exchange Policy. This will ensure NODCs are able to provide data of known quality to meet the requirements of a broad community of users. IODE has recently been accepted as a *network member* of the ICSU World Data System (WDS). Network members represent groups of members that serve as coordinating agents and have common characteristics and disciplines. As a contributing member of WDS, the NODCs will be required to demonstrate their capability to meet ICSU certification criteria. The transition to the new ICSU WDS creates an opportunity for IODE to collaborate with ICSU to become part of the new system and provide data to multiple communities through the ICSU WDS.

The Twenty-second Session of the IODE Committee (IODE-XXII) adopted Recommendation IODE-XXII.18 to establish the IODE Quality Management Framework. **The IODE Quality Management Framework (IODE-QMF) provides overall strategy, advice and guidance for NODCs to design and implement quality management systems (QMS) for the successful delivery of oceanographic and related data, products and services.** The IODE encourages NODCs to implement a QMS and to demonstrate they are in conformity with ISO 9001, the international standard for quality management. Formal ISO 9001 certification is not mandatory however NODCs must be able to demonstrate that an effective quality management system has been implemented.

The main objectives of the IODE-QMF are:

- Promote accreditation of NODCs according to agreed criteria;
- Provide assistance to NODCs to establish organizational quality management systems;

- Initiate and review existing standards and Manuals and Guides with respect to the inclusion of quality management procedures and practices; and
- Provide regular feedback to the IODE Committee.

This document outlines the IODE-QMF that will address the implementation of quality management systems to ensure NODCs can demonstrate their capabilities to provide data and services in compliance with established standards and responsibilities that will lead to accreditation.

2. DEFINITIONS

Quality Management Framework (QMF): the strategy, advice, guidance and tools necessary for an organization (such as a National Oceanographic Data Centre) to attain quality, efficiency, and effectiveness in performing its mission responsibilities.

Quality Management System (QMS): a management tool consisting of a set of rules to direct and control an organization with regard to quality, which is intended to assist in establishing policy and objectives and in achieving those objectives.

Quality Management: the coordinated activities to direct and control an organization with respect to quality. Quality management focuses on the quality of products and services as well as on the means to achieve it by undertaking the following activities: quality planning, quality control, and quality assurance.

Quality: the degree to which a set of inherent characteristics fulfils requirements. The quality of a product or service refers to the perception of the degree to which it meets the customer's expectations. Quality has no explicit meaning, unless it is related to a specific set of requirements.

Quality Assurance: that part of quality management focused on providing confidence that quality requirements will be fulfilled. This involves the systematic monitoring and evaluation of the processes associated with the generation of a product or service.

Quality Control: the process of monitoring the output of quality assurance activities to improve products and services so that quality requirements and/or standards are met.

Quality Manual: the document that defines the scope of the *Quality Management System* and that outlines documentation related to the QMS. It includes or references documented procedures and describes how processes interact to form the QMS.

Quality Objectives: performance indicators for measuring the progress of the quality system; for example, the number of hours of staff training per year, the number of datasets processed, etc.

Quality Planning: the process of identifying quality requirements and/or standards for products and services and documenting how an organization will demonstrate compliance to these quality requirements and/or standards.

Quality Policy: the principle defining the commitment to quality by an organization's senior management, including a framework for setting quality objectives. A quality policy exists to shape behaviour and establishes the core values in an organization.

Additional definitions can also be found in the *Guide to the Implementation of a Quality management System for national and Hydrological Services* (World Meteorological Organization, 2013).

3. IODE NETWORK OF NATIONAL OCEANOGRAPHIC DATA CENTRES

The International Oceanographic Data and Information Exchange Programme (IODE) system of national data facilities was established in 1961 to:

> *"enhance marine research, exploration, and development by facilitating the exchange of oceanographic data and information between participating Member States."*

The IODE system forms a worldwide service oriented network consisting of National Oceanographic Data Centres (NODC) and Designated National Agencies (DNA). During the past 50 years, IOC Member States have established over 80 oceanographic data centres. This network has been able to collect, control the quality of, and archive millions of ocean observations, and make these available to Member States.

The objectives of the IODE programme are:

(i) to facilitate and promote the exchange of all marine data and information including metadata, products and information in real-time, near real time and delayed mode, in compliance with the IOC Oceanographic Data Exchange Policy;
(ii) to ensure the long term archival, management and services of all marine data and information;
(iii) to promote the use of international standards, and develop or help in the development of standards and methods for the global exchange of marine data and information, using the most appropriate information management and information technology;
(iv) to assist Member States to acquire the necessary capacity to manage marine data and information and become partners in the IODE network; and
(v) to support international scientific and operational marine programmes of IOC and WMO and their sponsor organisations with advice and data management services.

3.1 CURRENT PROCEDURES TO BECOME AN IODE NODC

Any IOC Member State can establish an NODC according to the steps outlined in IOC Manuals and Guides No. 5 (*Guide for establishing a National Oceanographic Data Centre (Second revised edition, 2008))* (http://www.iode.org/mg5).

This Guide is intended as a tool for policy makers at the national level to assist them with the decision-making related to the establishment of national facilities for the management of oceanographic data. It is also intended to be a reference document for national organizations involved in, or planning to be involved in, oceanographic data management. The Guide provides a step-by-step recommended process to verify the suitability of an institution to become an NODC but there is currently no instrument within IODE to review compliance with this process. As stated in the Guide: "*these steps and principles are suggestions for guidance only*". The Guide does not specify a formal process for accreditation of NODCs.

IODE traditionally had two levels of data centres: the Designated National Agencies (DNA) and National Oceanographic Data Centres (NODC). The function of each level of data centre has not been articulated however the former could be considered as a "light" version of the latter. In recent years this distinction has been used less and less and most Member States now establish a NODC.

According to Manuals and Guides No. 5 the most important requirement in establishing an NODC is to secure the support and cooperation of the oceanographic, and in some cases meteorological, organizations that collect and use oceanographic data. Without this cooperation the new centre will have great difficulties in acquiring data and will lose its most natural group of clients, i.e. the data providers. Currently the only formal requirement to be considered an IODE NODC is for the IOC focal point to send an official letter to the IOC Executive Secretary informing him/her of the designation of a particular national institution as an IODE NODC. It is assumed that the NODC will perform the tasks as defined in Manuals and Guides No. 5.

In 2013 the IODE Committee agreed to abolish the category of DNA and to establish the IODE Associate Data Unit (ADU) as a new structural element of IODE.

3.2 TASKS OF AN IODE NODC

According to IOC Manuals and Guides No.5, the mission of an NODC is:

> *"to provide access and stewardship for the national resource of oceanographic data. This effort requires the gathering, quality control, processing, summarization, dissemination, and preservation of data generated by national and international agencies"*

The range of data management tasks to be carried out by an NODC can be summarized as:

- Receiving data from national, regional and international programmes collecting oceanographic data;
- Verifying the quality of the data (using agreed upon standards);
- Ensuring the long term preservation of the data and associated information required for correct interpretation of the data; and
- Making data available, nationally and internationally.

An NODC has responsibilities to both the national and international communities. At the national level a NODC's responsibilities include:

- Receiving data from the research and observation communities, performing quality control, and archiving;
- Receiving data from buoys, ships and satellites on a daily basis, processing the data in a timely way, and providing outputs to various researchers, forecasters, experiment managers, or to other centres participating in the data management plan for the data in question;
- Reporting the results of quality control directly to data collectors as part of the quality assurance process;
- Participating in the development of data management plans and establishing systems to support major experiments, monitoring systems, fisheries advisory systems, etc.;
- Disseminating data on the Internet and through other means, such as CDROM, DVD, etc.;
- Publishing statistical studies and atlases of oceanographic variables;
- Providing indicators for the different types of data being exchanged in order to track progress.

International activities include:

- Participating in the development of international standards and methods for data management through the IODE and JCOMM, (the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology) (*http://www.jcomm.info*);
- Participating in international oceanographic data and information exchange through the IODE and JCOMM;
- Assisting with data management aspects of global or regional programmes or pilot projects through IODE and JCOMM and in the framework of, inter alia, the IOC's Strategic Plan for Oceanographic Data and Information Management;
- Operating as a data assembly and quality control centre for part of an international science experiment;
- Operating regional or specialized data centres on behalf of the international science community.

3.3 IODE OCEAN DATA PORTAL

The objective of the Ocean Data Portal (ODP) is to facilitate and promote the exchange and dissemination of marine data and services through the provision of seamless access to collections and inventories of marine data from the NODCs in the IODE network and to allow for discovery, evaluation and access to data via web services. This is achieved through a standards-based infrastructure that provides the integration of marine data and information from a network of distributed IODE NODCs as well as the resources from other participating systems.

The key principle of the Ocean Data Portal is interoperability with existing systems and resources. Participating NODCs agree to accept and implement a set of interoperable arrangements including the technical specifications and web services for the integration and shared use of the metadata, data and products. This interoperability is achieved through the use of internationally endorsed standards and best practice and does not require data centres to change their internal data management systems.

The ODP supports the marine data access requirements of all IOC programmes areas, including GOOS (Global Ocean Observing System – *http://www.ioc-goos.org*), HAB (Harmful Algal Blooms – *http://www.ioc-unesco.org/hab*) and the Tsunami Programme (*http://www.ioc-tsunami.org*), as well as JCOMM.

The ODP web site is available at *http://www.oceandataportal.org*. This site provides background information on the project, software, documentation and training materials in addition to assistance to users on how to use ODP and how to become ODP data providers. The ODP data access is available through a link from this site.

3.4 IODE STANDARDS AND BEST PRACTICES

The diverse data standards and formats that have evolved within the oceanographic community make data exchange complex and the IODE community has recognized standards are critical in defining the way data is managed and exchanged. To ensure the interoperability of data exchanged between the NODCs and the Ocean Data Portal, the IODE, together with JCOMM, has initiated a standards process to support the recommendation and adoption of core standards by the marine meteorological and oceanographic communities. The IODE/JCOMM Ocean Data Standards (ODS) Pilot Project was established through the recommendations of IODE (IODE-XX.2) and JCOMM (Recommendation 4, JCOMM-III) for the development and acceptance of community wide standards for marine data and information management and exchange. In 2013, IODE-XXII formally closed the ODS Pilot Project and established the Ocean Data Standards and Best Practices Project (ODSBP) that also incorporates a catalogue of best practices. For more information see *http://oceandatastandards.org*.

IODE and JCOMM have prepared and published an online catalogue of best practices and standards for integrating of instrument best practices and related standards among the marine meteorological and oceanographic communities. The web site provides access to over 60 publications of WMO and IOC. The JCOMM Catalogue of Practices and Standards is available at *http://bestptactice.iode.org*.

4. IOC OCEANOGRAPHIC DATA EXCHANGE POLICY

The exchange of oceanographic data is central to the mission of IODE and the free and unrestricted exchange of oceanographic data will ensure the maximum use is made of all available data. Open access to data and derived products can contribute to the beneficial public use and protection of the ocean environment, resources, protection of life and property and for the prediction of weather and climate.

The IOC Oceanographic Data Exchange Policy, which was adopted as Resolution IOC-XXII-6 at the 22nd Session of the IOC Assembly in 2003, promotes free and open access to data, metadata and products, and aims to maximize the amount of data exchanged without infringing the rights of data originators.

The policy describes the recommended practices and associated institutional arrangements for the exchange of oceanographic data. This policy states that Member States shall provide timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programs. The Policy aims to maximise the amount of data exchanged and promotes the use of National Oceanographic Data Centres as long-term repositories for data and metadata, and encourages capacity building.

Data centres that are part of the IODE network of National Oceanographic Data Centres are expected to comply with the IOC Oceanographic Data Exchange policy and this Policy should be included as part of the NODC quality management system.

The complete Resolution is available from the IODE web site *http://www.iode.org/policy*.

5. IODE QUALITY MANAGEMENT FRAMEWORK

At its 20th and 21st Sessions (IODE-XX, 2009 and IODE-XXI, 2011), the IODE Committee discussed the need to establish a framework to ensure that NODCs are established and accredited according to defined principles, including adherence to agreed standards and the requirements of the IOC Oceanographic Data Exchange Policy. Accreditation of data centres, based on relevant criteria that can be translated into quantitative indicators, will ensure NODCs are able to provide quality data to meet the requirements of a broad community of users.

The IODE Quality Management Framework (IODE-QMF) provides an overall strategy, advice and guidance for NODCs to design and implement quality management systems for the successful delivery of oceanographic and related data, products and services. The main objectives of the IODE-QMF are:

- Promote accreditation of NODCs according to agreed criteria;
- Provide assistance to NODCs to establish organizational quality management systems;
- Initiate and review existing standards and Manuals and Guides with respect to the inclusion of quality management procedures and practices; and
- Provide regular feed-back to the IODE Committee.

The IODE-QMF addresses the implementation of quality management systems by its NODCs, as well as providing an overall strategy for IODE to deliver oceanographic data, products and services.

5.1 THE IODE-QMF AND ITS RELEVANCE TO COOPERATION WITH OTHER ORGANIZATIONS

5.1.1 JCOMM

JCOMM, the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology, is an intergovernmental body of technical experts that provides a mechanism for international coordination of oceanographic and marine meteorological observing, data management and services, combining the expertise, technologies and capacity building capabilities of the meteorological and oceanographic communities.

IODE collaborates with JCOMM through the JCOMM Data Management Programme Area (DMPA) and its JCOMM/IODE Expert Team on Data Management Practices (ETDMP). IODE and JCOMM have undertaken a number of important joint activities through the ETDMP such as the Ocean Data Standards Pilot Project, IODE Ocean Data Portal, and the JCOMM Pilot Project for WIGOS (for the integration of marine meteorological and other appropriate oceanographic observations into the WMO Integrated Global Observing Systems).

JCOMM is actively taking steps to implement a QMS for met-ocean data, products and services. At its third session in 2009, JCOMM adopted *Recommendation 8 (JCOMM-III) – Implementation of Quality Management Systems for Met-ocean data, products and services by Members/Member States*, which recommends to Members/Member States:

(i) To propose and implement quality management systems for met-ocean data, products and services, based on the IODE-JCOMM Standards Process, the WMO Quality Management Framework and the principles of ISO or any relevant quality management standards, as appropriate to their circumstances;
(ii) To participate in ISO activities through their appropriate national channels and to assist WMO and UNESCO/IOC in the development of common standards with ISO, within the framework of the WMO-ISO Working Arrangements;
(iii) To share relevant experience and cooperate with one another, as appropriate, in developing quality management systems, including assisting Members/Member States with specific quality management system implementation needs;
(iv) To collaborate with the Inter-Commission Task Team on Quality Management Framework in furthering this approach of peer reviews as an example of effective implementation of the WMO-wide Quality Management Framework;
(v) To submit their common practices in collecting, managing and exchanging oceanographic and marine meteorological data though the IODE-JCOMM Standards Process.

JCOMM has recognized that the implementation of a QMS is likely to assist Members/Member States in adopting good management practices and enhance confidence in the quality of their data, products and services and encourages Members/Member States to implement a quality management system following, as far as possible, the ISO Quality Management Standards.

The establishment of the new Marine Climate Data System (MCDS) and its network of WMO-IOC Centres for Marine-meteorological and Oceanographic Climate data (CMOCs) as joint activities of marine meteorology and oceanographic services will better integrate met-ocean data, products and services. The MCDS will implement a Quality Management Framework that will be fully compliant, if not identical to, the IODE-QMF.

5.1.2 WMO

The World Meteorological Organization (WMO) recognizes the high importance of having quality management systems underpinning many aspects of the work of WMO and its Members. In 2003 the WMO Congress adopted Resolution 27 (Cg-XIV) and decided that WMO should work towards a Quality Management Framework (WMO-QMF) for National Meteorological and Hydrological Services (NMHS) which should assist Members to achieve their individual quality management related objectives. The WMO-QMF includes the following elements:

- WMO technical standards
- Quality management systems including quality control
- Certification procedures

The WMO QMF is founded on the eight principles of quality management (see Section 6.1) which are designed to underpin the achievement of objectives and the enhancement of capacity building activities for Members. WMO encourages NMHSs to implement Quality Management Systems and seek certification according to the ISO 9001 standard.

A formal agreement between WMO and ISO was established in 2008 for the development of joint technical standards. WMO is now recognized as an international standardizing body by ISO giving WMO the status and authority for the development of international standards related to meteorological, climatological, hydrological, marine and related environmental data, products and services.

The WMO has established the Task Team on Quality Management Systems to promote and provide guidance for the development and implementation of Quality Management Systems in National Meteorological and Hydrological Services (NMHS), particularly in developing and least developed countries, and those providing services to international civil aviation to achieve certification of compliance with the *ISO 9001-Quality management systems – requirements.* Further information pertaining to the work on the Task Team can be found on the WMO Quality Management website at http://www.bom.gov.au/wmo/

The IODE-QMF will seek to promote quality management and standards in cooperation with the WMO Quality Management Framework.

6. DEFINITION OF A QUALITY MANAGEMENT SYSTEM

Quality management is defined as "*coordinated activities to direct and control an organization with regard to quality*" (ISO 9000:2005). A quality management system (QMS) is a management tool consisting of a set of rules to direct and control an organization with regard to quality. It is not just a set of documents but a group of interrelated processes that brings resources, activities and behaviours used to improve an organization's effectiveness and efficiency in attaining its objectives.

Any size organization can benefit from the efficiency of an established QMS as this will help the organization keep customer focus, involve everyone from the top down and drive continual improvement. The International Organization for Standardization (ISO) has defined a good quality management system as "process-based". A process-based QMS uses a process approach to manage and control how its quality policy is implemented and how its quality objectives are achieved. A process-based QMS is a network of interrelated and interconnected processes with each process using resources to transform inputs into outputs. Since the output of one process becomes the input of another process, processes interact and are interrelated by means of such input-output relationships. Figure 1 illustrates the model of a process-based QMS (from ISO 9001:2008).

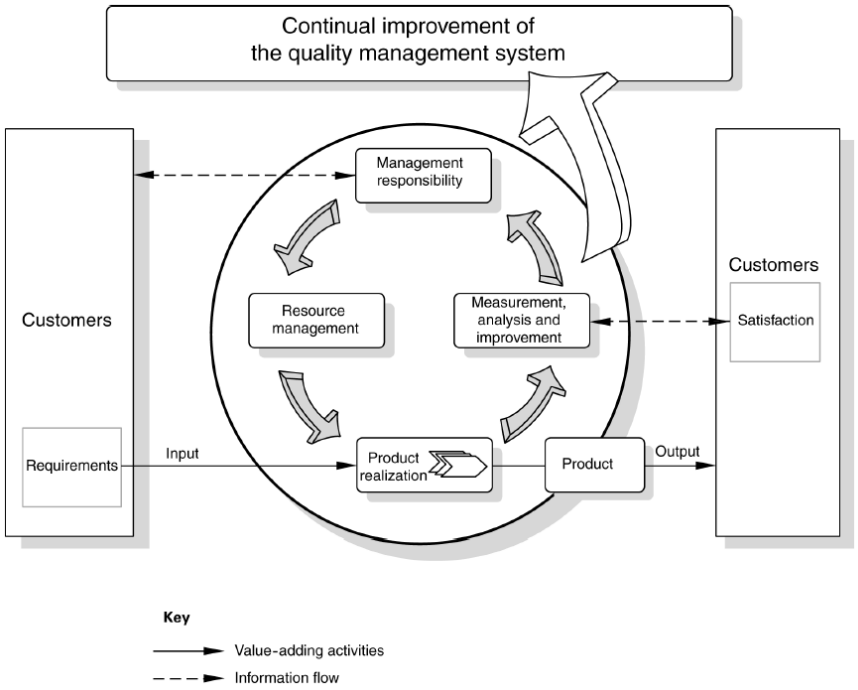

Figure 1. Model of a process-based quality management system

The following is an example of how this model might operate:

- Management defines requirements under *Management responsibility*;
- Necessary resources are determined and applied within *Resource management*;
- Processes are established and implemented under *Product realization*;
- Results are measured, analysed and improved through *Measurement analysis and improvement*; and
- Analysis and management review then provide feedback to initiate system improvement.

The model also recognizes that customers and other relevant interested parties play a key role in defining input requirements. Process management is then implemented to realize the required products or service and the outputs are verified. Satisfaction measurements of customers and other interested parties are used as feedback to evaluate and validate whether customer requirements have been achieved.

6.1 QUALITY MANAGEMENT PRINCIPLES

ISO has developed eight quality management principles (ISO 9000:2005) which form the basis for the quality management system standards within the ISO 9000 family of standards. These principles reflect best practice and are designed to enable continual improvement of the QMS and can be used by management of an organization, such as an NODC as a framework to guide their organization towards improved performance.

These principles are as follows:

a) **Customer focus.** Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations
b) **Leadership.** Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives
c) **Involvement of people.** People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit
d) **Process approach.** A desired result is achieved more efficiently when activities and related resources are managed as a process
e) **System approach to management.** Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives
f) **Continual improvement.** Continual improvement of the organization's overall performance should be a permanent objective of the organization
g) **Factual approach to decision making.** Effective decisions are based on the analysis of data and information
h) **Mutually beneficial supplier relationships.** An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value

The adoption of these quality management principles will facilitate the efficient and effective management and operation of an NODC and the implementation of a QMS is likely to assist IOC Member States in adopting good management practices and enhance confidence in the quality of oceanographic data, products and services.

6.2 THE ISO 9000 SERIES OF STANDARDS FOR QUALITY MANAGEMENT

The ISO 9000 series of quality management standards is the generic name given to a family of international standards developed to provide a framework around which a quality management system can effectively be implemented. The standards are published by the International Organization for Standardization (ISO). Collectively, these standards provide a model that allows an organization to implement and operate effective quality management systems.

The family of ISO 9000 standards is made up of the following core standards:

- ISO 9000:2005. *Quality management systems – Fundamentals and Vocabulary*
- ISO 9001:2008. *Quality Management Systems – Requirements*.
- ISO 9004:2009. *Managing for the sustained success of an organization – A quality management approach*
- ISO 19011:2011. *Guidelines for auditing management systems*

An overview of the ISO 9000 core standards can be found in Annex I.

7. A QUALITY MANAGEMENT SYSTEM FOR NATIONAL OCEANOGRAPHIC DATA CENTRES

IODE NODCs must ensure that their responsibilities for oceanographic data management and delivery of services and products are performed efficiently and effectively. Implementation of quality management systems will assist the NODCs in the provision of good management practices and ultimately will enhance confidence in the quality of their data, products and services which will enhance the standing of the NODC among clients, users and stakeholders. Quality management does not only control the final product, but the entire process.

A QMS addresses on one hand the general management of an NODC including financial resources, staff, objectives, etc., and on the other hand the technical documentation describing, for example, how data and products are managed and generated. The QMS should be designed specifically for every NODC. The description of processes and procedures has to be developed by the staff of the NODC so that it corresponds to the work habits of the organization. However, many processes can be based on commonly used standards and procedures, such as IOC Manuals and Guides and IODE recommended standards. The full commitment of the executive management is essential for the implementation of a QMS.

The IODE Committee encourages NODCs to implement a QMS but does not propose a specific standard. ISO 9001 is an internationally recognized standard that specifies the basic requirements for a quality management system that can result in certification. Another option is to implement ISO 9004 which provides guidance for the continual improvement of an organization's overall performance, efficiency and effectiveness and does not require formal certification.

Some NODCs may be required to implement the ISO 9001 standard by government directive, requests from their customers, the need for competitiveness, etc., or may already have in place systems or practices that address the ISO requirements. In these cases the NODC may want to seek ISO 9001 quality management certification. Those NODCs that have undergone ISO 9001 certification are urged to share their experience and documentation with other NODCs seeking certification.

Achieving ISO 9001 certification through a third party certification body can be an effective way to demonstrate conformity and provides important credibility. Although ISO 9001 certification may be the ideal arrangement, NODCs can successfully implement an efficient and effective quality management system without going through formal ISO 9001 certification.

7.1 NODC QUALITY MANUAL

The first step in building a Quality Management System is the creation of a **Quality Manual** which forms an important part of the process of building, consolidating and clarifying the quality management framework. A quality manual is a document detailing the scope of an organization’s QMS, including references to documented policies and procedures, and describes the scope and extent of the QMS. It provides a "*road map*" as to how the organization operates. The manual has several uses such as:

- A means to communicate the vision, values, mission, policies and objectives of the organization
- A means of showing how the system has been designed
- A means of showing linkages between processes
- A means of showing who does what
- An induction tool that describes how the organization operates and the processes associated with achieving its outcomes
- A tool in the analysis of potential improvements
- A means of demonstrating compliance with external standards and regulations

The quality manual should be easy to understand and reflect the values that the organization wishes to convey to the reader. Typical elements of a quality manual consist of the following:

- Title and scope — the manual should make a brief description of the processes in the organization included within the QMS
- Review, approval and revision — evidence of the review, approval, revision status and date of the quality manual should be clearly stated

- Quality policy and objectives — can be separately documented but referenced in the manual or be included in the quality manual
- Organization, responsibility and authority — a description of the structure of the organization should be included. Organization charts, flow charts and job descriptions may be included or referenced in the manual
- Quality management system description — a description of the processes and their interactions, documented procedures or references to them is to be included. An example might be a process map that shows all the steps in the process beginning from responding to a request from a customer for a data product through to its delivery via a web site
- References — a list of documents referred to but not included in the manual.
- Appendices — any supportive information such as flow charts of processes and organization charts

ISO 9001:2008 specifies the minimum content for a quality manual. The format and structure of the manual is a decision for each organization, and will depend on the organization's size, culture and complexity. Some organizations may choose to use the quality manual for other purposes besides that of simply documenting the QMS. A small organization may find it appropriate to include the description of its entire QMS within a single manual while a large organization may need several manuals and a hierarchy of documentation. A simple outline of a Quality Manual for an NODC QMS is described in Annex II.

In developing a quality manual for an NODC it helps to look from the perspective of a new employee who would use the manual as an induction tool. It should provide them with a clear picture of how the NODC operates and the processes associated with achieving its outcomes. The quality manual can also contain additional information about the NODC such as policy, information about customer service, future strategies, past history, organizational structures and charts as required. It is important that this document is easy to read and understand and reflects the values of the organization.

The WMO has published the *Guide to the Quality Management System for the Provision of Meteorological Service for International Air Navigation* which provides an example of a quality manual for implementing a quality management system for the aviation weather service and obtaining the ISO 9000 certification of the system (World Meteorological Organization, 2011).

8. ACCREDITATION OF NATIONAL OCEANOGRAPHIC DATA CENTRES

8.1 INTRODUCTION

With the development of the Ocean Data Portal, which will provide on-line access to the marine data resources of an NODC and support the data access requirements of all IOC programmes areas, NODCs will be encouraged to contribute data to the ODP and the OBIS portal as a data provider. An NODC should be able to demonstrate capability to provide data and services in compliance with established functions and

responsibilities. The adherence to agreed standards and the requirements of the IOC Oceanographic Data Exchange Policy must be met and sustained. Providing data of the highest quality is essential to make the IODE Ocean Data Portal widely accepted and trusted data systems.

To ensure an NODC is able to provide quality data to meet the requirements of a broad and varied community of users, an accreditation process will be introduced by IODE. This process is based on compliance to a set of requirements that can be translated into quantitative indicators to set up standard metrics which will be part of a regular review of an NODC. Existing NODCs will need to apply for accreditation and meet the prescribed accreditation requirements.

8.2 IODE AND THE ICSU WORLD DATA SYSTEM CERTIFICATION

The new ICSU World Data System (WDS) has been created through a decision of the 29th General Assembly of the International Council for Science (ICSU) to replace the World Data Centre system (WDC) and the ICSU Federation of Astronomical and Geophysical data-analysis Services (FAGS).

IODE has collaborated with the World Data Centres (Oceanography) for many years. At its twenty-first Session, the IODE Committee considered the role of the IODE in the ICSU WDS and expressed its strong interest in sharing its network, expertise, data and information with the ICSU WDS and agreed to further develop the marine component of the ICSU WDS through the application of IODE methodologies and technologies. IODE has been formally accepted as a ***network member*** of the ICSU WDS and will contribute to the WDS through its network of NODCs.

ICSU has developed a certification process for a WDS based on a catalogue of evaluation criteria (Annex III). This catalogue of criteria comprises four sections covering policies, organizational framework, management of data, metadata, and services, and technical infrastructure.

All NODCs should be able to demonstrate their capability to meet the ICSU certification requirements and the IODE accreditation process will ensure the ICSU certification requirements are met. In this way NODCs accredited by IODE will also be accredited as a component of the WDS.

8.3 NODC ACCREDITATION REQUIREMENTS AND REPORT FORMAT

In order to obtain and maintain accreditation, an NODC will need to fulfil a **minimum set of requirements** to ensure compliance with IODE standards and to establish a mechanism to regularly monitor and assess the quality of data and service. IODE has established accreditation criteria to ensure NODCs meet these requirements which are given in Table 1.

Table 1: IODE Accreditation Requirements and Report Format for NODCs

Criteria	IODE NODC accreditation requirement
1 ORGANIZATIONAL FRAMEWORK	
1.1 Quality Management System	The NODC shall establish and maintain a quality manual that includes a) the scope of the quality management system b) documented procedures established for the quality management system c) a description of the interaction between the processes of the quality management system. In addition, details of any QMS accreditation attained should be stated.
1.2 Proof of expertise and reputation in the area of oceanographic data management	The NODC shall describe the range and length of expertise of both the organisation and their staff. Details of datasets and products available from the NODC should also be provided. Any appropriate affiliations (e.g. national or international bodies, etc.) should be noted.
1.3 Commitment to provide sufficient resources for NODC operations	The NODC shall provide evidence that it is hosted by a recognized institution to ensure long-term stability and sustainability. Sufficient funding, including staff resources, IT resources and a budget for attending meetings, should be provided, ideally for a 3 to 5 year period.
1.4 Commitment to return data holdings to originators, or lodging with an alternative repository, if the NODC becomes unsustainable	A long-term stewardship plan should be available including: • A statement on how the NODC is funded and for how long. • Action to be taken in the event that the NODC becomes unsustainable
1.5 Provide national reports to the IODE Committee	The NODC shall provide a national report to each session of the IODE Committee in accordance with the standard format provided.
2 QUALITY CONTROL AND MAINTENANCE	
2.1 Adherence to IODE Standards and Best Practice	The NODC must provide evidence of adherence to IODE recommended standards and best practice to ensure the quality of exchanged data. For more information see IODE/JCOMM Ocean Data Standards (*http://www.oceandatastandards.org*) and the JCOMM Catalogue of Practices and Standards (*http://bestpractice.iode.org*)
2.2 Maintain a discovery metadata catalogue	The NODC shall maintain a discovery metadata catalogue that will store metadata about their datasets. ISO 19115 (Geographic Information - Metadata) is the international standard that sets out a number of metadata fields for describing spatial information datasets. ISO 19139 (Geographic Information - Metadata - XML schema implementation) is the standard that aims to define an XML encoding for the metadata elements defined in ISO 19115. The ISO 19115 metadata standard (or a profile) is to be used to generate metadata records.
2.3 Ensure data are collected according to defined quality principles and accepted procedures	The NODC should be able to advise on data collection procedures and should be able to direct data collecting organisations to appropriate standards, where these exist. Provide details of data guidelines used for the collection of data.
2.4 Description of quality control procedures applied to data	The NODC should provide descriptions of quality control procedures and algorithms that are used to process data. This should include references to the quality flag system used.
3 USER ACCESS AND COMMUNICATION	
3.1 Committed to, and focus on, customer service	The NODC should be committed to customer service and should provide information on: • Response times to enquiries for data and information • Description of aimed service level for responding to user requests

	(if these not available online). • Whether an Enquiries or Help Desk is available • Details of surveys of customer satisfaction undertaken
3.2 Committed to raising awareness of the holdings and promoting the use of the data	Describe facilities available at the NODC for the data Discovery-Access-Retrieval including details of how the data can be searched (e.g. online metadata catalogue or data portal) The NODC should provide information on: • Data products available • Linkages with other organisations who use the data for generation of products • Current projects aiming to increase and promote data use • Statistics/metrics indicating data usage
3.3 Published Data Policy and adherence to the IOC Oceanographic Data Exchange Policy	The NODC should have a policy on data access. In general the NODC should aim to make data and metadata freely available, although it is recognised there may be restrictions on access to data for a number of reasons including national security, commercial confidentiality, and for scientific research to allow the principle investigators to exploit the data. The data access policy should include the following: • Details of what data are accessible • Licensing arrangements • The format(s) that data can be provided in • The media used for providing data (if data are not on-line) • Any costs associated with data provision – including cost of media as well as staff time Adherence to the IOC Oceanographic Data Exchange Policy is mandatory for accreditation.
4 TECHNICAL INFRASTRUCTURE	
4.1 Description of hardware and software systems used to manage and archive data	The NODC shall provide documentation on the data centre's operating environment (hardware, software). This should be appropriate to the services provided to its customers.
4.2 Security Policy outlining the infrastructure for protection of the facility and its data, products and services	The NODC should have a security policy describing how the data holdings are protected from both malicious and accidental loss. A policy should include the following: • How the holdings are physically protected (e.g. how access to the building is controlled, how secure the building is, who has access) • Access to the network – what is the access policy, how is user access limited and by who, whether there is an internet link and details of how the firewall is configured and altered, how machines are patched, which users can log on to particular machines, policy on passwords • Policy when staff leave organisation • Description of the data archival system including backup and off-site storage procedures. Note that the security policy should exist but should not be made public as it potentially exposes vulnerabilities.

These criteria have been developed with reference to the WDS catalogue of evaluation criteria and the UK Marine Environmental Data and Information Network (MEDIN) requirements for data archiving centres (*http://www.oceannet.org/*).

Those NODCs that meet the accreditation requirements will be awarded the status of ***Accredited IODE National Oceanographic Data Centre***.

The IODE Committee has agreed that the category of Designated National Agency (DNA) will be withdrawn. Current DNAs are encouraged to work towards accreditation as NODCs. The focus of IODE capacity development will be to advance the capability of NODCs so they can become Accredited IODE National Oceanographic Data Centres.

8.4 IODE ASSOCIATED DATA UNIT (ADU)

The IODE Committee has established the Associate Data Unit (ADU) as a structural element of the IODE network. ADUs will allow the wider ocean research and observation communities to join IODE as key stakeholders, so these communities can share, provide access to and preserve all ocean research and observation data. All ADUs are encouraged to apply the IODE-QMF principles and to implement quality management systems to ensure they can demonstrate their capabilities to provide data and services in compliance with established IODE standards and procedures.

8.5 PROCEDURES TO APPLY FOR ACCREDITATION

8.5.1 IODE STEERING GROUP FOR THE IODE QUALITY MANAGEMENT FRAMEWORK

The IODE Steering Group for the IODE Quality Management Framework (SG-QMF) will have the following terms of reference:

(i) advise the IODE Committee on procedures, manuals and guidelines for the accreditation of NODCs;
(ii) advise the IODE Committee on the accreditation of NODCs; and
(iii) receive and review applications for accreditation of existing NODCs.

Membership: The membership of the SG-QMF will be decided upon by the IODE Committee, based upon names (and curriculum vitae) submitted by Member States, in response to a Circular Letter issued not less than 3 months prior to a Session of the IODE Committee. The Steering Group will elect its own Chair.

Meetings: The SG-QMF shall work by electronic means (video and phone conference) and by email, unless otherwise required. If a meeting is required then the cost of participation will be met by the Member States providing the members.

8.5.2 ACCREDITATION PROCEDURE

NODCs will have a period of two years to apply for formal accreditation. The accreditation procedure will consist of:

(i) Submission of the accreditation request (including the IODE Accreditation Requirements and Report Format) and associated documentation to the SG-QMF through its Chair;
(ii) Review of the documentation referred to under (i) by the Steering Group within three months after submission;
(iii) Formulation of recommendation regarding accreditation for consideration by the IODE Committee (within two months after (ii));
(iv) Decision by the IODE Committee (during IODE Committee Session);
(v) Report to applicants and publication on IODE web site (within two months after IODE Committee Session).

If successful, the status of ***Accredited IODE National Oceanographic Data Centre*** will be awarded.

If the advice provided by the Steering Group for accreditation is negative then the NODC will be given one year to remedy the shortcomings that were reported. After that period (or sooner) the institution can re-apply for accreditation and the same procedure will be followed.

8.5.3 REGULAR ASSESSMENT

Once accredited, the capability and performance of each NODC will be reviewed by the SG-QMF every four years. If it is found that compliance to the accreditation requirement has not been met the NODC will be required to take remedial action within one year. If compliance has not been met after this period accreditation can be withdrawn. If an NODC loses accreditation it would need to reapply.

9. CAPACITY DEVELOPMENT

Personnel at all levels should be trained to meet their organization's commitment to quality management and the IODE recognizes the importance of appropriate training and continuous education to improve the competence of personnel. The ISO quality management principles emphasize the importance of human resource management and the need for appropriate training.

The International Standard ISO 10015 (*Quality management — Guidelines for training*) defines competency as the application of knowledge, skills, and behaviours in performance (ISO, 1999). ISO 10015 provides guidelines to assist organizations and their personnel when addressing issues related to training. The guidelines include the development, implementation, maintenance, and improvement of strategies and systems for training that affect the quality of the products supplied by an organization.

ISO 10015 describes a four-stage approach to training that can make an important contribution in helping an organization to improve its capabilities and to meet its quality objectives. The training process is shown in Figure 2 and comprises the following stages:

(a) defining training needs
(b) designing and planning training
(c) providing for the training
(d) evaluating the outcome of training

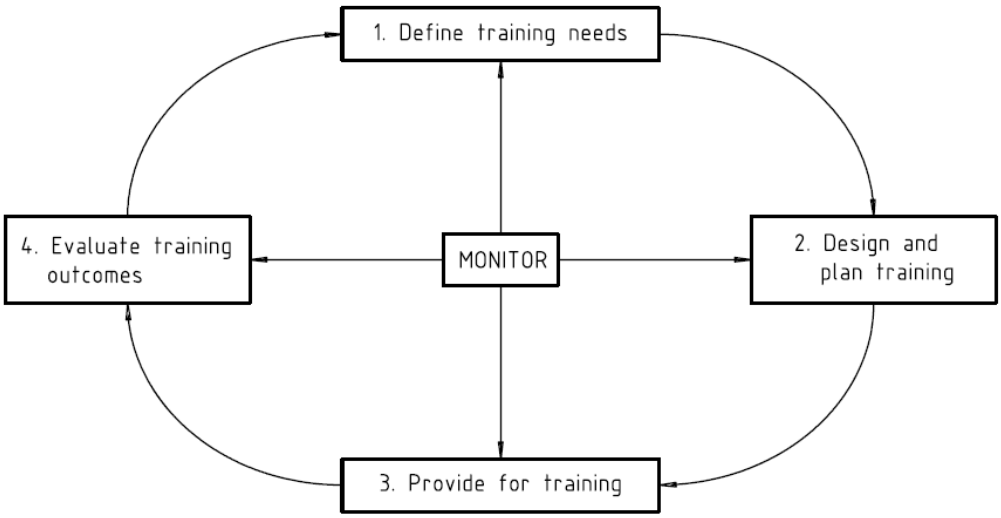

Figure 2.Training cycle (ISO, 1999)

The IODE has developed the OceanTeacher training system for ocean data managers and marine information managers. OceanTeacher is a knowledge-based system related to ocean data and information management to support IODE training activities by providing appropriate training tools. These tools are used traditionally during training activities but can also be used for self-training and continuous professional development. To further advance the OceanTeacher model, the IODE has initiated the OceanTeacher Academy to provide an annual teaching programme of courses related to oceanographic data and information. Training courses are held at the IOC Project Office for IODE in Ostend, Belgium, and the OceanTeacher Academy promotes the establishment of regional training facilities to contribute to the long-term sustainability of capacity development activities of IODE and other IOC programmes.

IODE capacity development, centred on OceanTeacher, will focus on providing the necessary training so that all NODCs can achieve full accreditation. Quality management will be included in the OceanTeacher training programme.

10.REFERENCES AND FURTHER READING

Intergovernmental Oceanographic Commission of UNESCO, 2008. *Guide for establishing a National Oceanographic Data Centre*, Second revised edition. Oostende, 27 pp. (IOC Manuals and Guides No. 5, 2nd. rev. ed.)

International Organization for Standardization, 1999. *Quality management— Guidelines for training*. ISO 10015:1999.

International Organization for Standardization, 2002. *Guidelines for quality and/or environmental management systems auditing*. ISO 19011:2002.

International Organization for Standardization, 2005. *Quality management systems — Fundamentals and vocabulary.* ISO 9000:2005.

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International Organization for Standardization, 2009. *Managing for the sustained success of an organisation – A quality management approach*. ISO 9004:2009.

International Organization for Standardization, 2011. *Guidelines for auditing management systems*. ISO 9011:2011.

World Meteorological Organization, 2013. *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services*. WMO-No 1100

World Meteorological Organization, 2011. *Guide to the Quality Management System for the Provision of Meteorological Service for International Air Navigation*. WMO-No. 1001

ANNEX I. OVERVIEW OF THE ISO 9000 CORE STANDARDS

ISO 9000:2005. This standard provides the fundamentals and vocabulary used in the entire ISO 9000 family of standards. It sets the stage for understanding the basic elements of quality management as described in the ISO standards. ISO 9000 introduces users to the eight Quality Management Principles as well as the use of the process approach to achieve continual improvement.

ISO 9001:2008. This standard specifies the basic requirements for a quality management system that an organization must fulfil to demonstrate its ability to consistently provide products and services that enhance customer satisfaction and meet applicable statutory and regulatory requirements. It is the standard in the family against which an organization can be certified. While an organization can follow ISO 9001 without being certified, taking this additional step can help raise an organization's image and credibility. ISO 9001 basically requires the organization to:

1. Determine the needs and expectations of customers and other interested parties.
2. Establish policies, objectives and a work environment necessary to motivate the organization to satisfy these needs.
3. Design, resource and manage a system of interconnected processes necessary to implement the policy and attain the objectives.
4. Measure and analyse the adequacy, efficiency and effectiveness of each process in fulfilling its purpose and objectives.
5. Pursue the continual improvement of the system from an objective evaluation of its performance.

The focus of ISO 9001 is on results and the processes that produce these results.

ISO 9004:2009. This standard provides comprehensive guidance for the continual improvement of an organization's overall performance, efficiency and effectiveness based on a process-based approach. It focuses on meeting the needs and expectations of customers and other relevant stakeholders, through a long term balanced approach. It also provides an overarching internationally recognized and accepted management framework that enables an organization to establish the effectiveness or otherwise of its corporate governance and day-to-day activities. It is not a guide to implementing ISO 9001 and is not intended for certification. An NODC could consider as a first step, the implementation of ISO 9004 as this does not require formal certification but it does provide an excellent self-assessment tool.

ISO 19011:2011. This standard provides guidance on the principles of auditing, managing audit programmes, conducting quality management system audits, as well as guidance on the competence of quality and management system auditors. It provides an overview of how an audit programme should operate and how management system audits should take place. Effective audits ensure that an implemented QMS meets the requirements specified in ISO 9001.

ISO 9001 certification. An organization, which has implemented all the requirements of the ISO 9001 standard, may invite an external body to audit its QMS as regards its conformity with the standard. If the QMS complies with the standard, the certification body will issue ISO 9001 quality management certification and register the organization in a list of certified organizations. It should be remembered that ISO is the organization which developed the ISO 9001 Standard, but is not a certification body. Organizations independent from ISO carry out

the certification according to the ISO 9001 Standard. Certification of compliance to ISO 9001 is intended to provide confidence in the organization's ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements. ISO certification, once achieved, must be renewed at regular intervals recommended by the certification body, usually around three years. Becoming ISO 9001 certified is a rigorous process, however the benefits that can be realized include increased efficiency, increased customer satisfaction, and enhanced improvement processes. A common criticism of ISO 9001 is the amount of money, time, and paperwork required for certification.

ANNEX II. OUTLINE OF A QUALITY MANUAL FOR AN IODE NODC

1. Introduction

This section provides an introduction to the quality manual. It should contain an introduction to the NODC (stating the name, address, phone, fax, email, etc), explaining what it does and how it does it and summarizes its history and experience. It should describe the NODC's quality policy and objectives and include a statement of the Mission and Vision of the organization. It could also include a flowchart of the organization and provides a list of products and services available to users. This section should also show who reviewed and approved the quality manual for distribution and use, identify the manual's version status, including when the current version was approved and issued, describe how manual changes and revisions should be initiated, prepared, approved, and distributed, and indicate whether the manual is for internal use only, or whether it can be distributed to outsiders.

2. Scope of the Quality Management System

This section describes the scope of the QMS. The scope can include facilities, products, processes, quality management and standards.

3. Responsibility

This section lists the key responsibilities of management, including the Director, the Representative of Quality, the head of Quality Section, Technical Divisions, Administration Division and Heads of regional centres and concerned staff, with respect to the QMS.

4. Structure of the QMS

This constitutes the main section of the Quality Manual. It includes a general description the QMS requirements and flowcharts depicting processes. It also includes the description of the activities related to the following headings:

- General requirements includes the requirements for the organization to establish, document, implement and maintain a quality management system and continually improve its effectiveness in accordance with ISO 9001:2008.
- Documentation requirements includes quality policy, quality manual, quality procedures, quality Instructions, guides, records, control of documents and records.
- Management responsibility, customer focus, quality policy and objectives, planning process, internal communication and the mechanisms for management review.
- Resource management covers requirements concerning the resources needed for the effective implementation of the quality management system.
- Product realization covers requirements concerning the production cycle, which involves determining product requirements, designing the product, acquiring the raw materials, manufacturing the product and delivery of the finished product.
- Measurement, analyses and Improvement addresses requirements for monitoring and measuring the effectiveness of the quality management system of the organization, and conformity of its products, and continual improvement of the quality management system.

ANNEX III. CATALOGUE OF CRITERIA FOR WDS CERTIFICATION

1. WDS general requirements and policies (Organization specific requirements)
1.1 Signed Letter of Agreement, Intent to Cooperate or similar with ICSU 1.2 Have relevant external experts to provide advice and guidance to WDS node 1.3 Should attend WDS meetings every 2 years 1.4 Promote active communication with research community and other users 1.5 Provide full, open, timely, non-discriminatory and unrestricted access to metadata, data, products and services, at no cost or at the Cost of Fulfilling User Request (COFUR)
2. Organisational framework
2.1 The facility has defined: (a) the scope of the data and/or product (services) it offers; (b) its responsibility for the long-term preservation of its data, products and services; (c) its target user communities and their needs; (d) the rights of its users to access and use data; and (e) processes for responding to changing scientific requirements and to evolving technologies 2.2 The organizational form is adequate for the facility in terms of funding, sufficient numbers of qualified staff, organizational structure and long-term planning 2.3 Expertise of the host organisation offers local oversight (scientists, data specialists) of international repute 2.4 Maintenance of a continuity plan in the event of a host institution shift of interests or reaction to substantial changes 2.5 Facility is committed to formal, periodic review and assessment to ensure responsiveness to scientific and technological developments and evolving requirements
3. Management of data, products and services
3.1 The facility ensures integrity and authenticity of data sets during ingest, archival storage, data quality assessment and analysis, product generation and access and delivery 3. 2 The facility accepts data sets from its producers based on defined criteria for collection, selection and evaluation 3.3 Archival storage of the data sets is undertaken to defined specifications 3.4 The facility permits efficient usage of archived data sets, products and services based on defined criteria and preferably open standards (searchable, accessible, and usable objects and services)
4. Technical infrastructure
4.1 Facility functions on well-supported operating systems and other core infrastructural software 4.2 Facility is using hardware and software technologies appropriate to the services it provides to its designated community(ies) 4.3 Security: Technical infrastructure for protection of the facility and its users, data, products and services

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