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D.2.2.1. Report on requirements from GEOSS, INSPIRE, GMES, SEIS and related initiatives and projects

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These are Dublin Core metadata elements. See for more details and examples http://www.dublincore.org/

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Name
ADC	Archtecture and Data Committee
AIP-2	Architecture Implementation Pilot, Phase 2
AOC	Advanced Operating Capacity
BPEL	Business Process Execution Language
CAP	Common Agricultural
CEN	European Committee for Standardization
CRS	Coordinate Reference System
CSR	Component and Services Registry
CS-W	Catalog Service
CT	Consolidation Team
DEM	Digital Elevation Models
DOPA	Digital Observatory of Protected Areas
DoW	Description of Work
DS DS	Data Specifications Drafting Team
EbRIM	electronic business Registry Information Model
ENM	Ecological Niche Model
EO	Earth Observation
EO-DAIL	Earth Observation Data Access & Integration Layer Implementation
ERCS	Emergency Response Core Services
ESA	European Space Agency
ESDI	European Spatial Data Infrastructure
EU	European Union
FP7	Seventh Framework Programme
FTS	Fast Track Service
GAS	GMES Atmosphere Service
GCI	GEOSS Common Infrastructure

GEMS	Global and regional Earth-system (Atmosphere) Monitoring using Satellite and in-situ data (GEMS)
GEO	Group on Earth Observations
GeoRM	Geo Rights Management
GeoRSS	Geospatially-enabled RSS and Atom feeds
GEOSS	Global Earth Observation System of Systems
GIGAS	GEOSS, INSPIRE and GMES an Action in Support
GMES	Global Monitoring for Environment and Security
GSCB	Ground Segment Coordination Body
HMA	Heterogeneous Mission Accessibility
IG	Implementation Group
INSPIRE	Infrastructure for Spatial Information in Europe
IOC	Initial Operating Capacity
IPCC	Intergovernmental Panel on Climate Change
IR	Implementing Rules
ISO	International Organization for Standardization
JRC	Joint Research Centre
LMCS	Land Monitoring Core Service
MACC	Monitoring Atmospheric Composition and Climate
MCS	Marine Core Service
MS	Member State
NDVI	Normalize Difference Vegetative Index
NGO	Non-Governmental Organization
NSDI	National Spatial Data Infrastructure
O&M	Observation and Measurement
OGC	Open Geospatial Consortium
OWS	OGC Web Services
PROMOTE	PROtocol MOniToring for the GMES Service Element
QC	Quality Control
SA	Support Action

SAFER	Services and Applications For Emergency Response
SBA	Societal Benefit Area
SEIS	Shared Environmental Information System
SensorML	Sensor Markup Language
SIF	Standards and Interoperability Forum
SIR	Standards and Interoperability Registry
SOS	Sensor Observation Service
UML	Unified Modeling Language
UN	United Nations
UNEP	United Nations Environment Programme
W3C	World Wide Web Consortium
WCMC	World Conservation Monitoring Centre
WCS	Web Coverage Service
WCS-T	Web Coverage Service, Transactional
WFS	Web Feature Service
WFS-T	Web Feature Service, Transactional
WMS	Web Map Service
WPS	Web Processing Service
WP	Work Package
XML	eXtensible Markup Language

1 INTRODUCTION

EuroGEOSS demonstrates the added value to the scientific community and society of making existing geographic systems and applications interoperable and used within the GEOSS and INSPIRE frameworks. The project will build an initial operating capacity for a European Environment Earth Observation System in the three strategic areas of Drought, Forestry and Biodiversity.

The concept of inter-disciplinary interoperability requires research in advanced modelling from multi-scale heterogeneous data sources, expressing models as workflows of geo- processing components reusable by other communities, and ability to use natural language to interface with the models.

1.1 Purpose and scope

In order to develop an initial operating capacity for multidisciplinary interoperability a review of requirements from the main international projects and initiatives addressing such issue is to be done. The goal of this document is analyzing the state of the art of relevant European and international initiatives concerning multidisciplinary interoperability, namely: GEOSS, INSPIRE, GMES, GIGAS and SEIS.

The collected requirements will contribute to provide specifications, guidelines and prototypical implications in order to support the implementation of the EuroGEOSS Initial Operating Capacity (IOC) and the infrastructures in each of the thematic areas of EuroGEOSS.

2 THE GLOBAL EARTH SYSTEM OF SYSTEMS (GEOSS)

2.1 Introduction

The Global Earth Observation System of Systems will provide decision-support tools to a wide variety of users. As with the Internet, GEOSS will be a global and flexible network of content providers allowing decision makers to access an extraordinary range of information at their desk. This 'system of systems' will proactively link together existing and planned observing systems around the world and support the development of new systems where gaps currently exist. It will promote common technical standards so that data from the thousands of different instruments can be combined into coherent data sets. The 'GEOPortal' offers a single Internet access point for users seeking data, imagery and analytical software packages relevant to all parts of the globe. It connects users to existing databases and portals and provides reliable, up-to-date and user-friendly information – vital for the work of decision makers, planners and emergency managers. For users with limited or no access to the Internet, similar information is available via the 'GEONETCast' network of telecommunication satellites[1].

2.2 GEOSS Societal Benefit Areas

An objective for GEOSS is to provide decision-support tools to a wide variety of users. The Global Earth Observation System of Systems is simultaneously addressing nine areas of critical importance to people and society (hereafter SBA, Societal Benefit Areas). On each of these areas there was recognition that clear societal benefits could be derived from a coordinated global observation system.

[1] "What is GEOSS?: The Global Earth Observation System of Systems", http://earthobservations.org/geoss.shtml

In each of the SBAs, GEOSS works with the appropriate societal benefit area community to facilitate execution of delineated target actions. Achievement of these actions is necessary to realize the outcomes by societal benefit area.

The SBAs are:

- Health
- Disasters
- Weather
- Energy
- Water
- Climate
- Agriculture
- Ecology
- Biodiversity

2.3 GEOSS Architecture Overview

As a "system of systems", GEOSS is composed of contributed Earth Observation systems, ranging from primary data collection systems to systems concerned with the creation and distribution of information products. Although all GEOSS systems continue to operate within their own mandates, GEOSS systems can leverage each other so that the overall GEOSS becomes much more than the sum of its component systems.

The infrastructure that coordinates access to the systems, applications, models, and products by the SBA users is the *GEOSS Common Infrastructure* (GCI).

The GCI includes three major capabilities:

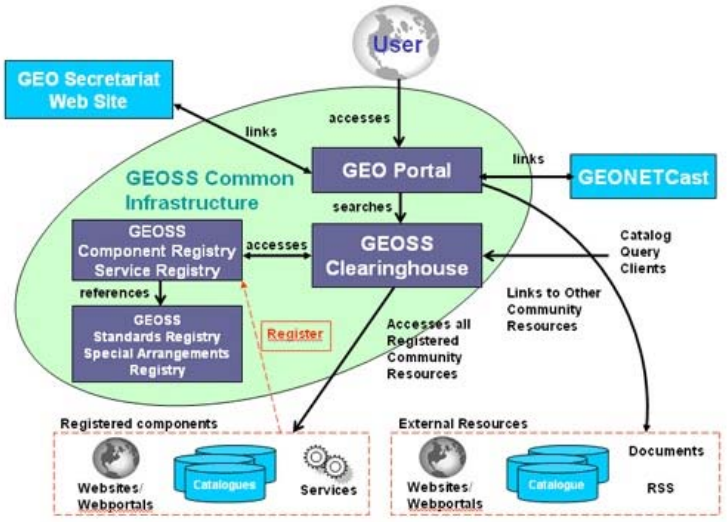
- registries of GEOSS components, services, standards, requirements, and best practices;
- a common search facility, known as the GEOSS Clearinghouse, that simplifies search across all offered and registered resources;
- a web portal that provides human users a "one stop" access to all GEOSS resources.

The infrastructure consists of four main elements:

- The GEOPortal provides the direct web interface through which the user accesses GEOSS and searches for information and services.
- The GEOSS Clearinghouse is the engine that drives the entire system. It connects directly to the various GEOSS components and services, collects and searches their information and distributes data and services via the Portal to the user.
- The GEOSS Components and Services Registry is similar to a library catalogue. All of the governments and organizations that contribute components and services to GEOSS provide essential details about the name, contents, and management of their contribution. This assists the Clearinghouse, and ultimately the user, to identify the GEOSS resources that may be of interest.
- The GEOSS Standards and Interoperability Registry enables contributors to GEOSS to configure their systems so that they can share information with other systems. This Registry is vital to the ability of GEOSS to function as a true system of systems and to provide integrated and cross-cutting information and services. Contributors can also share ideas and proposals informally via the associated Standards and Interoperability Forum.

Two key resources available through the GCI are “Components” and “Services.” A "GEOSS Component" is one of many earth observation resources that are contributed by a GEO Member or Participating organization. Example types of contributed Components include observing systems, data sets and products, catalogues, websites, models, training materials, or initiatives. Where appropriate, registered service interfaces can be defined and linked to a Component. A "GEOSS Service" describes a service interface to a component resource. Typically implemented as an Internet-accessible resource, these service interfaces promote the exchange of structured messages for the selection or processing of information.

Figure 1 - GEOSS Common Infrastructure Diagram (credits: GEOSS Web Site)



2.4 GEOSS Interoperability

GEOSS interoperability is based on non-proprietary standards, with preference to formal international standards. Interoperability is focused on interfaces, defining only how system components interface with each other and thereby minimizing any impact on affected systems other than where such affected systems have interfaces to the shared architecture.

GEOSS heterogeneous components (systems) interoperability is based on a set of Interoperability Arrangements. These arrangements are registered in GEOSS Standards and Interoperability Registry (SIR).

GEOSS Standards and Interoperability Registry is used to register and share standards and special arrangements nominated by GEO Members and Participating Organizations. Users may nominate standards or special arrangements to be included in this registry through a nomination form (registration client).

Each standard or special arrangement is given a name, a unique identifier, a description, and is classified by type of standard.

These items are reviewed for inclusion by the *Standards and Interoperability Forum* (SIF). The SIF was established to provide an oversight group to the accession of formal external standards and less formal but shared practices, known in GEOSS as “special arrangements” into the Standards and Interoperability Registry.

This group meets regularly to discuss and approve candidate external standards and practices in the registry where they are documented and named in a consistent way to promote re-use throughout GEOSS. They also work with users to facilitate the understanding and use of standards

within GEOSS. Once approved by the SIF, nominated standards are visible for GEOSS registry users.

Each implemented GEOSS service interface may be associated with one or more GEOSS-registered standards or special arrangements to promote interoperability; these linkages identify the standard service protocol, data or metadata format, schema, and other criteria that will allow client software to use it.

2.5 GEOSS Interoperability Requirements

EuroGEOSS needs to identify the GEOSS requirements concerning "interoperability", with particular regard to "multidisciplinary interoperability". In the next sections we will extract such requirements among the general requirements emerging from GEOSS.

We will also dedicate a section to the GEOSS Architecture Implementation Pilot Phase 2 (hereafter GEOSS AIP-2) which is the most recent activity in GEOSS.

2.6 GCI Consolidated Requirements

In the document "GCI Consolidated Requirements" issued by 12th march 2009 the requirements for the GEOSS Common Infrastructure (GCI) are listed and described. Globally, about 80 requirements are collected in seven categories:

- A.1 Requirements common to all GCI Components
- A.2 GEO Web Portal Requirements
- A.3 Component and Service Registry requirements
- A.4 GEOSS Clearinghouse requirements
- A.5 GEOSS Standards and Interoperability Registry requirement
- A.6 GEO Best Practices Wiki requirements
- A.7 GEO User Requirements Registry requirements

The A.5 category specifically deals with interoperability, therefore it has a particular importance for EuroGEOSS objectives, and however interoperability issues are present in other categories as well.

2.7 Requirements for Catalogue(s)

One of the key components for interoperability in the GEOSS architecture is the clearinghouse:

Users searching GEOSS catalogues will find descriptions of GEO Members and Participating Organizations and the components they support, leading directly to whatever information is needed to access the specific data or service in a harmonized way, independent of the specific provider. (GEO 2005)

For the Clearinghouse, catalogue(s) play a fundamental role since:

In this sense, the interoperable GEOSS catalogues form the foundation of a more general 'clearinghouse'. GEOSS data resources can be fully described in context, and data access can be

facilitated through descriptions of other useful analysis tools, user guides, data policies, and services (GEO 2005)

GCI Recommendations specify an important characteristic of catalogues:

In order to access resources contained within catalogue(s) of data holdings, the need to implement both distributed search and harvesting techniques is recognised and implemented, as appropriate. (GEO 2009f)(GEO 2009f)

Starting from this view the requirement A.4/5 “Clearinghouse as catalog client” specifies that:

in order to perform search and discovery of external (to GEOSS) resources, the GEOSS catalogue(s) should operate as discovery brokers. To act as community catalogues they need to provide a CSW interface and then perform queries to heterogeneous catalogue(s) (e.g. based on special interoperability arrangements)

GEOSS Clearinghouse utilizes the OGC Catalog Service protocol 2.0.2 (client) to access the Component and Service Registry and community catalogs external to the GCI. Community Catalogues shall either be searched at the time of a user query or the contents shall be harvested in advance and cached locally. (GEO 2009c)

Concerning the types of queries, GEOSS does not pose any particular problem with the exception of supporting specific concepts like SBAs and SBA sub-categories:

Users must be able to search GEOSS-registered resources, interacting with the GEOSS Clearinghouse, based on (1) location (i.e. place name, bounding box, etc.), (2) keywords or text, (3) Societal Benefit Area (SBA), (4) SBA sub-categories, and (5) temporal parameters where such properties are managed in metadata.

However, it is important to note that discovery must be supported not only on data, but also on any kind of resource (e.g. service, etc.):

GCI Component shall provide access to information content (metadata) to enable the discovery, evaluation, and integration of contributed service and data resources for decision-support systems, modelling, and related workflows. Resource metadata shall be exposed for registered data and service resources.

2.8 Requirements for specification support

In common with Spatial Data Infrastructures and services-oriented information architectures, GEOSS system components are to be interfaced with each other through interoperability specifications based on open, international standards. (GEO 2009c)(GEO 2005).

Although the adoption of international standards is proposed, GEOSS recognizes the importance to address also the existing interoperability best-practice at community level

The Standards and Interoperability Forum (SIF) was established to provide an oversight group to the accession of formal external standards and less formal but shared practices, known in GEOSS as "special arrangements," into the Standards and Interoperability Registry (SIR). Supported by the FP7 GIGAS project, an European SIF Team was set up and operated.

Moreover, the support for recent and widespread specifications for information interoperability is considered:

GCI Component supports the loading, visualization, and navigation of geospatially-enabled RSS and Atom feeds (GeoRSS). Feeds are registered by the Component and Service Registry, indexed by the GEOSS Clearinghouse, and loaded/presented by the GEO Web Portals. GEO Web Portal visualization includes mapping and selection of hyperlinks provided in the GeoRSS feed elements.

2.9 Semantic Interoperability Requirements

As part of the Best Practices Registry, create an Ontology and Taxonomy section to get an overview of available ontologies and taxonomies. Compare and analyze ontologies and taxonomies such as to avoid unnecessary overlaps and conflicts. As appropriate, develop ontologies and taxonomies stored in the Best Practices Registry into standards. (GEO 2005)

The semantic gap among the various disciplines that are involved in the project is thus addressed in GEOSS by, first, comparing and analyzing available ontologies and taxonomies. This work is done with the intent of creating an ontology registry to be incorporated in the GEOSS infrastructure.

The ontology registry will become a component of GEOSS Interoperability Infrastructure (GEO 2009d)

Thus, Catalogue(s) should be able to provide ontology-based query interface. This feature may become a crucial functionality when a processing service needs to search for appropriate input, as outlined in the GEOSS Architecture Implementation Pilot Phase 2 (AIP-2) Use Scenario "Workflow and Processing" Engineering Report.

Semantic support was provided through geospatial ontology .

2.10 Workflow Interoperability Requirements

Workflow creation/management capabilities are addressed in GEOSS by Sub-task "Model Web Development" (GEO 2009f).

Develop a dynamic modelling infrastructure (Model Web) to serve researchers, managers, policy makers and the general public. This will be composed of loosely coupled models that interact via web services, and are independently developed, managed, and operated. (GEO 2005)

The goal of the Model Web is to enable the development of a modelling infrastructure.

To achieve this, the Model Web focuses on enhancing interoperability of existing models and making their outputs more accessible (GEO 2009e).

Two requirements can be formulated from the above indication:

For interoperability the use of standard services for publishing the models (e.g. OGC Web Processing Service 1.0) is crucial.

Publication of the model outputs so that these can be used as input for other models. This second requirement can be satisfied adopting transactional data access services as described in AIP-2 "Use Cases" Engineering Report.

The workflow can embed the steps to inject the results into standard, persistent storage services through their transaction capabilities (e.g. WCS-T or WFS-T) (GEO 2009e)

Moreover, it is important to outline how ontologies are to be used in this context:

A mature model web will need mature ontologies, for example, as well as descriptors of models and the services they offer (GEO 2009e)

While from the discovery point of view ontologies were used for data description only, in this context they are used for describing the model semantic too.

2.11 GEOSS Architecture Implementation Pilot Phase 2

The GEOSS AIP-2 is the most recent activity in GEOSS. It was conducted from June 2008 to August 2009 as task of GEOSS Architecture and Data Committee (ADC).

In the context of EuroGEOSS multidisciplinary interoperability the main achievements of AIP-2 are:

- Definition and development of SBA Scenarios.
- Definition of ten general Use Cases (called transverse technology use cases) for the GEOSS SOA that transversely support all SBAs. Several of the use cases can be specialized in order to meet specific needs of SBAs.

Scenarios are narrative description of the activities of the SBA communities with minimal discussion of the implementation architecture. Scenarios provide an end user view of the value of GEOSS. Scenarios are implemented in the GEOSS architecture by use cases. Use cases describe reusable functionality of the GEOSS service oriented architecture implemented through Interoperability Arrangements. (GEO 2009e)

Many of these scenarios make use of resources belonging to more than one SBA. This makes such scenarios multidisciplinary and thus relevant to EuroGEOSS context.

Implementation of the scenarios is based on the use of ten transverse technology use cases. These implicitly define the functionalities that the system must satisfy in order to support a multidisciplinary interoperability.

The transverse technology use cases describe reusable functionality of the GEOSS service oriented architecture implemented through Interoperability Arrangements. Each generalized use case encompasses a unit of useful functionality and describes a set of actions performed by various system actors in support of one or more actors or other stakeholders interacting with the system. Within AIP-2, several generalized use cases were refined and/or specialized as needed to meet specific SBA scenario requirements. Although developed specifically for leveraging the GEOSS Common Infrastructure and Community Components, the transverse technology use cases as defined and used in AIP-2 have been designed to remain general enough to be applicable for the wide range of SBAs and community scenarios. (GEO 2009b)

This is the list of the technology transverse use cases (from (GEO 2009b)):

- Register resources in GEOSS Components and Services Registry (CSR) or Community Catalog
    - This use cases covers making information about a GEOSS resource known to the GEOSS community, and "findable" through a GEOSS Clearinghouse, by either registering the resource directly with the GEOSS CSR or registering a community catalog/metadata service in which the resource has already been registered.
- Register, in the GEOSS Standards and Interoperability Registry (SIR), new and recommended interoperability arrangements) as well as utilized standards
    - This use case covers the action of closing the loop on interoperability practices and arrangements (standard and otherwise) that have been implemented for GEOSS. The arrangements are registered and moderated in the SIR both to provide more information on what has been implemented, and to provide other GEOSS participants with an arrangement choice for registering their own resources.
- Harvest and Query Metadata via GEOSS Clearinghouse
    - This use case describes the steps for harvesting and/or querying service or content metadata from community catalogs or services via a GEOSS Clearinghouse.
- Search for Resources via GEOSS Clearinghouse(s) or Community Catalogue(s)
    - This use case describes the conditions and steps for portals and application clients to support the GEOSS user in searching for resources of interest via the GEOSS Clearinghouse(s) or Community Catalogue(s).
- Present GEOSS User with Reachable Services and Alerts
    - This use case describes the conditions and steps for portals and application clients to present the GEOSS User with the reachable services and alerts as returned by the GEOSS Clearinghouse(s) and/or Community Catalogue(s) per the user's search criteria.
- Exploit Data Visually and Analytically
    - This use case describes the conditions and steps for exploitation in Client Applications of datasets served through Web Services and online protocols as used within GEOSS.
- Deploy Resources for use in GEOSS
    - This use case identifies many of the aspects that are, or should be, common to all or multiple Web Services interface Implementation Specifications. It refers notably

to the OGC Web Services Common document, OGC Web Map Service (WMS), Web Feature Service (WFS), and Web Coverage Service (WCS), but shall encompass as well OpeNDAP and W3C W*S. Web Services common aspects include: service operation request and response encoding; and parameters included in operation requests and responses. This use case also deals with best practices for readying the service for registration in the GEOSS CSR, ensuring proper service discovery, retrieval, and testing by the GEOSS communities of practice.

- Interact with Services
    - This use case describes many of the aspects that are common to OGC Web Services (WFS, SOS, WCS, and WMS). These common aspects are primarily some of the parameters and data structures used in operation requests and responses.
- Test Services
    - Service Provider tests its service using a proper Test tool discovered in the GEOSS CSR.
- Construct and Deploy Workflow
    - This use case aims at capturing the alternative approaches to design, deploy and execute a workflow. The workflow can be described in Business Execution Language (BPEL), Sensor Markup Language (SensorML), or any other script language.

These transverse technologies (i.e. components, services, procedures) must be considered in the design of the EuroGEOSS IOC baseline.

Processing Service in GEOSS AIP-2

Among scenarios in the GEOSS AIP-2 activity, the ones developed by Climate Change and Biodiversity WG make use of processing service for cross-domain datasets. These scenarios are:

- The Impact of Climate Change on Pikas Regional Distribution
- Arctic Food Chain
- Polar Ecosystems Biodiversity Scenario

As far as data discovery is concerned, multidisciplinary interoperability is achieved by adopting the brokered SOA approach.

By analyzing multidisciplinary interoperability requirements that concern processing cross-domain datasets, the crucial component is a Processing Service. In the Polar Ecosystems Biodiversity Scenario a Normalized Difference Vegetative Index (NDVI) Processing Service, and in the other two scenarios an OGC Web Processing Service (WPS) publishing Ecological Niche Model (ENM) is available.

Thus, WPS is the component which actually interconnects resources (datasets) coming from different domains[2].

[2] NDVI can be published through an OGC WPS too

2.12 Conclusions and Remarks

GEOSS GCI and AIP-2 experiences are certainly relevant to European level with respect to methodology, user requirements and outcomes, e.g, broker SOA experimentation.

Table 1 summarizes the main multidisciplinary interoperability requirements stemming from the described GEOSS tasks.

Table 1 - GEOSS Multidisciplinary Interoperability Requirements

Requirements	Description
GR.1	Catalogue acts as a broker
GR.2	Catalogue(s) supports distributed queries
GR.3	Catalogue(s) supports harvesting
GR.4	Catalogue(s) supports queries on location, time, SBA, keyword
GR.5	Catalogue(s) supports discovery of data, services, and other resources
GR.6	Support of interoperability shared practices (special interoperability arrangements)
GR.7	Support for GeoRSS
GR.8	Catalogue(s) supports ontology-based queries
GR.9	Support (Availability) of Transactional Data Access Services
GR.10	Support (Availability) of OGC Web Processing Service

We want to stress the importance of GEOSS AIP – 2 activity as input for EuroGEOSS Project.

From the point of view of the System architecture, the SOA brokered approach was tested. In fact, through this approach it was possible to address the issues deriving from the heterogeneous environment that characterizes GEOSS. Important multidisciplinary aspects, i.e. the heterogeneous resources managing, became transparent for users and for the *SOA service consumer* components as well.

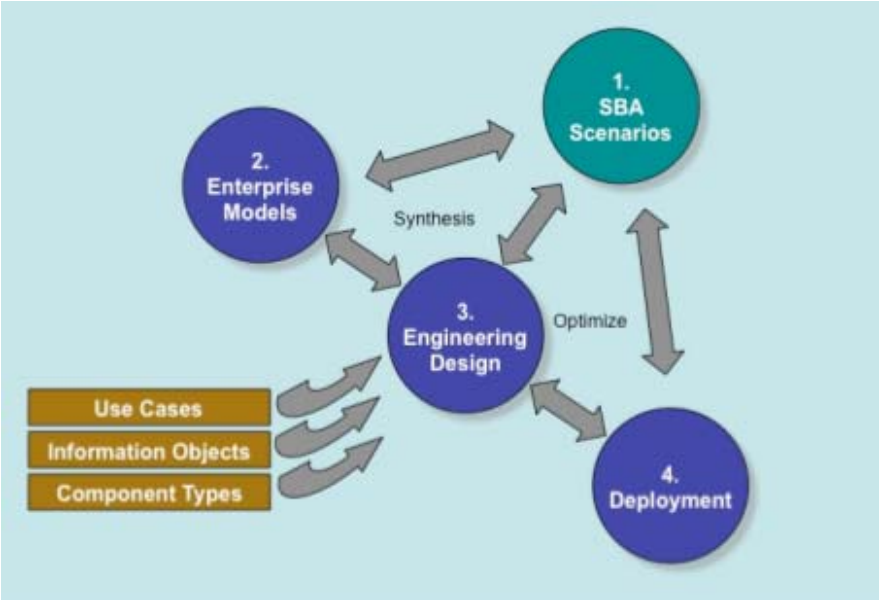
Moreover, the AIP-2 project defined and applied a *reusable process to deploy SAB Scenarios into GEOSS Architecture*. That provides a well defined and easy process for the integration of GEOSS components in support of SBA communities.

The AIP-2 process consists of four steps which are depicted in Figure 1 and described in the following (GEO 2009a):

1. **SBA Scenarios**: SBA community experts develop narrative description of the scenario with an understanding of the basic GEOSS architecture – e.g. transverse technology generalized use cases;
2. **Enterprise Models**: AIP system engineers in collaboration with community experts develop enterprise models for scenarios;
3. **Engineering Design**: AIP architects in collaboration with community experts and AIP system engineers develop optimized designs for the enterprise models by applying and refining generalized use cases;

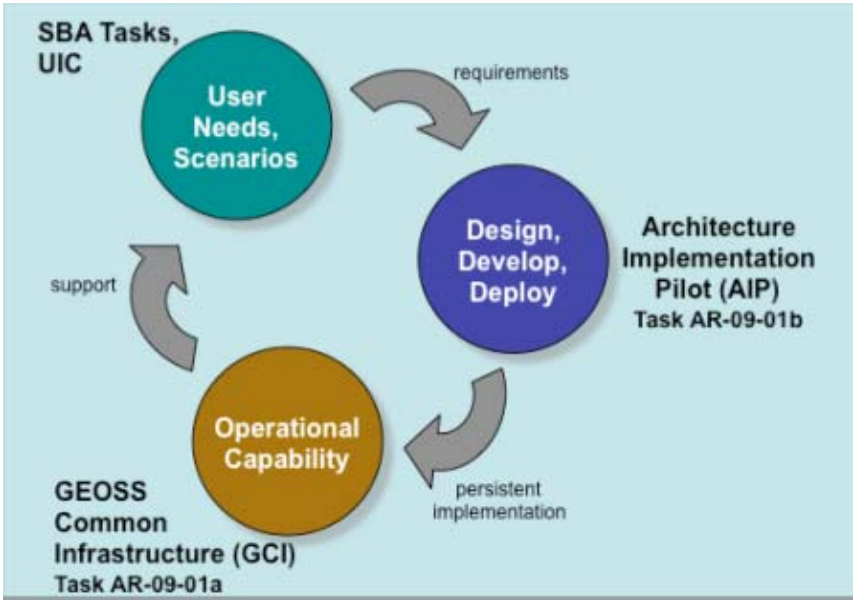
4. **Deployment**: Component providers identify, develop and register a set of components instances based upon engineering design.

Figure 2 - GEOSS Reusable SBA to SOA Process (credits: (GEO 2009a))



The above steps can be iterated in order to refine more and more each aspect of the scenario.

Figure 3– Elaboration of GEOSS Architecture (credits: (GEO 2009a))



Following the principles individuated by this process results in clear advantages from the point of view of interaction between technology experts and scientific experts in order to develop scenarios.

It is noteworthy that all steps have to be carried on by both scientific and technology experts. Step 1 is executed by scientific experts only; however, it influences and is influenced by all the other steps generating in this way collaboration between the technology and scientific parts, as well.

Finally we want to underline how the AIP task is inserted in the more general cycle which will converge to GEOSS Common Infrastructure GCI -see Figure 3.

3 INFRASTRUCTURE FOR SPATIAL INFORMATION IN THE EUROPEAN COMMUNITY (INSPIRE)

This part outlines the requirements of the European *INSPIRE Directive* (EC 2007/2) (European Parliament 2009a) that implement Initial Operation Capabilities of the project, EuroGEOSS.

The following sections briefly describe the INSPIRE Legislation, address the main structure of the INSPIRE requirements (*Implementing Rules*), provide an overview of the technical documents that support the creation of systems compliant to the INSPIRE Directive and the according Implementing Rules, and present the available INSPIRE web applications.

3.1 Introduction

The INSPIRE Directive establishes the legal framework for setting up and operating a European Spatial Data Infrastructure (ESDI) based on the infrastructures for spatial information (SDIs) of the Member States (MSs) of the European Union.

Specifically, the purpose of the INSPIRE Directive is *to "lay down general rules aimed at the establishment of the Infrastructure for Spatial Information in the European Community (hereinafter referred to as Inspire), for the purposes of Community environmental policies and policies or activities which may have an impact on the environment*. *Inspire shall build upon infrastructures for spatial information established and operated by the Member States (Article 1)".*

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) was published in the official Journal on the 25th April 2007. The INSPIRE Directive entered into force on the 15th May 2007[3].

3.2 Recommendations towards EuroGEOSS: Implementing Rules

This section summarizes the requirements for Implementing Rules based on the INSPIRE Directive. To ensure that the spatial data infrastructures of the Member States are compatible and usable in the Community and transboundary context, the Directive requires that common *Implementing Rules* (IR) were adopted in a number of specific areas: metadata, data specifications, network services, data and service sharing, and monitoring and reporting. These IRs are adopted as Commission Decisions or Regulations, and are binding in their entirety. The Commission is assisted in the process of adopting such rules by a regulatory committee composed of representatives of the Member States and chaired by a representative of the Commission (this is known as the Comitology procedure)[3].

3.2.1 Metadata Implementing Rules: Data and Services

[3] http://inspire.jrc.ec.europa.eu/

Description

The *Metadata Implementing Rules* sets out the requirements for the creation and maintenance of metadata for spatial data sets, spatial data set series and spatial data services corresponding to the themes listed in Annexes I, II and III to Directive 2007/2/EC (see 0). The Metadata Implementing Rules was adopted as Commission Regulation on the 3rd December 2008 (European Commission 2008a), and entered into force on 24th December 2008.

Requirements

The metadata describing a resource (spatial data set or spatial data set series, or spatial data set services) shall comprise the metadata elements or groups of metadata elements listed in Table 2.

Those metadata elements or groups of metadata elements shall be in accordance with the expected multiplicity (cardinality) and the related conditions set out in Table 2.

When no condition is expressed in relation to a particular metadata element, that element shall be mandatory. The table presents the following information:

- *Metadata elements*: name of the metadata element or group of metadata elements.
- *Description*: description of the metadata element.
- *Domain*: value domain of the metadata element.
- *Multiplicity*: the expression of the multiplicity follows the unified modelling language (UML) notation for multiplicity.
- *Condition*: when the multiplicity is 0..1 or 0..*, the condition defines when the metadata element is mandated.
- *Resource*: applicability; D=Metadata for spatial data sets and spatial data set series, S=Metadata for spatial data services.

Table 2 - Metadata for spatial data sets, spatial data set series and spatial data services

Metadata Elements	Description	Domain	Multiplicity	Condition	Resource
IDENTIFICATION					
Resource title	This a characteristic, and often unique, name by which the resource is known.	Free text.	1		D,S
Resource abstract	This is a brief narrative summary of the content of the resource.	Free text.	1		D,S
Resource type	This is the type of resource being described by the metadata.	Enumerated (see (European Commission 2008a), part D.1).	1		D,S
Resource locator	The resource locator defines the link(s) to the resource and/or the link to additional information about the resource.	Character string, commonly expressed as uniform resource locator (URL).	0..*	Mandatory if a URL is available to obtain more information on the resource, and/or access related services.	D,S
Unique resource identifier	A value uniquely identifying the resource.	Mandatory character string code, generally assigned by the data owner, and a character string namespace uniquely identifying the context of the identifier code	1..*		D

		(for example, the data owner).			
Coupled resource	If the resource is a spatial data service, this metadata element identifies, where relevant, the target spatial data set(s) of the service through their unique resource identifiers (URI).	Mandatory character string code, generally assigned by the data owner, and a character string namespace uniquely identifying the context of the identifier code (for example, the data owner)	0..*	Mandatory if linkage to data sets on which the service operates are available.	S
Resource language	The language(s) used within the resource.	Limited to the languages defined in ISO 639-2.	0..*	Mandatory if the resource includes textual information.	D
CLASSIFICATION OF SPATIAL DATA AND SERVICES					
Topic category	The topic category is a high-level classification scheme to assist in the grouping and topic-based search of available spatial data resources.	Enumerated (see (European Commission 2008a), part D.2).	1..*		D
Spatial data service type	This is a classification to assist in the search of available spatial data services. A specific service shall be categorized in only one category.	Enumerated (see (European Commission 2008a), part D.3).	1		S
KEYWORD	If the resource is a spatial data service, at least one keyword from (European Commission 2008a), part D.4 shall be provided. If a resource is a spatial data set or spatial data set series, at least one keyword shall be provided from the general environmental multilingual thesaurus (GEMET) describing the relevant spatial data theme as defined in Annex I, II or III to Directive 2007/2/EC.				
Keyword value	The keyword value is a commonly used word, formalised word or phrase used to describe the subject. While the topic category is too coarse for detailed queries, keywords help narrowing a full text search and they allow for structured keyword search.	Free text.	1..*		D,S
Originating controlled vocabulary	If the keyword value originates from a controlled vocabulary (thesaurus, ontology), for example GEMET[4], the citation of the originating controlled vocabulary shall be provided.	This citation shall include at least the title and a reference date (date of publication, date of last revision or of creation) of the originating controlled vocabulary.	1..*		D,S
GEOGRAPHIC LOCATION					
Geographic bounding box	This is the extent of the resource in the geographic space, given as a bounding box.	The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals.	1..*	Mandatory for services with an explicit geographic extent.	D,S
TEMPORAL REFERENCE	This metadata element addresses the requirement to have information on the temporal dimension of the data as referred to in Article 8(2)(d) of Directive 2007/2/EC. At least one of the metadata elements referred to the following elements shall be provided. The value domain of the metadata elements is a set of dates. Each date shall refer to a temporal reference system and shall be expressed in a form compatible with that system. The default reference				

[4] http://www.eionet.europa.eu/gemet

	system shall be the Gregorian calendar, with dates expressed in accordance with ISO 8601.				
Temporal extent	The temporal extent defines the time period covered by the content of the resource.	This time period may be expressed as any of the following: (i) an individual date, (ii) an interval of dates expressed through the starting date and end date of the interval, (iii) a mix of individual dates and intervals of dates.	1..*		D,S
Date of publication	This is the date of publication of the resource when available, or the date of entry into force.	There may be more than one date of publication.	0..*		D,S
Date of last revision	This is the date of last revision of the resource, if the resource has been revised.	There shall not be more than one date of last revision.	1		D,S
Date of creation	This is the date of creation of the resource.	There shall not be more than one date of creation.	1		D,S
QUALITY AND VALIDITY					
Lineage	This is a statement on process history and/or overall quality of the spatial data set. Where appropriate it may include a statement whether the data set has been validated or quality assured, whether it is the official version (if multiple versions exist), and whether it has legal validity.	Free text.	1		D
Spatial resolution	Spatial resolution refers to the level of detail of the data set. It shall be expressed as a set of zero to many resolution distances (typically for gridded data and imagery-derived products) or equivalent scales (typically for maps or map-derived products).	An equivalent scale is generally expressed as an integer value expressing the scale denominator. A resolution distance shall be expressed as a numerical value associated with a unit of length.	0..*	Mandatory for data sets and data set series if an equivalent scale or a resolution distance can be specified. Mandatory when there is a restriction on the spatial resolution for this service.	D,S
CONFORMITY					
Specification	This is a citation of the implementing rules adopted under Article 7(1) of Directive 2007/2/EC or other specification to which a particular resource conforms.	A resource may conform to more than one implementing rules adopted under Article 7(1) of Directive 2007/2/EC or other specification. This citation shall include at least the title and a reference date (date of publication, date of last revision or of creation) of the implementing rules adopted under Article 7(1) of Directive 2007/2/EC or of the specification.	1..*		D,S
Degree	This is the degree of conformity of the resource to the implementing rules adopted under Article 7(1) of Directive 2007/2/EC or other specification.	Enumerated (see (European Commission 2008a) part D).	1..*		D,S

CONSTRAINT RELATED TO ACCESS AND USE	A constraint related to access and use shall be either or both of the following metadata elements				
Conditions applying to access and use	This metadata element defines the conditions for access and use of spatial data sets and services, and where applicable, corresponding fees as required by Article 5(2)(b) and Article 11(2)(f) of Directive 2007/2/EC.	Free text. The element must have values. If no conditions apply to the access and use of the resource, 'no conditions apply' shall be used. If conditions are unknown, 'conditions unknown' shall be used. This element shall also provide information on any fees necessary to access and use the resource, if applicable, or refer to a uniform resource locator (URL) where information on fees is available.	1..*		D,S
Limitations on public access	When Member States limit public access to spatial data sets and spatial data services under Article 13 of Directive 2007/2/EC, this metadata element shall provide information on the limitations and the reasons for them. If there are no limitations on public access, this metadata element shall indicate that fact.	Free text.	1..*		D,S
ORGANISATIONS RESPONSIBLE FOR THE ESTABLISHMENT, MANAGEMENT, MAINTENANCE AND DISTRIBUTION OF SPATIAL DATA SETS AND SERVICES					
Responsible party	This is the description of the organisation responsible for the establishment, management, maintenance and distribution of the resource. This description shall include: (i) the name of the organisation as free text, (ii) a contact e-mail address as a character string.		1..*		D,S
Responsible party role	This is the role of the responsible organisation.	Enumerated (see (European Commission 2008a), part D).	1		D,S
METADATA ON METADATA					
Metadata point of contact	This is the description of the organisation responsible for the creation and maintenance of the metadata.	This description shall include: (i) the name of the organisation as free text, (ii) a contact e-mail address as a character string.	1..*		D,S
Metadata date	The date which specifies when the metadata record was created or updated.	This date shall be expressed in conformity with ISO 8601.	1		D,S
Metadata language	This is the language in which the metadata elements are expressed.	The value domain of this metadata element is limited to the official languages of the Community expressed in conformity with ISO 639-2.	1		D,S

Roadmap

Table 3 and Table 4 show the roadmap of Metadata specification adoption and implementation.

Table 3 - Metadata specification adoption

Milestone date	Article	Description
14-May-2008	5§4	Submission for opinion of the INSPIRE committee of IR for the creation and updating of metadata.
03-Dec-2008	5§4	Adoption of INSPIRE Metadata Regulation.
24-Dec-2008	5§4	Entry into force of INSPIRE Metadata Regulation.

Table 4 - Metadata specification implementation

Milestone date	Article	Description
03-Dec-2010	6(a)	Metadata available for spatial data corresponding to Annex I and II.
03-Dec-2013	6(b)	Metadata available for spatial data corresponding to Annex III.

3.2.2 Implementing Rules on Network services

Description

The INSPIRE Directive requires that INSPIRE shall build upon infrastructures for spatial information established and operated by the Member States (Article 1) and in particular that Member States shall establish and operate a network of services for the spatial data sets and services for which metadata have been created in accordance with this Directive. For this reason, the European Commission is adopting common Implementing Rules on the following *Network Services*:

- *discovery services* making it possible to search for spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata;
- *view services* making it possible, as a minimum, to display, navigate, zoom in/out, pan, or overlay viewable spatial data sets and to display legend information and any relevant content of metadata;
- *download services*, enabling copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly;
- *transformation services*, enabling spatial data sets to be transformed with a view to achieving interoperability;
- *invoke spatial data services*, allowing spatial data services to be invoked.

Those services shall take into account relevant user requirements and shall be easy to use, available to the public and accessible via the Internet or any other appropriate means of telecommunication (Article 11) and Member States shall ensure that public authorities are given the technical possibility to link their spatial data sets and services to the network referred to in Article 11.

This service shall also be made available upon request to third parties whose spatial data sets and services comply with implementing rules laying down obligations with regard, in particular, to metadata, network services and interoperability (Article 12).

Rules for implementation designed to amend non-essential elements shall, in particular, lay down technical specifications for the services referred to in Articles 11 and 12 and minimum performance criteria for those services. This should be taking into account existing reporting requirements and recommendations adopted within the framework of Community environmental legislation, existing e-commerce services and technological progress.

Requirements

In what follows, a description of the current Quality of Service requirements is given (European Commission 2008c).

Linked third party Network Services, pursuant to Article 12 of directive 2007/2/EC, shall not be taken into account in the quality of service appraisal to avoid the potential deterioration due to cascading effects. The following Quality of Service criteria relating to performance, capacity and availability shall be ensured.

- Performance:
  - The response time for sending the initial response to a Discovery service request shall be maximum 3 seconds in normal situation.
  - For a 470 Kilobytes image (e.g. 800 × 600 pixels with a colour depth of 8 bits), the response time for sending the initial response to a Get Map Request to a view service shall be maximum 5 seconds in normal situation.
  - Normal situation represents periods out of peak load. It is set at 90 % of the time.
- Capacity:
  - The minimum number of served simultaneous requests to a discovery service according to the performance quality of service shall be 30 per second.
  - The minimum number of served simultaneous service requests to a view service according to the performance quality of service shall be 20 per second.
- Availability:
  - The probability of a Network Service being available, shall be 99% of the time.

Roadmap

The Network Services have been adopted as a commission Regulation on 19th October 2009 (Discovery and View services). Implementing rules for Download and Transformation were voted favourably by the INSPIRE Committee on 14th December 2009 and will need to go through the scrutiny of the European Parliament in 2010. Drafts are available on the INSPIRE web page[5] (INSPIRE Network Service Drafting Team 2009) (Network Services Drafting Team 2009a) (European Commission 2008c). Table 5 and Table 6 show the roadmap of Network Services specification adoption and implementation.

[5] http://inspire.jrc.ec.europa.eu

Table 5 - Network Services specification adoption

Milestone date	Article	Description
19-Dec-2008	16	Submission for opinion of the INSPIRE committee of IR for discovery and view services.
19-Oct-2009	16	Adoption of INSPIRE Regulation on discovery and view services.
14-Dec-2009	16	Favourable vote of the INSPIRE committee of IR for download services.
14-Dec-2009	16	Favourable vote of the INSPIRE committee of IR for transformation services.
June 2012[6]	16	Submission for opinion of the INSPIRE committee of IR for the services allowing spatial data services to be invoked.

Table 6 - Network Services specification implementation

Milestone date	Article	Description
October 2011[7]	16	Discovery and view services operational.
June 2012[6]	16	Download services operational.
June 2012[6]	16	Transformation services operational.

3.2.3 Network Services: Discovery Service

Description

The INSPIRE Directive asks Member States in article 11(1) (a) to establish and operate a network of services for the discovery of spatial data sets and services "for which metadata have been created". "Discovery services making it possible to search for spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata."

INSPIRE Discovery Services shall provide the functionality for users both to manage and search catalogues for the purpose of discovery and evaluation within the context of the INSPIRE Directive. The network of services should also include the technical possibility to enable public authorities to make their spatial datasets and services available. The INSPIRE Directive specifies that Member States shall ensure that public authorities are given the technical possibility to link their spatial datasets and services to the network. This "linking" service is also offered in the context of a discovery service as a "capability" of the discovery service.

Requirements

The *Network Services Commission Regulation* (European Commission 2008c) establishes the following requirements:

- *Search Criteria*: in order to conform to the minimum set of search criteria set out in Article 11(2) of Directive 2007/2/EC, the Discovery Service shall support searching with the INSPIRE metadata elements listed in Table 7.

[6] Date proposed by the commission

[7] Date depending on entry into force of measure

Table 7 - Search criteria

Minimum search criteria	INSPIRE metadata elements
Keywords.	Keyword.
Classification of spatial data and services (For spatial data sets and spatial data set series)	Topic category[8].
Classification of spatial data and services (For spatial data services)	Spatial data service type.
The quality and validity of spatial data sets	Lineage.
The quality and validity of spatial data sets.	Spatial resolution.
Degree of conformity with the implementing rules provided for in Article 7(1) of Directive 2007/2/EC.	Specification.
Degree of conformity with the implementing rules provided for in Article 7(1) of Directive 2007/2/EC.	Degree.
Geographical location.	Geographic bounding box.
Conditions applying to the access to and use of spatial data sets and services.	Conditions applying to access and use.
Conditions applying to the access to and use of spatial data sets and services.	Limitations on public access..
The public authorities responsible for the establishment, management, maintenance and distribution of spatial data sets and services.	Responsible party.
The public authorities responsible for the establishment, management, maintenance and distribution of spatial data sets and services.	Responsible party role.

The INSPIRE metadata elements or set of elements in Table 8 shall be also available as search criteria.

To allow for discovering resources through a combination of search criteria, logical and comparison operators shall be supported.

Table 8 - Additional Resource Elements available as search criteria

Additional Resource Elements available as search criteria
Resource Title
Resource Abstract
Resource type
Unique Resource Identifier
Degree of conformity with the implementing rules provided for in Article 7(1) of Directive 2007/2/EC.
Temporal Reference

[8] http://inspire-registry.jrc.ec.europa.eu/registers/GLOSSARY/items/164

To allow for discovering resources based on the geographic location of the resource, the spatial operator listed in Table 9 shall be supported.

Table 9 - Spatial operators for discovery services

Operator Name	Property
Intersects	Requires the Geographic Bounding Box INSPIRE metadata element to intersect a defined Area of Interest.

- *List of operations:*

In order to be in conformity with the Directive 2007/2/EC, the Discovery Service shall provide the operations listed in Table 10 (Article 11(1)) and in Table 11 (Article 12).

Table 10 - List of Operations (Article 11(1))

Operation	Role
Get Discovery Service Metadata	Provides all necessary information about the service and describes service capabilities.
Discover Metadata	The Discover Metadata operation allows requested INSPIRE metadata elements (of resources based on a query statement) to be retrieved from the target Discovery Service.

Table 11 - List of Operations (Article 12)

Operation	Role
Publish Metadata	The Publish Metadata operation allows INSPIRE metadata elements of resources in the Discovery Service (push or pull metadata mechanisms) to be edited. Editing means to either insert, update and/or delete.
Link Discovery Service	The Link Discovery Service function allows the declaration of the availability of a Discovery Service for the Discovery of resources (through the Member State Discovery Service) while maintaining the resource metadata at the owner location.

The request and response parameters of each operation complete the description of each operation and form an integral part of the Discovery Service technical specification (see (European Commission 2008c), Annex 2).

Roadmap

(See Table 5 and Table 6)

3.2.4 Network Services: View Service

Description

The INSPIRE Directive asks Member States in article 11(1) (b) to establish and operate "*view services making it possible, as a minimum, to display, navigate, zoom in/out, pan or overlay viewable spatial data sets and to display legend information and any relevant content of metadata*".

Where public authorities levy charges for view services, the Member States shall ensure that e-commerce services (including rights management services) are available (article 14(4)).

Requirements

The *Network Services Commission Regulation* (European Commission 2008c) establishes the following requirements:

- *List of operations*

In order to be in conformity with Article 11(1) of the Directive 2007/2/EC, the View Service shall provide the operations listed in Table 12.

Table 12 - List of Operations (Article 11(1))

Operation	Role
Get View Service Metadata	Provides all necessary information about the service and describes service capabilities.
Get Map	Returns a map containing the geographic and thematic information coming from the available spatial datasets. This map is an image spatially referenced.

In order to be in conformity with Article 12 of Directive 2007/2/EC, the view Service shall support the operations listed in Table 13.

Table 13 - List of Operations (Article 12)

Operation	Role
Link View Service	Allows a Public Authority or a Third Party to declare a view Service for the viewing of its resources through the Member State View Service while maintaining the viewing capability at the Public Authority or the Third party location.

The request and response parameters of each operation complete the description of each operation and form an integral part of the Network Services technical specification (see (European Commission 2008c), Annex 3).

- *Other Characteristics*

The View Service shall have the following characteristics:

- *Coordinate Reference Systems*: the layers shall be simultaneously viewed using a single Coordinate reference system and the View Service shall support at least the Coordinate Reference Systems in Annex I, point 1 of Directive 2007/2/EC.
- *Image Format:* the View Service shall support at least one of the following image formats: a) the Portable Network Graphics (PNG) format; b) the Graphics Interchange Format (GIF), without compression.

Roadmap

(See Table 5 and Table 6)

3.2.5 Monitoring and Reporting

Description

In order to have a solid basis for decision making related to the implementation of INSPIRE Directive and to the future evolution of INSPIRE, continuous monitoring of the implementation of the Directive and regular reporting are necessary.

Monitoring and reporting have to cover the 4 main fields of INSPIRE Directive: metadata, spatial data sets and services, network services, data sharing. Monitoring follows a quantitative approach and takes place every year, while reporting covers more qualitative aspects and takes place every 3 years.

Article 21 of INSPIRE Directive defines the basic principles for monitoring and reporting and specifies that detailed rules for the implementation of this Article will be adopted by the Commission.

Requirements

The implementing rules for monitoring and reporting consist of two parts, one for monitoring and one for reporting. The *Implementing rules regarding INSPIRE monitoring and reporting* establish the following requirements (European Commission 2009)(summary):

- *Monitoring* follows a quantitative approach and is based on a list of spatial data sets and services of the Member States. The list should cover already conformant data sets and services as well as those that still have to be brought into conformity. This list should basically reflect the Member State's plans for the implementation of INSPIRE. Based on the information collected for all the items of the list, indicators can be calculated to evaluate:
    - Existence of metadata for spatial data sets and services.
    - Conformity of metadata for spatial data sets and services with the implementing rules on metadata.
    - Geographical coverage of spatial data sets.
    - Conformity of spatial data sets with the data specifications and of their metadata with the implementing rules on metadata.
    - Accessibility of metadata for spatial data sets and services through discovery services.
    - Accessibility of spatial data sets through view and download services.
    - Use of network services.
    - Conformity of network services to the implementing rules on network services.
- *Reporting* follows a qualitative approach. Member states will provide information on five main areas:
    - Coordination and quality assurance, including information on the Member State contact point and the coordination structure, as well as a description and evaluation of the quality assurance procedure, including measures taken to improve it.
    - Contribution to the functioning and coordination of the infrastructure, including an overview of the stakeholders and of their roles, the measures taken to facilitate sharing and a description on how they cooperate
    - Use of the infrastructure for spatial information, in general and by public authorities in particular; examples of cross border use and efforts made to improve it.

- Data sharing arrangements between public authorities of the Member State, between public authorities and Community institutions and bodies as well as barriers to sharing.
- Cost and benefit aspects, that is an estimate of the costs related to INSPIRE Directive and examples of the observed benefits.

All results of monitoring and reporting will be made available to the public on the Internet.

Roadmap

Implementing rules regarding INSPIRE monitoring and reporting received the positive opinion of the INSPIRE Committee in December 2008 and have been adopted as COMMISSION decision regarding INSPIRE monitoring and reporting on the 5th of June 2009 (European Commission 2009). The first monitoring and reporting is due by 15th of May 2010.

Table 14 and Table 15 summarize the roadmap of Monitoring and Reporting specification for adoption and implementation, respectively.

Table 14 - Monitoring and Reporting specification adoption

Milestone date	Article	Description
19-Dec-2008	21(4)	Submission for opinion of the INSPIRE committee of IR for monitoring and reporting.
05-Jun-2009	21(4)	Adoption of COMMISSION DECISION regarding INSPIRE monitoring and reporting.

Table 15 - Monitoring and Reporting specification implementation

Milestone date	Article	Description
15-May-2010	21§1 21§2	Implementation of provisions for monitoring and reporting.

3.2.6 Network services: Download Service

Description

The INSPIRE Directive asks Member States in article 11(1) (c) to establish and operate a network of "download services, enabling copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly". In addition, where public authorities levy charges for the download services, Member States shall ensure that e-commerce services (including rights management services) are available (article 14(4)).

A download service supports:

- download of a complete dataset or datasets, or
- a part of a dataset or datasets, and
- where, practicable, provides direct access to complete datasets or parts of datasets,
- gazetteer like services are also covered by a type of download service.

In the context of INSPIRE and the scope of the Implementing Rules, datasets are restricted to the categories defined by the Annexes I-III (see Article 4), where exist, and where they are updated according to Article 5 and where spatial datasets are interoperable and harmonised according to Article 7-10 of the INSPIRE Directive.

It is worth noting that the conceptual or application schema of a local or national spatial data set may and will often differ from the INSPIRE harmonised specification of the spatial object types in the data specification. In this case, a download service may transform content between the application schema of the spatial dataset and the harmonised schema on-the-fly, if possible, or a transformation service may be invoked. Alternatively, a Member State may provide a download service based on derived datasets converted in advance of receiving the query. Search criteria need to support a variety of criteria, including spatial and temporal extents, metadata elements, and feature properties.

Requirements (under preparation)

Download services are coupled to the data sets to which they give access. Member States shall implement download services that provide access to every spatial data set within the scope of Article 4 of the INSPIRE Directive.

The implementing rule describes download services at a generic level, that is, independent of the concrete underlying INSPIRE theme. The draft version of *Implementing Rules for Download Services* (INSPIRE Network Service Drafting Team 2009) is available and provides the description of the functions and elements, the download output format, the geo-rights managements and the Quality of Service requirements (performance, capacity and availability):

- *Spatial objects*: the spatial object types and associated attributes shall be compliant with the Implementing Rules on Interoperability of Spatial Data Sets and Services.
- *Query in the case of download services*: in the context of INSPIRE, the spatial data set relate to one or more of the themes listed in Annexes I, II or III. The result of applying a query will be a part of the data set or data sets, as required by the directive. This implementing rule requires that a query expression shall be able to select spatial objects based on all aspects defined by the implementing rules for the interoperability of data sets and services. Predicates in a query expression shall be applied to appropriate properties of the spatial object types. General predicates can be applied to other data types or between predicates of any kind. A query expression shall include one or more of the predicate types as defined in 2.7.4 of the draft implementing rule (INSPIRE Network Service Drafting Team 2009).

A download service can either download a pre-defined data set or pre-defined part of a data set, or give direct access to the spatial objects contained in the data set (the service metadata elements shall specify if the service is a direct access download service or not), and download selections of spatial objects based upon a query:

- A *pre-defined data set* will represent a full or partial Member State part related to one or more of the INSPIRE themes. It will be available in one of the Coordinate Reference Systems according to the implementing rule for coordinate reference systems of Annex I of the INSPIRE Directive, if applicable, and be expressed in an INSPIRE encoding specified by the corresponding INSPIRE Implementing Rule on the interoperability of spatial data sets and services, if applicable. In the case of pre-defined data sets or pre-defined parts of data sets, the corresponding INSPIRE metadata elements shall be available through the INSPIRE discovery service. If applicable, the metadata shall include a list of spatial object types, in conformance with the corresponding INSPIRE Implementing Rule on the interoperability of spatial data sets and services.
- Direct access download service: the directive states that Member State shall operate download services enabling “copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly”. In the case where the download service provides access to the spatial objects contained in the data set based upon a query it is defined as a direct access download service.

Every spatial object accessed through an INSPIRE Download Service shall conform to a spatial object type specified by an INSPIRE Implementing Rule on the interoperability of spatial data sets and services. The service shall also provide description of the spatial object type as specified by such INSPIRE Implementing Rule.

Download services shall be described by service metadata and be discovered using a Discovery service.

The *Draft Implementing Rules for Download Services* (INSPIRE Network Service Drafting Team 2009) establish the following requirements:

***Download Service functions*:**

- Table 16 and Table 17 summarize the INSPIRE Download Service functions.

Table 16 - Download services functions for non-direct access

Function	Description	M/O/C
Get Download Service Metadata	Provides metadata about the service and data sets offered by the service to a user and describes service capabilities. Shall at least contain the INSPIRE metadata elements defined for spatial data services as described by the Metadata Implementing Rule.	M
Get Spatial Objects	The Get Spatial Objects operation allows spatial object instances to be retrieved. In the case of non-direct access, the operation will retrieve a pre-defined data set or a pre-defined part of a data set. In the case of download service of a pre-defined data set or pre-defined part of data set, the operation shall return spatial objects in at least one of the Coordinate Reference Systems (CRS) defined by the Implementing Rule the Annex 1 theme coordinate reference systems.	M
Describe Spatial Object Types	The Describe Spatial object Type operation generates a description of the spatial object types that the service offers. In the case of download service of a pre-defined data set or pre-defined part of data set, the function shall return the description of the complete set of spatial object types contained in the data set or part of data set.	O
Link Download Service	Allows the declaration of a Download Service for downloading of its resources through the Member State Download Service while maintaining the downloading capability at the Public Authority or the Third party location.	M

M/O/C: Mandatory/Optional/Conditional

Table 17 - Download services functions for direct access

Function	Description	M/O/C
Get Download Service Metadata	Provides metadata about the service and data sets offered by the service to a user and describes service capabilities. Shall at least contain the INSPIRE metadata elements defined for spatial data services as described by the Metadata Implementing Rule.	M
Get Spatial Objects	The Get Spatial Objects operation allows spatial object instances to be retrieved. In the case of direct access, the retrieval can be based on an optional query defined by the Define Query operation. In the case of direct access the operation shall support user requested CRS belonging to the	M

	INSPIRE defined CRSs.	
Describe Spatial Object Types	The Describe Spatial object Type operation generates a description of the spatial object types that the service offers. In the case of a direct access download service, the function can have as parameter a set of named spatial object types for which the description is requested.	O
Define Query	Defines a query to be used in the Get Spatial Objects operation. The predicates shall express selection criteria based upon the model of the data sets as defined by an INSPIRE Implementing Rule on the interoperability of spatial data sets and services. This function is applicable only in the case of direct access download service. The capability to define a query is mandatory, but a query can be omitted in a concrete Get Spatial Objects request.	M
Link Download Service	Allows the declaration of a Download Service for downloading of its resources through the Member State Download Service while maintaining the downloading capability at the Public Authority or the Third party location.	M

Additionally to the functions, an INSPIRE Download Service must follow rules for the elements described in the Implementing Rules (Nature of Metadata, Coordinate Reference Systems and Temporal data dimension).

- *Download Output Format – encoding:* the result of an INSPIRE Download Service is one or more data sets containing instances of spatial objects in conformance with the implementing rule for the interoperability of spatial data sets and services. Such a data set or data sets will be in a format according to some encoding principles, or, encoding for short.
  The Download Services shall support at least one of the encodings defined by the corresponding specification of the INSPIRE themes, if applicable.
- *Geo Rights Management*: Member States may allow restricted access to spatial data sets and services, and/or license, and/or require payment from, the public authorities or institutions and bodies of the Community that use these spatial data sets and services. Security, protection and rights management aspects shall be as transparent as possible for service users. Any functionality of this kind shall be compatible with digital right managements and restriction of access and use as envisioned in the INSPIRE Directive. When access to a download service is restricted, then the following elements shall be given as part of the Get Download Service Metadata response: *a) Access constraints ty*pe of constraints for accessing the download service; b) *Fees information about p*ricing/licensing.

- *Quality of Service*

  o *Performance*: Table 18 presents the Download Services performance requirements.

Table 18 - Performance for Download Services

Operation	Response time
Get Download Service Metadata	10 seconds in normal situations *).
Get Spatial Objects	30 second initial response, then the service shall maintain a sustained response > 0,5 MB/s, alternatively 500 spatial objects/s in normal situations *) This performance requirement is applied only in the case where the query consis*t of a bounding bo*x only.

Describe Spatial Object	Types 10 seconds initial response, then the service shall maintain a sustained response > 0,5 MB/s, alternatively the attribute values of 500 spatial object types per s in normal situations *) .
Define Query	Performance criteria are not applicable.

*) Normal situation represents periods out of peak load. It is set at 90% of the time.

- *Capacity:* 10 requests per second. The service may limit the number of requests processed in parallel to 50.
- *Availability*: 99%.

Roadmap

(See Table 5 and Table 6)

3.2.7 Network services: Transformation Service

Description

The INSPIRE Directive requires, in Article 11(1)(d), Member States to *"establish and operate a network of … transformation services, enabling spatial data sets to be transformed with a view to achieving interoperability"*.

The Transformation Service, as presented in the Directive, is an individual, independent spatial processing service. Instead of relying on this kind of transformation service, a data provider can set up the same transformation as an internal function of a Download Service. The function can be realized as a batch process resulting in a conforming service database or as an on-the-fly transformation organized on top of a native database. For service performance and robustness reasons this is the recommended way for achieving INSPIRE-compliancy through data transformations. However, these approaches are entirely internal to the data provider and thus out of scope from Transformation Service definition point of view.

When connected with a Pre-defined data set Download Service, the Transformation Service carries out only data transformation from a local form into the corresponding INSPIRE-specified common form. If a Transformation Service is combined with a Direct Access Download Service, the Transformation Service might be required to carry out a two-way transformation, because the data query potentially has to be transformed (from the common form to the native form). In practical terms this might involve transforming the bounding box of the query sentence from the common coordinate reference system into the system used natively, or transforming other query predicates, expressed in terms of the common schema, to the equivalent expressions in the native schema. The Transformation Operation assumes the availability of data models and mapping allowing the transformation of the input spatial data to be performed unequivocally and with the declared and expected accuracy.

Requirements (under preparation)

The draft version of the *Implementing Rules for Transformation Services* (Network Services Drafting Team 2009a) contains a high level description of the service, the list of the operations and the Quality of Service requirements:

***List of Operations*:**

- Table 19 gives the list of operations of the Transformation Service.

Table 19 - List of operations of the Transformation Service

Operation	Description	M/O/C
GET SERVICE METADATA	Provides access to service metadata, like information about the supported transformation category, supported transformations, accepted input data types, supported model definition and mapping languages etc.	M
TRANSFORM	Carries out the actual transformation process. The parameters of this operation are detailed in a subsequent table.	M
IS TRANSFORMABLE	By this request the calling application can ascertain, if the given transformation can be performed by the transformation service. Used to avoid unnecessary effort in the case of an impossible transformation.	O
GET TRANSFORMATION	Enables the calling application to retrieve the definition of a specific transformation. This definition can be used as input parameter in a subsequent TRANSFORM -operation.	O
PUT TRANSFORMATION	Enables the calling application to store a transformation definition into the service. This transformation can be referenced later on in a TRANSFORM -operation.	O

- *Quality of Service*

  - *Performance*: the performance requirements for the concrete types of INSPIRE Transformation Services are to be defined in the respective Technical Guidance documents. (As an example, the following value is given for a Coordinate Transformation Service carrying out a simple map projection on an input data set consisting of GML-encoded feature data with only geometric properties included: 1 MB/s with 2 MB/s initial response time).
  - *Capacity:* transformation Service is required to support 5 requests per second.
  - *Availability:* the probability of the Transformation Service to be up shall be 99%.

Roadmap

(See Table 5 and Table 6)

3.2.8 Network services: Invoke spatial data services

Description

The INSPIRE Directive asks Member States in Article 11(1)(e) to establish and operate a network of “services allowing spatial data services to be invoked”. In addition, where public authorities levy charges for invoke spatial data services, Member States shall ensure that e-commerce services (including rights management services) are available (Article 14(4)).

The “Invoke Spatial Data Service” service allows defining both the data inputs and data outputs expected by the spatial service and define a workflow or service chain combining multiple services. It also allows the definition of a web service interface managing and accessing (executing) workflows or service chains.

The “Invoke Spatial Data Services” service supports invoking individual (spatial) services, as well as combinations of individual (spatial) services both synchronous and asynchronous, in service chains through a (web) service orchestration engine a.k.a. “workflow engine”. The service chains are expressed in a standard (e.g. XML-based) notation that can be consumed by commercial as well as open-source orchestration engines from multiple sources.

For spatial data services available on the Internet, the "Invoke Spatial Data Service" service will enable a user or client application to run them without requiring the availability of a GIS. This requires that a client application can discover the service, bind to it and invoke it. The orchestration/combination of Spatial Data Service with other services will require the precise definition the interactions between services. Therefore, the interaction between the (spatial) services to be invoked is defined as a workflow or composite service in a standard notation (e.g. XML-based).

Requirements (under preparation)

The specification work for invoking spatial data service is in progress, as there seems no stable and well-established approach available.

Roadmap

(See Table 5 and Table 6)

3.2.9 Data Specification

Description

The INSPIRE Directive addresses the possibilities to store, maintain and retrieve information on relevant topics enumerated in the Annex I, II and III of the INSPIRE Directive, in a consistent way for the complete European Community. Although there is no thematic hierarchy in the INSPIRE Directive, each theme represent a cluster/collection of different data sets.

The Annex I contains the thematic areas of Coordinate Reference Systems, Geographical Grid Systems, Geographical Names, Administrative Units, Addresses, Cadastral Parcels, Transport Networks, Hydrography, Protected Sites.

Annex II listed following themes: Elevation, Land Cover, Orthoimagery, and Geology.

Annex III comprises Statistical Units, Buildings, Soil, Land Use, Human Health and Safety, Utility and Governmental Services, Environmental Monitoring Facilities, Production and Industrial Facilities, Agricultural and Aqua-cultural Facilities, Population Distribution – Demography, Area management/Restriction/Regulation Zones and Reporting Units, Natural Risk Zones, Atmospheric Conditions, Meteorological Geographical Features, Sea Regions, Bio-geographical Regions, Habitats and Biotopes, Species Distribution, Energy Resources, Mineral Resources.

For all the listed themes, expert teams of the European Member States define common data contents following different timelines (see

Table **20** and Table 21). The data content is binding in order that information on these topics is provided, i.e. Member States must provide ways to access their data according to the common requirements.

Requirements (under preparation)

The *Implementing Rules for Data Specification* of the Annex I themes are available on the INSPIRE web page[9] . They were submitted to the INSPIRE Committee, and voted favourably on the 14ty December 2009. They will go through the scrutiny of the European Parliament in 2010. The drafts for data specifications contain UML models with the requested feature types, their attributes, relations, cardinalities and types. The final legally binding implementing rules will describe the models in textual and tabular form.

[9] http://inspire.jrc.ec.europa.eu

In addition to the data content for the annex themes, the datasets have to be described with appropriate metadata. In the *INSPIRE Directive's* Article 5, basic aspects for the metadata, especially concerning quality, accessibility and responsibility are formulated.

Moreover, the INSPIRE Directive formulates (in Article 11) the obligation for the Member States to offer network services to access and use spatial data and its according metadata. The Services include mechanisms to discover, visualise and download the data of the INSPIRE Annexes. Additionally, services should be set up to perform transformations on the spatial data and to invoke geodata services.

Roadmap

Table 20 anTable 21 show the roadmap about the data specification adoption and implementation.

Table 20 - Data specification adoption

Milestone date	Article	Description
14-Dec-2009	9(a)	Favourable vote of the INSPIRE committee of IRs for the interoperability of spatial data sets and services for Annex I spatial data themes
15-May-2012	9(b)	Submission for opinion of the INSPIRE committee of IRs for the interoperability of spatial data sets and services for Annex II and III spatial data themes

Table 21 - Data specification implementation

Milestone date	Article	Description
June 2012[10]	7§3, 9(a)	Newly collected and extensively restructured Annex I spatial data sets available
January 2015[10]	7§3, 9(b)	Newly collected and extensively restructured Annex II and III spatial data sets available
June 2017[10]	7§3, 9(a)	Other Annex I spatial data sets available in accordance with IRs for Annex I
30-May-2019	7§3, 9(b)	Other Annex II and III spatial data sets available in accordance with IRs for Annex II and III

3.2.10 Data and Service sharing

Description

Article 17(8) of INSPIRE Directive requires the development of implementing rules to regulate the provision of access to spatial data sets and services from Member States to the institutions and bodies of the Community.

Principles for the sharing of spatial data sets and services between public authorities within and between Member States are contained directly in the Directive; the definition of the concrete measures to be implemented to this end is left to the responsibility of each Member State and is not within the scope of these implementing rules.

Requirements (under preparation)

[10] Date depending on entry into force of measure

The main points of the *Draft Regulation on INSPIRE Data and Service Sharing* (European Parliament 2009b) are the following, mainly related to the EC's institutions or bodies.

- *Restrictions on access: upon request by the Community institution or body, Member States shall give reasons for any limitation of sharing pursuant to Article 17(7) of Directive 2007/2/EC. Member States may state under which conditions access is restricted in accordance with Article 17(7).*
- *Arrangements: any arrangements concerning access to spatial data sets and services shall be fully compatible with the requirements of this Regulation. The definitions laid down in Article 3 of Directive 2007/2/EC shall be used in any arrangements concerning access to spatial data sets and services.*
- *Use of spatial data sets and services:*
  - Institutions or bodies of the Community may make spatial data sets or services available to contractors acting on their behalf.
  - Where spatial data sets and services are made available in accordance with paragraph 1, Community institutions and bodies shall make every possible effort to avoid unauthorised use of spatial data sets and services.
  - Where a spatial data set or service has been made available pursuant to paragraph 1, the party who received it may not make the spatial data set or service available to any other party without the written consent of the original data or service provider.
- *Metadata:* Conditions applicable to the Community institutions and bodies in compliance with this Regulation shall be expressed in metadata element 8.1, referred to in Part B of the Annex to Commission Regulation (EC) No 1205/200811.
- *Transparency:*
  - Where an institution or body of the Community requests the provision of access to a spatial data set or service, the Member States shall also make available, upon request, information for its evaluation and use. This should include the mechanisms for collecting, processing, producing, quality control and obtaining access to the spatial data sets and services, where that additional information is available and it is reasonable to extract and deliver it.
  - Where requested, offers for the provision of access to spatial data sets and services to the Community institutions and bodies made by Member States shall include the basis for charges and the factors taken into account.
- *Response Times*: Member States are requested to provide access to spatial data sets and services without delay and at the latest within 20 days after receipt of a written request; mutual agreements may allow an extension of this standard deadline.

Roadmap

Table 22 shows the roadmap about the data and service sharing specification adoption and implementation.

Table 22 - Data specification adoption

[11] OJ L 326, 4.12.2008, p. 12.

Milestone date	Article	Description
05-Jun-2009	17(8)	Submission for opinion of the INSPIRE committee of IR governing the access rights of use to spatial data sets and services for Community institutions and bodies
December 2009[12]	17(8)	Adoption IR governing the access rights of use to spatial data sets and services for Community institutions and bodies

3.3 Technical Documents

This section provides an overview of the technical documents that support the creation of systems compliant to the INSPIRE Directive and the according Implementing Rules.

Specifically, it presents the *Technical Guidelines* that are informative guidance documents to help set up systems compliant to the *INSPIRE Directive,* the according *Implementing Rules*, and to existing international standards and specifications.

3.3.1 Metadata

The *INSPIRE Metadata Implementing Rules: Technical Guidelines based on EN ISO 19115 and EN ISO 19119* (Drafting Team Metadata & European Commission Joint Research Centre 2009) makes it possible to implement the INSPIRE Metadata Regulation in a way that is compatible with ISO standards.

The technical guidelines: (i) compare the core requirements of ISO 19115 and ISO 19119, (ii) list INSPIRE specific constraints and extensions, and *(iii)* describe basic and detailed mappings between the metadata elements of INSPIRE, as defined in the INSPIRE implementing rules for metadata, and ISO 19115/ISO 19119.

An INSPIRE metadata editor has been made available through the INSPIRE Community Geoportal. The INSPIRE Metadata editor makes it possible to create INSPIRE compliant metadata and to download it as an xml file.

3.3.2 Network Services

The following technical guidelines are available for each network service:

- *The Technical Guidance Discovery Services (2.0)* document (Network Services Drafting Team 2009b) maps and extends the abstract functions of the INSPIRE discovery service as described in the Implementing Rules to the concrete functions of the *OpenGIS Catalogue Service Implementation Specification* (Open Geospatial Consortium 2007).
- The INSPIRE View Service Technical Guidance (Version 2.0) (Network Services Drafting Team 2009a) maps and extends the functions described in the Implementing Rules to the interface described by the ISO 19128:2005(E) international standard (ISO/TC 211 2005). Additionally minimum requirements towards compliance are made, Quality of Service requirements are specified, the INSPIRE profile of Tiling Web Map Service (WMS) is considered for future work and the extension for multilingualism capabilities is defined.
- The *Draft Technical Guidance for INSPIRE Download Services (version 2.0)* (Network Services Drafting Team 2009b) is split into the mapping of INSPIRE implementing rules for: *(i)* download services for pre-defined data sets or pre-defined parts of data sets (they have a metadata record and can be discovered using an INSPIRE conformant discovery service, and the metadata contains a URL whereby the data set (or a part of it) can be immediately downloaded by a simple HTTP-protocol GET-request); and *(ii)* direct access download services including a query capability (refers to direct access the capability of a

[12] Under scrutiny by European Parliament and Council

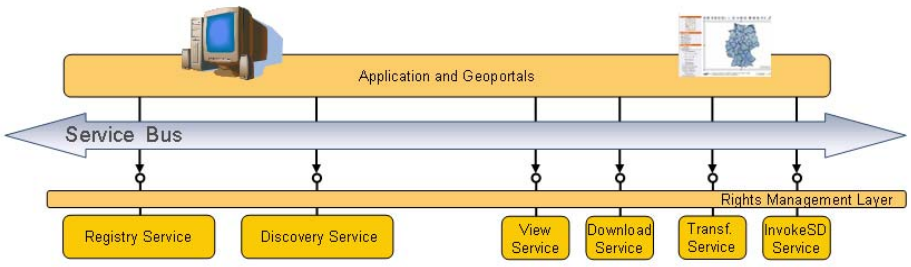
client application or client service to interact directly with the repository, e.g. by retrieving parts of the repository based upon a query).

- The *Draft Technical Guidance for INSPIRE Coordinate Transformation Services (version 2.0)* (INSPIRE Network Services Drafting Team 2009) defines the interfaces of an INSPIRE compliant OGC Web Processing Service (WPS) (Open Geospatial Consortium 2001). Currently, there is not any official, internationally agreed service interface specification available for coordinate transformations. The approach adopted in (INSPIRE Network Services Drafting Team 2009) is to incorporate the only mandatory operation *Transform* defined in of the OGC Discussion Paper "Web Coordinate Transformation Service" (WCTS) as an Application Profile of the OGC Implementation Specification WPS (Open Geospatial Consortium 2007).

Other related documents currently available include:

- The *INSPIRE Network Services Architecture* (Network Services Drafting Team 2008) (see Figure 4), which is comprised of the network services plus an additional Registry Service that keeps track of changes so that data created in the past can still be interpreted completely and correctly; i.e. superseded or retired register items will remain in the register.

Figure 4 - INSPIRE Network Services Architecture



- *INSPIRE SOAP primer for INSPIRE Discovery and View Services providing simple examples of the proposed INSPIRE SOAP framework and additional* : "similar" to W3C SOAP primer, this describes how to obtain Web Service Description Language (WSDL) and Simple Object Access Protocol (SOAP) for INSPIRE services (in this first version discovery and view services).
- *Proposals for the documentation of the communication of the view and discovery service using the Web Service Description Language* (WSDL), which provide the WDSL definitions of the view and discovery INSPIRE Network Services.
- *Technical Report: Resources orientated Architecture and REST* (Joint Research Centre - Institute for Environment and Sustainability 2009): in light of the emerging discussion on Resource Oriented Architectures (ROA) and REpresentational State Transfer (REST) technology platform as solutions for spatial data distributed infrastructures, the aim of this document is to capture ROAs principles and assess the feasibility, as well as the advantages, of using such approaches compared to Service Oriented Architectures (SOAs).
- *Technical Report: INSPIRE NETWORK SERVICES SOAP Framework* (Joint Research Centre - Institute for Environment and Sustainability 2008): the goal of this document is to provide a definition and rationale for a proposed INSPIRE SOAP framework (SOAP nodes

policy, RPC, attachments, WS-I, WSDL…) taking into account the issues and solutions pertaining to the specific geospatial domain (for example GML handling in SOAP messages or interface definitions of the OGC specifications).

- *Technical Report: SOAP HTTP Binding Status - Survey on OGC and ORCHESTRA Specifications Relevant for the INSPIRE Network Services* (Joint Research Centre - Institute for Environment and Sustainability 2008): describes and motivates the technologies (and versions) to be used for SOAP, WSDL, attachments, compression, binary information, multilingual aspects, security, etc, particularly in the context of INSPIRE network services.

3.4 INSPIRE web applications

3.4.1 Geoportal

Description

The INSPIRE geoportal[13] provides the means to search for spatial data sets and spatial data services. Subject to access restrictions, spatial data sets can be viewed and downloaded from the EU Member States, within the framework of the INSPIRE Directive.

The geoportal does not provide data itself, but addresses the services for search, view, transformation and download of the national infrastructures.

The current version is a prototype INSPIRE geoportal and allows for discovery and viewing of spatial data sets and services. Its aim is to identify issues related to its implementation and access distributed INSPIRE services, to help towards the development of the operational geoportal. To ensure that the INSPIRE geoportal has full, functional access to the Discovery and View services, testing is done in close cooperation with the Member States.

Roadmap

Table 23 shows the roadmap for the INSPIRE Geo-portal implementation.

Table 23 - Geo-portal Implementation

Milestone date	Article	Description
30-Nov-2010	15	The EC establishes and runs a geo-portal at the Community level
October 2011[14]	16	Discovery and view services operational
June 2012[15]	16	Download services operational
June 2012[15]	16	Transformation services operational

3.4.2 Registry

Description

The INSPIRE Registry[16] is used for the development of the INSPIRE Implementing Rules by the INSPIRE Drafting Teams and by Thematic Working Groups for data specifications for the testing of the draft data specifications, alongside other participants in the consultation process. As such, the Registry does not represent a final consolidated version of any document, where the content,

[13] http://www.inspire-geoportal.eu/

[14] Date depending on entry into force of measure

[15] Date proposed by the commission

[16] http://inspire-registry.ec.europa.eu

functionality and access are subject to change to capture the development of the INSPIRE Implementing Rules.

Currently the INSPIRE registry contains the INSPIRE Glossary and Feature Concept Dictionary registers which are part of an ongoing process to develop the INSPIRE Implementing Rules and build upon the data specification development framework requirements and recommendations. The INSPIRE Glossary and Feature Concept Dictionary are maintained as an ISO 19135 (Procedures for item registration) conformant register and registry is available for public view. Registered users, however, involved in the INSPIRE Implementing Rules development, have access to additional functionality.

4 THE GLOBAL MONITORING FOR ENVIRONMENTAL AND SECURITY (GMES)

4.1 Introduction

The Global Monitoring for Environmental and Security (GMES) is the European programme implementing an Earth observation service system with satellites and other sensors to monitor our planet's environment and to support the security of every citizen. The information provided by GMES will help us understand better the changes in our planet. This information, used by decision –makers, scientists, business operators, etc. will improve people's safety in many ways, such as by providing information on natural disasters such as forest fires or floods.

The infrastructure needed to collect the observations used by GMES services is owned and operated either by international, European or national entities with their respective political and financial responsibilities. GMES aims at ensuring seamless data flow for sustainable services through effective coordination of all these capacities.

GMES is an initiative driven by the needs of its users, and the information it provides is freely and openly accessed. Significant impact on the economy is expected through the creation of large downstream value-adding service markets, which will grow and flourish provided that a long-term commitment to the GMES programme is secured[17].

4.2 GMES components

The objective is to rationalise the use of multiple-sources data to get timely and quality information, services and knowledge, and to provide autonomous and independent access to information for policy-makers, particularly in relation to environment and security. GMES main pillars are: the space component, (satellites and associated ground segment), in-situ measurements (ground-based and airborne data gathering networks), services to users and data harmonisation and standardization:

- *Space:* the GMES Space Component consists of space observation infrastructure addressing service data needs with missions observing land, atmospheric and oceanographic parameters. In practice it will rely on existing European space infrastructure mainly satellites of ESA, EUMETSAT and Member States and space infrastructure co-financed by the EU and ESA (European Commission 2008b)**.** The requirements here, pointed as the need to capture Earth Observation (EO) data by setting up the needed infrastructure is out of the scope relevant to EuroGEOSS.
- *In situ*: the GMES In-Situ Component will rely on a large number of facilities, instruments and services owned and operated at national, regional and intergovernmental levels inside and outside the EU (European Commission 2008b). Here like in the space component the

[17] http://ec.europa.eu/gmes/overview.htm

requirements are not relevant to EuroGEOSS. Although it is worth noting that in situ facilities and services may have to comply with INSPIRE where relevant

- *Services:* GMES services are the basis for Europe's autonomy in information provision world-wide. The scope and delivery schemes of GMES services should be designed to ensure an operational implementation based on user requirements and applicable legislation, but might have to be prioritised according to institutional and policy needs (European Commission 2008b)..In this line, the requirements of the Service component of GMES, to set up services in information systems, rely in the same context as EuroGEOSS goals. In the next section, the different GMES service types are described along with their main requirements.

4.3 GMES Fast Track Services

The GMES initiative comprises a group of *vertical services* aimed at monitoring Earth sub-systems (land, ocean, and atmosphere) and *horizontal services* addressing emergency and security issues, the information provided by these services contributes to efforts in the climate change domain.

Three *Fast Track Services* (FTS) proceed into the implementation of the pilot operational phase. This phase has established a process for confirming these and defining their exact scope and modalities. The three services already proposed to the EU and ESA Member States in the GMES Advisory Council are: Emergency Response, Land Monitoring, and Marine Services (European Commission 2005).

Special attention has been given to the functions and structuring of the FTS at European level. More specifically, the GMES services are structured around *'Core'* and '*Downstream*' service layers:

- '*Core services'* are pan-European in scope and generic in nature;
- '*Downstream services*' are more specialised than Core services and they meet the needs of a range of different users (e.g. national, regional or local. Downstream services can be derived from core services by further value-adding and customisation.

4.3.1 Land Environmental Services

Land Monitoring Core Services (LMCS) will consist of:

- **Core Mapping Services**: The backbone of the LMCS will be three Core Mapping Services providing information on a global, European and local level. While the temporal variation of biophysical parameters will be monitored globally with a high temporal resolution, detailed land cover, land use and land use change information will be acquired with high spatial resolution for the pan-European area
- **Core Information Services**: On the basis of the information acquired by the Core Mapping Services, the Core Information Services will provide specific thematic information relevant for all of Europe to support the reporting obligations arising from the EU directives and international treaties as well as environmental and urban planning measures (Kaptein et al. 2008).

In general terms, LMCS should encompass operational information services matching several user requirements. Relevant requirements in the context of EuroGEOSS are:

- to share common data and services among the users community, by implementing catalogue and archive facilities;
- geographical scale should be: Global, Continental, Local;

- time scale should be: near real-time, periodic;
- data products should be categorized into: *basic products* and *elaborated products*;
- service-oriented architecture approach based on interoperable service components needs to define component interfaces, capable of ensuring interoperability both, with other GMES services as well as internally between components and core and downstream elements. Internationally agreed standards (e.g. ISO, CEN) and open specifications (e.g. W3C, OGC) expressed in widely accepted languages (e.g. XML, UML) provide a sound framework for interface definitions;
- *interoperability*: Here at least the data harmonisation component will be addressed along with service interoperability in the strict sense at service level. Both aspects will take into account the ongoing work for the INSPIRE Implementing Rules (IR) under development. IRs are being drafted for data specifications and network services. Ortho-imagery and land-cover/ land-use are part of the themes listed in the annexes of the INSPIRE Directive. High-level harmonisation aspects are available in a first draft. The INSPIRE network service IRs focus on middleware service layers and their necessary interfacing;
- *coordination and compliance checking*: In a distributed architecture which is expected to deliver operational services, an effective coordination mechanism is an absolute prerequisite for success;
- data access facilities will have to bridge the EO ground segment and service providers infrastructure by providing timely access to imagery at a sufficient level of processing for further use. This involves a proper metadata documentation of each dataset according to international standards putting the EC in a position to provide, from a centralised data portal, continued access to all datasets acquired under GMES;
- the space data access facilities must be networked with appropriate spatial data infrastructure (ESDI, NSDI, etc...) for data integration and dissemination (Kaptein et al. 2008).

Evaluation of the user needs, definition and demonstration of services was carried out within the project *Geoland* funded under the 6th Framework Programme of the European Commission. The pre-operational land service of GMES is currently provided through the FP7 project *Geoland2*[18].

4.3.2 Marine Environmental Services

The Marine Core Service (MCS) has been identified as achievable and important for a rapid implementation, and selected as such by the European Commission in its priorities.

The objective of the MCS is to deliver a range of fully validated core operational oceanographic products and services which can be used by intermediate service providers to meet information needs of the European Union, Member States, European industry and European Citizens (Bahurel 2008).

The main requirement from the MCS is to have a long-term, continuous access to the core operational satellite observations required for the global and regional ocean monitoring and forecasting systems. Sea level, SST, Ocean Colour, sea ice and winds are the backbone prognostic parameters in operational oceanography. Such data are needed to constrain ocean models. Sea Surface Salinity will be needed on the longer run but feasibility must be first demonstrated (SMOS and Aquarius). In addition, radar backscatter signals are the basic source for operational oil spill and sea ice monitoring (Ryder 2007).

[18] http://www.gmes.info/pages-principales/projects/land-projects/geoland2/

The MCS was enjoined to concentrate on the global to the regional European scales, so that the European concerted effort will be justified. MCS should then be configured as an initial European contribution to the marine segment for GEOSS(Ryder 2007).

The main requirements in EuroGEOSS context are:

- a global system of observations, communications, modelling and assimilation that will deliver regular, comprehensive information on the state of the oceans;
- network: observing systems differ depending on the area and the phenomena to be sampled. They are usually sorted into 3 categories: global, regional, coastal (Ryder 2007);
- architecture must conform to the specifications of the WMO Information System (WIS). It is articulated around Data Collection and Production Centers (DCPC), whose mission is to fulfil an international responsibility for the generation and provision for international distribution of data, forecast products, processed or value-added information, and/or for providing archiving services; and to provide basic WIS functions such as metadata catalogues, internet portals and data access management (Ryder 2007);
- service generation, access, delivery and support: portal for each domain, this comprises a discovery service, a viewing service, a download service, which will need to include or be supported by the facility for sustained, scheduled delivery of high volume datasets for intermediate users, who are themselves running continuous operations that need such a service. Product descriptions are to be standardized and available in a homogenous catalogue;
- standards: consistent quality and standard of service. In order to achieve this goal, the MCS delivery of data and data products should conform to International Open standards as required by the INSPIRE directive and IRs;
- organisation of the sustainable development and operations (interoperable & coherent) of:
    - the modelling & forecasting facilities
    - the data harmonization and information for the global & regional scales.

The pre-operational marine service of GMES is currently provided through the FP7 project MyOcean[19](Bahurel 2008), it is the first implementation project of this Marine Core Service.

4.3.3 Atmospheric Environmental Services

The GMES Atmosphere Service (GAS) will provide coherent information on atmospheric variables in support of European policies and for the benefit of European citizens. Services are proposed to cover: air quality, climate change and stratospheric ozone and solar radiation. The scope of GAS will be based on a Core Service, which will deliver standard operational products and information services that provide direct support to European policy initiatives (GMES 2006). The Core Service shall represent the bedrock of the GAS in terms of implementation, sustained operation and availability. It will provide standard European data, on which downstream services will be based.

The most relevant requirements of the GMES atmosphere service (GMES 2006):

- service architecture: core and downstream services: The definition of the specifications for GAS will be user driven;
- an open approach to data exchange and availability is a requirement to achieve a successful GAS. Exchange should be facilitated through the provisions set in the legislative context, such

[19] http://www.gmes.info/pages-principales/projects/marine-projects/myocean/

as implementing provisions of the new air quality directive. Data exchange has to be in-line with the INSPIRE guidelines and principles in particular with a focus on facilitating re-use;

- GAS infrastructure has to build on the INSPIRE Implementing Rules and the Shared Environmental Information System (SEIS) concepts and be with agreement of the group of 4 (EU division of responsibilities for operation of data centres), which defines the European Environment Agency (EEA) as the data centre for air.

The pre-operational atmosphere service of GMES is currently provided through the FP7 project MACC[20], which is continuing and refining the provision of the main sets of data products provided by PROMOTE and GEMS[21], two projects funded by the European Space Agency and the European Commission respectively. MACC's product lines include data records on atmospheric composition for recent years, and current data for monitoring present conditions and forecasting the distribution of key constituents for a few days ahead.

4.3.4 Support to Emergencies and Humanitarian Aid

Accurate and comprehensive information makes better decision-making. The user needs, expressed both by civil protection and by actors in charge of humanitarian assistance during a workshop held in 2005, have been reported and further detailed in 2006 by the Emergency Response Core Service (ERCS). The key service requirements are (Denis 2008)**:**

- From data acquisition to delivery to the final users. Specific thematic products, depending on the type of event (floods, volcanoes, etc.) can bring additional specialised information;
- GMES Emergency Response services will rely on information provided by advanced technical and operational capabilities making full use of space earth observation and supporting their integration with other sources of data and information;
- ERCS services will provide at least three levels of products (De Bernardinis 2007): the first one foresees that user requests are strictly limited to basic EO datasets, the second one foresees that a user requests value added EO datasets5, the third one concerns the delivery of final thematic maps.
- efficient data management and information sharing system which takes INSPIRE duly into account;
- in compliance with other GMES Core Services data policy, data must be preserved so that their usefulness will be retained for all time. They must also be distributed so that a user can easily merge them with other relevant datasets. They must be catalogued in a way which will facilitate their use. This is the purpose of correctly defining data format as well as maintaining metadata (data on the data) that need to be preserved for future processing;
- a common vocabulary to record metadata, as well as, standards for spatial data and information, may be achieved through INSPIRE implementing rules.

Other preliminary user requirements for GMES-like services

- Common platform for service provision for all EU actors in external emergencies;
- interoperability at different levels, from local to global efficiently in case of emergency management;

[20] http://www.gmes.info/pages-principales/projects/atmosphere-projects/macc/

[21] http://www.gmes.info/pages-principales/projects/atmosphere-projects/former-atmosphere-projects/

- interoperability and information sharing between all Commission/EU services involved in an emergency/crisis;
- as technology for situation monitoring should be small, internet mapping services can provide resources for acquiring and updating relevant geo-information;
- standardization of available systems.

The pre-operational emergency service of GMES is currently provided through the FP7 project SAFER[22]. The main objective of SAFER is to prepare the implementation of operational versions of the Emergency Response Core Service. In the domain of emergency management, numerous projects[23] paving the way towards a pre-operational GMES service have been funded by European institutions over the last years. These include projects such as Respond, RISK-EOS, PREVIEW, ORCHESTRA, OSIRIS, etc.

4.4 General GMES Requirements

Efficient data management and information sharing are a prerequisite for the producing GMES services**.** GMES contributes to facilitate access, use and harmonisation of geospatial information at pan- European level (European Commission 2005).

GMES will constitute a growing element in the EU's bilateral relations with international partners. It will be developed taking into account the activities of the Group on Earth Observations (GEO). With its federating role, GMES will be the main European contribution to the global 10-year implementation plan for a Global Earth Observation System of Systems (GEOSS) (European Commission 2005).

The following Council conclusions on Global Monitoring for Environment and Security (GMES): "Towards a GMES programme"(COUNCIL OF THE EUROPEAN UNION 2008) are relevant to EuroGEOSS:

- GMES is user-driven by integrating user requirements throughout the development and delivery phases of the Services, thus guaranteeing optimal usability of these Services; All GMES Services should meet the quality and reliability standards required by their users;
- GMES Services should be considered a public good; the information that they deliver should be openly accessible to all users, at the exception of restrictions mainly driven by security purposes and national and Community rules;
- GMES should be cost-efficient and maximize the use of existing relevant capacities and services in Europe, when available;
- the major innovation of GMES is to direct the focus onto user needs at a pan-European level and to reformulate those needs as a catalogue of user-driven services. These services will be implemented in a standard, coordinated manner across national frontiers, so as to achieve economies of both scale and scope (Moutarlier 2008).

The main GMES requirements pointed out to be considered as input requirements for EuroGEOSS are:

- Shared methodology so that services can be integrated and aggregated at European level;

[22] http://www.gmes.info/pages-principales/projects/emergency-projects/safer/

[23] http://www.gmes.info/pages-principales/projects/emergency-projects/former-emergency-projects/

- many service types, like emergency services, have to be shared by many different user domains, this could mean in our context that one important requirement could be open accessibility and interdisciplinary interoperability;
- effective handling of data security as Member States' data security requirements by identifying and mitigating risks such as proliferation of data, disclosure of interest or doubts about the reliability of GMES services;
- ensure or maintain access to observation data, and to define the European contribution to international endeavor;
- users need to be assured that the services will be available on a long-term basis. This requires action to guarantee the availability of the space-based, in-situ and data management infrastructures;
- integration of data from space-based and in-situ (airborne, water-based and ground-based) earth observation capacities into user-driven operational application services;
- achieve fusion of data from different sources at different levels;
- internet tools for decision maker to get information. Like Web sites for disaster alerts and plan and deliver aid for implementing partners (UN agencies and NGO community);
- accessible geographic information disseminated through internet better that paper maps, for field officials and experts;
- interpretation, integration and analysis: GMES services should provide more than cartographic maps, they should provide information, thus, this implies processing capabilities;
- common IT platform for information sharing. A structured global observation system is required (Lucht 2008).

Service Interoperability requirements

- Ensure the maximum user base and effectiveness, thus care needs to be taken to establish standards and interoperability at the various levels of the service provision: user, provider, data, system, product/service;
- To fulfill interoperability arrangements, ESA has implemented OGC's geospatial interoperability standards in interfaces and encodings that are essential parts of the Heterogeneous Mission Accessibility (HMA) initiative. HMA is ESA's interoperability framework for coordinated data discovery and access set up in collaboration with the European and Canadian Space Agencies of the GSCB. HMA will be exploited within the Global Monitoring for the Environment and Security activity (GMES) to ensure interoperability.

User requirements (partially extracted from (Piers et al. 2008) (VEGA et al. 2004)*)*

There is limited evidence of mature and repeatable products in the face of immature requirements from industry and institutional markets. Most value adding companies have expert skills but a strong regional focus. They usually have only few automated processes and are very dependent on satellite data providers, i.e. availability of EO data (Piers et al. 2008)*.*

- Integration of multiple data sources: 80% of the current services incorporate non-EO data and indicate there will be an increase in the integration of non-EO data into future products and services (VEGA et al. 2004)*;*
- the degree of customisation indicates how much the services depend on the expertise of the providers for configuration or tailoring to meet specific user requirements. According to the

VEGA 2004 study 70% of the current services are highly customised and only 8% are not customised at all (VEGA et al. 2004).

5 THE GEOSS INSPIRE AND GMES ACTION IN SUPPORT (GIGAS) PROJECT

5.1 Introduction

The GEOSS INSPIRE and GMES Action in Support (GIGAS) project seeks to carry out a Support Action (SA) aiming at a rapid adoption of standards, protocols, and open architectures in support of INSPIRE, GMES, and GEOSS initiatives.

The three existing initiatives GEOSS (Global Earth Observation System of Systems), INSPIRE (Infrastructure for Spatial Information in Europe) and GMES (Global Monitoring for Environment and Security) share commonalities, including their focus on environmental policy support, use of geomatic and geographic information, their Europe- or worldwide dimension, their reliance on international standards and the advanced Spatial Data Infra-structures that are needed for their implementation. In this respect, all three initiatives are key facilitators for the vision of “Digital Earth”. However, at the same time each initiative follows its own timeline and approach for technical development, thereby risking evolving into separate, incompatible services and not profiting from the benefits of a common approach.

The GIGAS Support Action was launched in 2008 with the specific aim to assess and address interoperability gaps and opportunities for establishing bridges between GEOSS, INSPIRE, and GMES. GIGAS makes use of a formal and structured approach to identify and analyse commonalities and interoperability gaps in architectures, standards and governance issues in the three initiatives. This study and the subsequent comparative analysis lead to a set of draft recommendations directed towards the initiatives and the main standardization bodies (OGC, ISO, and CEN).

The GIGAS approach is based on four subsequent steps: monitoring, comparison, discussion and consensus, and influence and shape. This process will be iterated twice in the course of the project (loop1 and loop2).

These recommendations are made towards the converging requirements for interoperability common and also suggested by GIGAS along the following set of thematic areas or themes:

- Architecture
- Cross-initiatives scenario deployment plan
- Catalogue, meta-data and discovery
- Data access and processing
- Data harmonisation and semantic interoperability
- User management

which are the defined themes in loop2 of the GIGAS project. The GIGAS project finishes in June 2010 and final loop2 deliverables are not yet available, so the updates of this deliverable (EuroGEOSS D2.2.1 at M15 and M27) will be able to take them into account along will with the final GIGAS recommendations.

The comparative analysis and the GIGAS recommendations are useful for EuroGEOSS because they outline some of the important challenges that the project must address. Besides, they advice the IOC designer to select solutions that can facilitate the three Initiatives interoperability.

5.2 Architecture

The main results of the Technology Watch Architecture study from Loop 1 activities can be summarized as follows:

- Different scopes (enterprise viewpoints) of INSPIRE, GMES and GEOSS result in differences in the architecture of the initiatives. It will be important to determine where architectural coherence and cross-initiative interoperability is key and to focus on these aspects.
- Interoperability between GEOSS, INSPIRE and GMES will dependent on their ability for reaching a common understanding of the differing information models. It will be important to understand how these different concepts relate to each other in order to achieve interoperability.
- Very importantly, the Initiatives share an emphasis on using a Service Oriented Architecture (SOA) approach. For example they all have elements of the Publish-Find-Bind pattern. But there are differences, too. For example, a comparison of the definition of "Service" in each initiative should be made.
- In addition to the analysis on architectural aspects also the schedules of the three initiatives as well as of the FP6/FP7 projects and standardization bodies need to be understood. Internal schedules are asynchronous and not correlated both among themselves and with GIGAS activities; an identification of respective key milestones or intervention points is needed. This has to drive the assignment of priorities to convergence and outreach activities in order to match the necessary deadlines, to provide timely inputs and to receive timely outputs.

5.3 - Catalogue, metadata and discovery

Metadata and catalogue services are a fundamental part of a spatial data infrastructure. They allow the end user to discover, evaluate and use the available data and services. They are the main entry point into the infrastructure. The three initiatives studied in GIGAS (GEOSS, INSPIRE, GMES) have thus set up catalogue services giving access to metadata instances.

Metadata are usually categorized according to three base user activities: *the discovery of resources, the evaluation of available resources, the use of adequate resources*.

The comparative analysis in D2.3 led to the following observations:

- The three initiatives have the same use cases for catalogues, metadata and resource discovery. GMES and GEOSS deal more specifically with EO data while INSPIRE covers a broader set of spatial data themes.
- GMES CDS EO-DAIL and GEOSS already have implementation running. Implementation of INSPIRE has taken place at the European level and partly on the national basis. Metadata for spatial data sets corresponding to themes listed in Annexes I and II of the INSPIRE Directive have to be provided by Member States until 2010. Metadata for spatial data sets corresponding to themes listed in Annex III of the INSPIRE Directive have to be provided by Member States until 2013.
- All three initiatives use ISO 19115 and ISO 19119 for their data and service metadata. All three use ISO 19139 encodings. However, each initiative has its own requirements in terms of metadata elements.
- The three initiatives use (at least) the CS-W catalogue service standard. However, INSPIRE recommends use of the ISO Application Profile of CS-W, GMES uses mainly the ebRIM Application Profile of CS-W with extension packages and GEOSS chose to implement several existing standards, including CS-W as well as the ISO and ebRIM Application Profiles

5.4 - Data access and processing

Adoption of standards ISO/OGC by the three initiatives seems to promote interoperability but differences in implementations preclude full interoperability. Harmonisation and interoperability of "Geographic model/information management services" for geographic data access and processing (ISO 19119) can be analysed within service categories:

- Feature access service. Service that provides a client access to and management of a feature store. An access service may include a query that filters the data returned to the client. ISO 19125-1 is relevant to feature access.
- Map access service. Service that provides a client access to a geographic graphics, i.e., pictures of geographic data. ISO 19128 is relevant to map access.
- Coverage access service. Service that provides a client access to and management of a coverage store. An access service may include a query that filters the data returned to the client. ISO 19123 and ISO 19111 are relevant to coverage access.
- Coverage Access Service – sensor. Service that provides access to a coverage where the source of the coverage data is a real-time sensor, i.e., not a persistent store.
- Product access service. Service that provides access to and management of a geographic product store. A product can be a predefined feature collection and metadata with known boundaries and content, corresponding to a paper map or report. A product can alternately be a previously defined set of coverages with associated metadata.
- Processing Service. Service that provides management of remote processing capabilities of geographic data and/or products. Processing could be a transformation of existing data until a production chain that deliver a product from raw data. OGC Web Processing Service Standard (2.0 currently in draft version) is relevant to processing service access.

5.5 - Data harmonisation and semantic interoperability

Data from observations and measurements form a fundamental element of the information pipeline for all three initiatives:

- INSPIRE, especially the environmental themes in Annex II and III,
- GMES, especially the in-situ component, and space-borne earth observation,
- GEOSS (concerned with observations in support of many societal benefit areas).

OGC has developed over some years an abstract conceptual model for Observations and Measurements (O&M). It has evolved since 2001, reaching a sufficient level of maturity to be formally published by OGC as version 1.0 late 2007. It was recently accepted as a New Work Item by ISO Technical Committee 211 and is now at Committee Draft stage (ISO/CD 19156). In descriptive terms, the model states that

"An observation measures some observed property of a feature-of-interest using a specified procedure, generating a result."

O&M offers the potential for developing a harmonized approach to information management across the three initiatives. In particular, O&M provides a key component to define interoperable data models across multiple data themes in INSPIRE, and to develop a coherent architecture for GMES In-Situ Observations. As well, the Information Viewpoint it provides fits neatly within the GEOSS component taxonomy across all the Societal Benefit Areas.

User management

User Management, is understood as issues related to authentication, authorisation, identity management, user profile management and Web service security. There have been some recommendations to ordering which can be related to this but this is not particularly relevant at the moment to EuroGEOSS.

A survey of the applicable standards from the main standardization bodies such as W3C, OASIS, IETF and OGC have been made.

The following standards present important goals of security management (these standards have already been used in GMES CDS to make a CDS tailoring):

- ISO/IEC 17799:2005 Code of Practice for Information Security Management: this International Standard establishes guidelines and general principles for initiating, implementing, maintaining, and improving information security management in an organization.
- ISO/IEC 27001 Information Security Management Systems Requirements: this International Standard covers all types of organizations (e.g. commercial, government agencies)
- ISO/IEC15408 Evaluation criteria for IT security (i.e. common criteria): it permits independent security evaluations according to a “common criteria” base

User Management is not defined at the same level within the different initiatives although there are many similarities. The GMES CDS DAIL offering is based on mature standards and an instance is currently being implemented in the DAIL implementation project. The DAIL is using SOA based architecture and implements an authentication, authorisation model through SOAP, WS-Security, SAML and LDAP technologies.

The GEOSS initiative sits at a higher level and intentionally has relatively little defined in terms of user management. Authentication and authorization play a key role in protecting GEOSS components and services at all tiers. Currently, the GEOSS Architecture Implementation Pilot does not apply access control to participating web services. However, the OGC Geo Rights Management standard (GeoRM) is expected to form the basis of GEOSS access control in the future.

5.6 Useful inputs for EuroGEOSS

On the basis of the comparative analysis the input from GIGAS to EuroGEOSS mainly confirms the need to focus on an extended SOA introducing brokering services based on open and international standards and specifications. The brokering services should guarantee the flexibility needed to accommodate different technologies solutions proposed by the three initiatives, e.g. ISO vs ebRIM profile.

Hence, the EuroGEOSS IOC should be based on a broader services that facilitates bridging such different solutions.

Comments on some GIGAS recommendations and particular recent findings

Some other issue related to Sensor Planning Services and Sensor Web Enablement (Data access and processing section) need harmonisation between initiatives.

The above draft recommendations have been presented and discussed during the GIGAS workshop held in Bruxelles on 28-29 January 2009. Discussions from the research agenda (D3.4)

give insights into the challenges and routes to follow in developing the IOC and AOC for EuroGEOSS.

Architecture:

Principles of Service Orientated Architecture (SOA) need to be embedded in a Reference Model to increase the chances of interoperability. Can the ISO standard RM-ODP (Reference Model for Open Distributed Processing) give starting point for this?

Catalogue, meta-data and discovery:

All three initiatives use ISO 19115 and ISO 19119 for their data and service metadata. All three use ISO 19139 encodings. However, each initiative has its own requirements in terms of metadata elements which cause problems of interoperability in harvesting. Even when using CSW catalogue service, differences in application profiles (ISO or ebRIM) leads to interoperability problems or the clients. It was noted that GEOSS uses freely different application profiles and standards

Data access & processing:

For Sensor Web Enablement and particularly SPS the RESTful SPS specifications submitted to OGC has to be observed, as at the moment the initiatives use different approaches: WSDL/SOAP, http/KVP, and RESTful. Harmonisation may be needed for web service chaining or at workflow engine level.

Results from loop2 should give some insight onto processing services.

Data harmonisation and semantic interoperability:

O&M 'Observations and Measurements' (ISO 19156) appears to be a potential ground for harmonization in data specifications.

6 SEIS (SHARED ENVIRONMENTAL INFORMATION SYSTEM)

6.1 Introduction

The Shared Environmental Information System (SEIS) is a collaborative initiative of the European Commission and the European Environment Agency (EEA) to establish together with the Member States an integrated and shared EU-wide environmental information system. This system would tie in better all existing data gathering and information flows related to EU environmental policies and legislation. It will be based on technologies such as the internet and satellite systems and thus make environmental information more readily available and easier to understand to policy makers and the public. (European Commission 2008a)

The underlying aim of SEIS is also to move away from paper-based reporting to a system where information is managed as close as possible to its source and made available to users in an open and transparent way.

According to the SEIS concept, environmentally-related data and information will be stored in electronic databases throughout the European Union. These databases would be interconnected virtually and be compatible with each other. The proposed SEIS is a decentralized but integrated web-enabled information system based on a network of public information providers sharing

environmental data and information. It will be built upon existing e-infrastructure, systems and services in Member States and EU institutions. (European Commission 2008b)

6.2 SEIS Principles

SEIS will built on INSPIRE and GMES. The followings are SEIS common principles for timely, reliable and relevant information on the state of environment:

- Information should be managed as close as possible to its source;
- Information should be collected once, and shared with others for many purposes;
- Information should be readily available to public authorities and enable them to easily fulfil their legal reporting obligations;
- Information should be accessible to enable end-users, both public authorities and citizens, to make comparisons at the appropriate geographical scale
- Information sharing and processing should be supported through common, free open source software tools

To note that recent developments by the EEA in the framework of SEIS point to technological solutions based on Linked Data, semantic web technologies, RDF and REST (Roug 2009)

7 CONCLUSIONS

As an EU funded Project, EuroGEOSS must follow the European legislation: the INSPIRE Directive establishes the legal framework for setting up and operating an European Spatial Data Infrastructure based on the infrastructures for spatial information of the Member States of the European Union. Therefore, the requirements, discussed in the document, stemming from the INSPIRE IRs must be satisfied by the EuroGEOSS infrastructure (and its Initial Operating Capability, IOC).

The mission of EuroGEOSS is to provide a European contribution to the GEO/GEOSS Common Infrastructure (GCI). Naturally, the project must develop such contribution in keeping with the other European initiatives playing a role in GEO/GEOSS and/or developing a System of Systems for environmental and Earth Sciences resources sharing, namely: GMES, and SEIS. This document analysed the main requirements coming from these initiatives and programmes.

The outcome of this report shows the importance for the EuroGEOSS infrastructure to accommodate the many, and sometimes heterogeneous requirements coming from the initiatives and programmes analysed. Clearly, all System of Systems initiatives and programmes studied adopt the Information Modelling Approach sharing metadata and implementing interoperability through international standards. That is achieved by developing Service-Oriented Architectures (SOAs) which proved to be scalable and sufficiently neutral solutions. However, multi-disciplinary pilot projects raised several concerns about the flexibility of the SOA approach in relation to distributed System of Systems. In the context of GEOSS, service providers are many and “speak” different interoperability languages; thus, service consumers need to implement a plethora of different interoperability protocols and data models. As demonstrated by the recent GEOSS AIP-2 pilot and, previously by the GEOSS IP3 demos, an extended SOA approach can provide an effective solution by implementing brokering and mediation components: SOA-brokering approach.

On this basis, EuroGEOSS IOC should implement:

- a SOA-brokering approach to accommodate the interoperability requirements of INSPIRE, GEOSS, GMES, and SEIS –in the near future.
- a catalogue based discovery service applying the OGC CSW 2.0.2 specification (which appears to be the common interface adopted by the initiatives considered). However, the catalogue component should provide brokering and mediation functionalities to address the specific application profiles and extension packages used by the different initiatives (e.g. ISO and ebRIM profiles) and supported by the diverse disciplines (e.g. GBIF, THREDDS, etc.).
- Access and download services should implement the OWS specifications and application profiles (e.g. the CF-netCDF profile for WCS). However, it is also important that other well-adopted access protocols and services are supported. For example, the RESTFul services available on the GBIF web portal, which provide the download of a great amount of Biodiversity data. In general, most of the GEOSS interoperability arrangements should be supported to serve the different SBAs. The brokering solution seems to be the right answer In this respect.
- The AIP-2 methodology for addressing multi-disciplinarity issues, collect requirements and design a user-driven infrastructure (EuroGEOSS already started actions in keeping with such approach).

In respect to the EuroGEOSS Advanced Operating Capability, some areas to be investigated further relate to:

- Technological solutions based on Linked Data, semantic web technologies, RDF and REST. These technologies must integrate and support the discovery brokering framework implemented by EuroGEOSS in its IOC.
- OGC WPS specification (2.0 as soon as possible) to support the necessary workflows and the interaction with the environmental modelling systems.
- OGC O&M models to implement high level interoperability among different disciplines, supported by semantic services.

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