GROUP ON EARTH OBSERVATIONS

GEOSS AIP Architecture

GEOSS Architecture Implementation Pilot (AIP)

Version: 29 January 2010

Prepared for the AIP-3 Call for Participation

PREFACE

This document defines a multi-viewpoint architecture for the exchange and dissemination of observational data and information in the Global Earth Observing System of Systems (GEOSS). This architecture has been developed and is used in the GEOSS Architecture Implementation Pilot (AIP).

The Group on Earth Observations (GEO) is coordinating efforts to build GEOSS through a series of Tasks. GEO's Members include 80 Governments and the European Commission. In addition, 58 intergovernmental, international, and regional organizations with a mandate in Earth observation or related issues have been recognized as Participating Organizations.

AIP is a core Task (AR-09-01b) of the GEO Architecture and Data Committee (ADC). AIP supports the elaboration of the GEOSS Architecture. The requirements for AIP are based on meeting user needs and community scenario requirements. The Results of the AIP are transitioned to Task AR-09-01a and the GEOSS Common Infrastructure.

The version of the GEOSS AIP Architecture in this document was developed to support a Call for Participation (CFP) in the third phase of AIP. AIP-3 builds on the two prior phases of AIP along with requirements identified by the ADC and other GEO committees and tasks.

This version of GEOSS AIP Architecture was prepared in tandem with two other AIP documents:

- GEOSS AIP-3 Call for Participation, Version 29 January 2010
- GEOSS AIP Development Process, Version 29 January 2010

Both documents are available at this URL:
http://earthobservations.org/geoss_call_aip.shtml

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Foreword

The GEOSS AIP Architecture provides just an overview of the results of extensive development by hundreds of individuals from GEO Members and Participating Organizations.

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GEOSS AIP Architecture

1 Overview

1.1 Common Architecture and Standards

This document defines the architecture for the GEOSS Architecture Implementation Pilot (AIP). This architecture was developed based upon preparation, execution, and documentation of a prior AIP phases. Requirements were identified from the GEOSS Ten-Year Implementation Plan and from the GEO Tasks undertaken by GEO Members and Participating Organizations. This technical architecture for GEOSS is expressed the viewpoints of the RM-ODP International Standard (See Section 1.2).

1.2 Architecture Viewpoints

This architecture was developed using RM-ODP: ISO/IEC10746, Information technology — Open Distributed Processing — Reference model. The RM-ODP standards are used in multiple geospatial and earth observation architectures, e.g., the ISO 19100 series of geographic information standards, and the OGC Reference Model. Following the RM-ODP process is also in line with the existing efforts of numerous Spatial Data Infrastructure (SDI) efforts that work towards providing geospatial services[i].

RM-ODP defines five viewpoints that are useful to separate the various concerns in developing an architecture. A summary of RM-ODP Viewpoints is provided in Table 1.

ISO/IEC 19793, Information technology -- Open Distributed Processing -- Use of UML for ODP system specifications, describes a specification of the different ODP viewpoints of a system, using Unified Modeling Language (UML). The AIP CFP for Phase 2 includes the use of ISO/IEC 19793 for modeling the Enterprise Viewpoint. Other viewpoints in the CFP use UML but with less adherence to ISO/IEC 19793.

Table 1 – Architecture Viewpoints

Viewpoint Name	**Description of RM-ODP Viewpoint as used herein**
Enterprise	Articulates a "business model" that should be understandable by all stakeholders; focuses on **purpose, scope, and policies**.
Information	Focuses on the **semantics** of the information and information processing performed, by describing the structure and content types of supporting data.
Computational	**Service-oriented** viewpoint that enables distribution through functional decomposition of the system into objects that interact at interfaces.
Engineering	Identification of **component types** to support distributed interaction between the components.
Technology	Identification of **component instances** as physical deployed technology solutions, including network descriptions.

1.3 System Design Process

AIP uses a system design process to implement SBA Scenarios into the GEOSS AIP Architecture based upon engineering use cases. This reusable process for deploying SBA scenarios in a Service-oriented Architecture (SoA) – SBA to SoA process – can be reused by organizations external to AIP developments. The process if described in detail in the AIP Development Processes document.

The core of the reusable process are community *Scenarios* and transverse *Use Cases*. *Scenarios* are narrative description of the activities of the SBA communities with minimal discussion of the implementation architecture. *Enterprise Scenarios* provide an end user view of the value of GEOSS (See Section 2.4). *Scenarios* are implemented in the GEOSS architecture by *use cases*. *Engineering use cases* describe reusable functionality of the GEOSS service oriented architecture implemented through *Interoperability Arrangements* (See Section 5.6). This process builds on these core concepts using a system modeling process based on international standards tailored to the GEOSS environment.

The reusable process for deploying SBA Scenarios into the GEOSS AIP Architecture is shown in Figure 1. This process is iterative with the main flow of activities as shown in the Figure, but the process is not accomplished in one pass. It is important that the SBA communities are considering the SoA technology when conceiving of their objectives as SoA provides capabilities that not previously available.

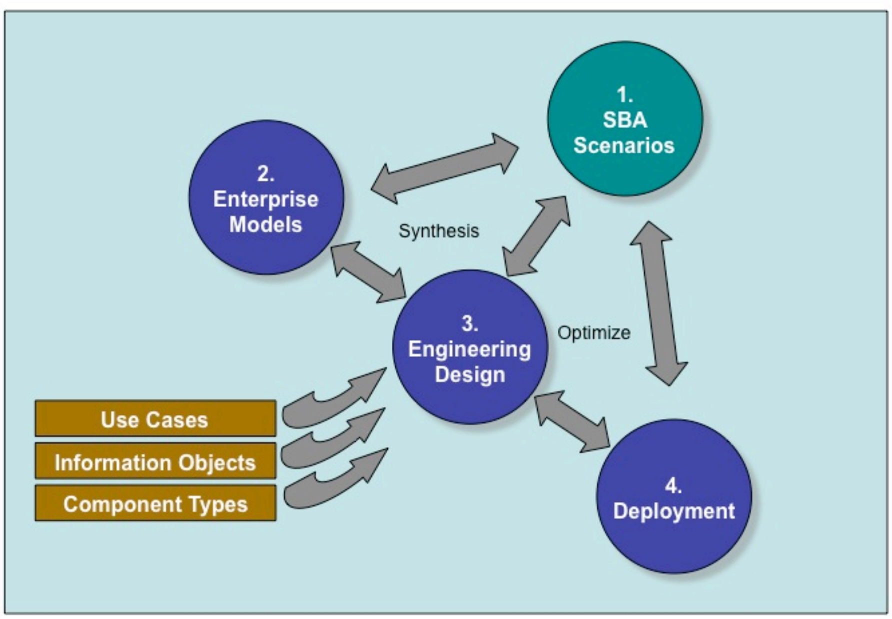


Figure 1 – Design Process to Deploy SBA Scenarios

1.4 GEO Architecture Data and Committee References

Task Teams of the GEO Architecture and Data Committee (ADC) have developed several documents that support the goals of the AIP. The architecture incorporates – directly or by reference – the following ADC documents[ii]:

- A Process for Reaching GEOSS Interoperability Arrangements (Developed by Task Team AR-06-01)
- GEOSS Interoperability Strategic Guidance (Developed by Task Team AR-06-02).
- GEOSS Interoperability Tactical Guidance (Developed by Task Team AR-06-02)
- GEOSS Components Registration (Developed by Task Team AR-06-04)
- GEOSS Clearinghouse: Demonstration of Existing Capability, Statement of Work, proposed, developed by Eliot Christian as an action of the ADC.

Also included in this document is a set of definitions developed by the ADC.

1.5 New in AIP Phase 3

AIP-3 will build upon previous phases of AIP and on the results of other GEO Tasks. An Initial Operating Capability of the GEOSS Common Infrastructure (GCI) was established based on AIP and other GEO Tasks. AIP-2 augmented the GCI AIP, contributed to the increase of registered GEOSS components and services and established a process for deploying SBA scenarios using the AIP Architecture.

Specific areas of emphasis for AIP-3 will be determined by the responses to the AIP-3 Call for Participation. Based upon discussions with the ADC and other GEO Committees, this document was prepared emphasizing these opportunities for development of the GEOSS AIP Architecture in AIP-3:

- Increase GEOSS capacity to support SBAs. SBA developments will continue in AIP-3 for Disaster Management, Health/Air Quality, Biodiversity, and Energy. New SBA developments in AIP-3 for Health/Disease and topics in Water.
- Build on the AIP Service Architecture and the GEOSS Common Infrastructure (GCI). Refine the service-oriented architecture and the evolutionary development process. Exploit the service architecture for mash-ups in a link-rich environment.
    - Build on both content and process
    - Increase emphasis on data provider point of view
    - Promote mash-ups in a "link-rich" environment
- Focus on increasing the data available through GEOSS component and service providers. In coordination with other GEO tasks, promote deployment and registration of EO information. Identify and refine Interoperability Arrangements for information: e.g., semantic approaches to geophysical parameters, and implementation of GEOSS Data Sharing Guidelines.
    - Coordination with ADC Data Tasks
    - Vocabulary registries and ontologies as resources for scenarios
    - Data Sharing Guidelines implementation
- Schedule to support Ministerial Summit, November 2010

Specific changes to the GEOSS AIP Architecture document for AIP-3 include material in the following sections:

- Refinement of the GEOSS Users and Actors in the Enterprise Viewpoint (Section 2.3)
- New SBA scenarios added to the SBA scenarios from AIP-2 (Section 2.4). The total list of scenarios for AIP-3 is:
    - Disaster Management Scenario
    - Air Quality Scenario
    - Biodiversity and Climate Change – Prediction of an Ecosystem Evolution Scenario
    - Biodiversity and Climate Change – Arctic Spatial Data Infrastructure – A Framework for Science
    - Energy Scenario
    - Water – Drought Scenario
    - Water – Water Quality Scenario
    - Water – Extreme Precipitation Scenario
    - Health and the Environment Scenario – Early Warning of Malaria
- Implementation of Data Sharing Guidelines in several sections:
    - Data Sharing Principles identified as an enterprise objective (Section 2.1.3),
    - User registration and data access conditions described in the Information Viewpoint (Section 3.7),
    - Engineering Viewpoint use cases for User Registration (Section 5.6.3) and Data Access Conditions (Section 5.6.4).
- Information Viewpoint revised to a new organization of topics (Section 3). An aim of AIP-3 is to advance this viewpoint in support of the data harmonization objective of the Architecture and Data Committee.
- Geophysical parameters and other controlled vocabulary from CEOS and WMO databases added (Section 3.3.1)
- Semantic mediation use case in the Engineering Viewpoint (Section 5.6.2). This use case will enable users to consider several vocabularies and ontologies in the SBA scenarios.
- Refinement of the taxonomy of service types in the Computational Viewpoint (Section 4.2). This refinement was based upon results of the GIGAS project recommendation regarding harmonization of GEOSS, GMES and INSPIRE.
- Addition of GEONET as a deployment environment for GEOSS Services (Section 5.5.2)

2 Enterprise Viewpoint – Value of Earth Observations

2.1 GEOSS context and community objective

2.1.1 GEO community objective

The enterprise viewpoint focuses on the purpose, scope and policies for that system and its environment. It describes the business requirements and how to meet them, without regard to system considerations such as the details of its software architecture, computational processes or the technology to be used to implement the system.

The other viewpoints of this architecture provide the detailed technology, components and interactions that collectively support the GEO community objectives as an emergent behavior of the systems of systems.

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. This synergy develops as each contributor supports common arrangements designed to make shared observations and products more accessible, comparable, and understandable.[iii]

For elaboration of the objectives of the GEO Community refer to the GEOSS 10 Year Plan; the GEOSS 10 Year Plan Reference Document; and to GEOSS Interoperability Strategic Guidance Document.

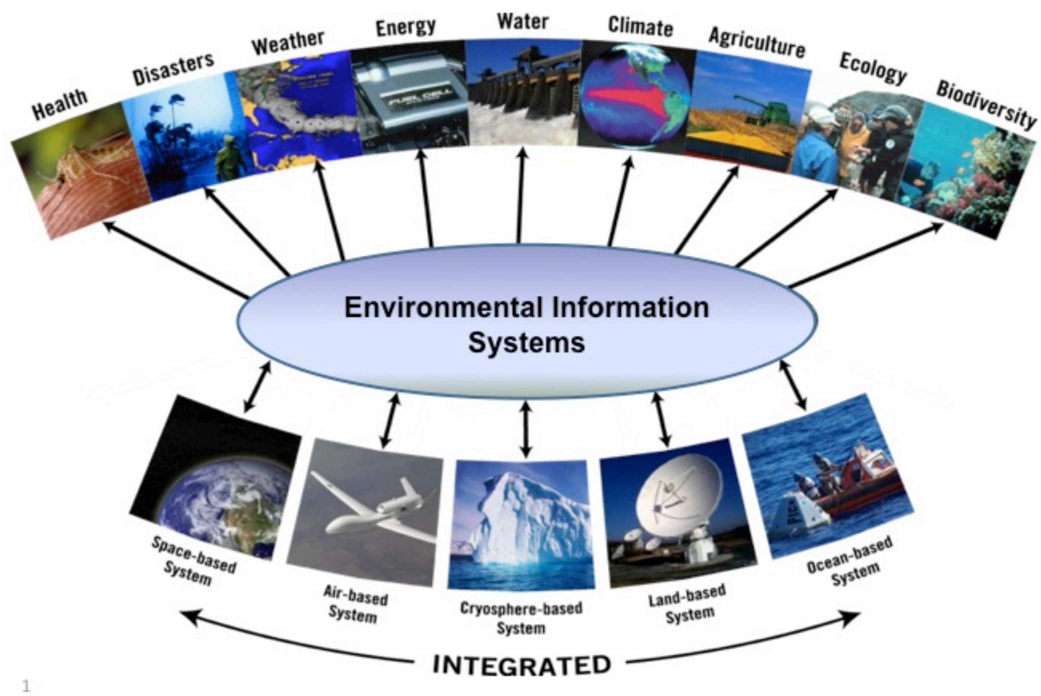


Figure 2 – A Global Earth Observation System of Systems GEOSS

2.1.2 Societal benefits

GEOSS will be primarily focused on issues of regional and global scale and on cross-sector applications, while also facilitating the operation and enhancement of Earth observing systems that are focused on national, local, and sector-specific needs. In this context, investments in Earth observations worldwide certainly exceed tens of billions of dollars per year. Those investments already yield substantial societal benefits, but those benefits will be increased through the collective actions enabled by GEOSS.[iv]

At present, GEOSS Implementation is concentrating on nine areas of societal benefits:

Reduction and Prevention of Disasters

Human Health and Epidemiology

Energy Management

Climate Change

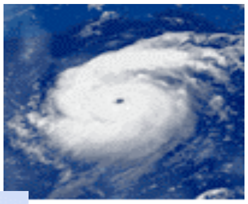
Water Management

Weather Forecasting

Ecosystems

Agriculture

Biodiversity



2.1.3 Data sharing principles

The GEOSS 10 Year Implementation Plan defines the GEOSS Data Sharing Principles:

> "There will be full and open exchange of data, metadata, and products shared within GEOSS, while recognizing relevant international instruments and national policies and legislation. All shared data, metadata, and products will be made available with minimum time delay and at minimum cost. All shared data, metadata, and products for use in education and research will be encouraged to be made available free of charge or at no more than the cost of reproduction."[v]

Since the 10 Year Plan was issued, a team of experts has worked on development of implementation guidelines for the GEOSS Data Sharing Principles as GEO Task DA-06-01 under the leadership of the Committee on Data for Science and Technology (CODATA) of the International Council for Science (ICSU). The GEO-V Plenary in November 2008 agreed to establish a Data Sharing Task Force to finalize the draft implementation guidelines and support development of a consensus on practical steps to implement the GEOSS Data Sharing Principles. The Task Force first met in early 2009 and developed a revised set of implementation guidelines that were accepted at the GEO-VI plenary in November 2009.[vi]

The guidelines are intended to provide more detailed definitions and guidance on implementation of the agreed GEOSS Data Sharing Principles, based on best practices and lessons learned in other relevant international initiatives. The guidelines can therefore serve as the basis for developing requirements that are valid at the enterprise viewpoint and have ramifications for development of the GCI and other elements of GEOSS. Some key points are:

- 'Full and open exchange' is defined as making data and information accessible through GEOSS "with minimal time delay and with as few restrictions as possible, on a nondiscriminatory basis, at minimum cost for no more than the cost of reproduction and distribution." Access for research and educational purposes should be free or no more than the cost of reproduction.
- Metadata should be made available without restriction. Contributors should register metadata for their data without restriction on re-use or re-dissemination.
- Reuse and redissemination of data should be supported to the extent possible with no or minimal restrictions, other than the applicable international instruments and national policies and legislation.
- Attribution should include recognition of all significant data sources or authors, as well as the GEOSS component that enabled access to and delivery of the data.
- The only allowable cost for data should be that of reproduction and distribution, or the marginal cost of fulfilling the user request.
- GEOSS should encourage approaches to cost recovery and licensing of data, metadata and products that do not require payment for re-use.
- Users receiving data at reduced or no cost should be strongly encouraged to provide impact metrics and information regarding their use of the GEOSS data, metadata, and products.

Three areas of impact on AIP-3 are the communication of data/service access conditions between data providers and users, the potential need to identify users or user types as part of metrics collection activities, and the possibility of federating access control to certain systems within the system of systems. License or access types and roles should be considered based on the requirements of the community in order to create a set of controlled terms for use in GEOSS. Data or service conditions must also be stored and propagated in consistent ways using ISO metadata. Relevant standards and practices (candidate interoperability arrangements) should be identified that would support rights management within GEOSS and, in particular, open access licensing approaches. It is important to note that GEOSS may be able to facilitate licensing arrangements between data sources and data users, but ultimately these arrangements are the responsibilities of the relevant parties. User registration is required by several GEOSS contributed systems, but at present, each has a different means to collect and manage user information. The ability to support federated access within GEOSS through a single set of credentials should be investigated in AIP-3 relative to provider requirements and industry capabilities.

2.1.4 Service Oriented Approach

Finding one needle in a haystack is hard enough; doing natural science is in some respects like looking for four needles (or more). A natural scientist looks for connections between observations, forms a hypothesis about relationships discerned in those connections, and then tests the hypothesis by looking for yet more connections. All of this involves finding or generating, processing, analyzing, and visualizing as much relevant data as possible in hopes of finding those critical connections which can truly illuminate natural processes.

Encapsulation of distinct parts of data access and processing as combinable services can have immense benefits for decreasing the effort of science while increasing its capacity and reach. SoA adds the capability to discover and trade services dynamically so that they can be combined on a global scale to do science and support decision-making.

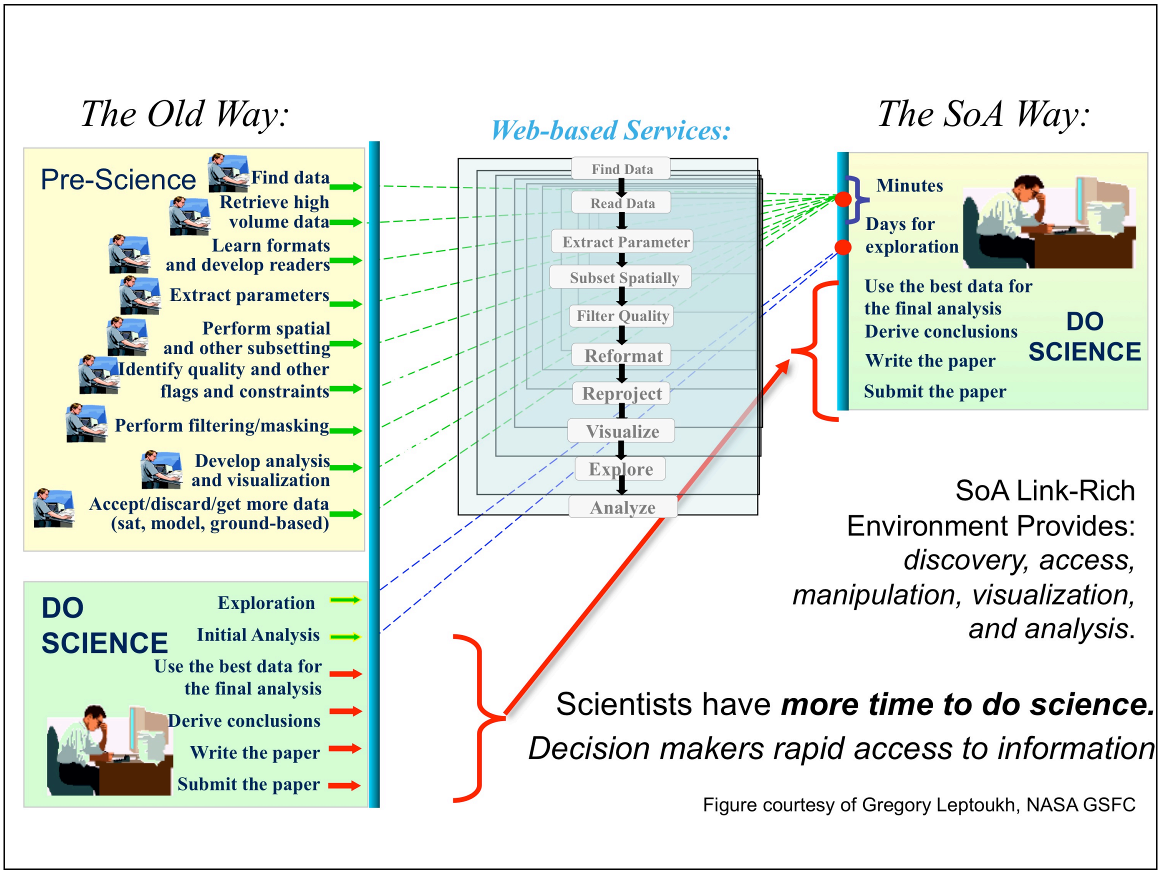


Figure 3 – SoA Allows Users to Concentrate on Decisions

For data providers, the benefits of SoA are also clear: much less effort to disseminate data and accompanying metadata, more opportunity to combine data and appropriate processing (e.g. visualization) in a distinct service offering, greater opportunity for users to find and exploit their data for scientific advancement and accompanying societal benefits.

Not all Service-oriented Architectures are equally useful for all applications. Particular architectural characteristics have been and will continue to be emphasized in AIP to optimize in particular the scientific effectiveness of GEOSS:

- Services which are based on standard interfaces, utilize common datatypes, and are well described by standard metadata are more likely to have the sort of discoverability and usability which adds to scientific capacity rather than diverting it.

- Distributed computing services may be based on many interaction and transport protocols. Web services based on the HTTP protocol have so far proved to be the usable and interchangeable means of providing access to data and processing resources in a globally federated and diverse environment.

Connections are what scientists and other service users want and need to find; the greater the quantity and variety of connections an architecture supports, the more successful it can be as a scientific tool. Sustaining a computing environment in turn that is "link-rich" and therefore rich in opportunity for scientific discovery depends on many factors, but especially advantageous are:

- Provision of services which support fine-grained access to data through Web links (URL's),
- Registration of metadata about components and services which provide (optional) online linkages and other means of publishing linked metadata,
- Access to linked metadata by search strategies which effectively leverage link relationships,
- Support in client applications for visualizing and resolving metadata / service links, and
- Opportunities for users to contribute the connections they discern in provided data, e.g. by way of Web feeds or other means of publishing annotated Web links, for other users in turn to make use of.

2.1.5 Interoperability arrangements

The success of GEOSS will depend on data and information providers accepting and implementing a set of interoperability arrangements, including technical specifications for collecting, processing, storing, and disseminating shared data, metadata, and products. GEOSS interoperability will be based on non-proprietary standards, with preference to formal international standards. Interoperability will be 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.[vii]

At minimum, all GEOSS Components are bound by the requirements on contributed systems as stated in The GEOSS 10 Year Implementation Plan and its companion Reference Document. These stated requirements, referenced in GEOSS documents as "interoperability arrangements", are expected to be further expanded, clarified, or otherwise modified over time. Any new GEOSS Component is understood to be bound by the GEOSS interoperability arrangements as documented at the time it was contributed[viii].

Following are excerpts of interoperability requirements on contributed systems as stated in the GEOSS 10-Year Implementation Plan (Section 5.3 pg 7):

> The success of GEOSS will depend on data and information providers accepting and implementing a set of interoperability arrangements, including technical specifications for collecting, processing, storing, and disseminating shared data, metadata, and products. GEOSS interoperability will be based on non-proprietary standards, with preference to formal international standards. Interoperability will be 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.
>
> For those observations and products contributed and shared, GEOSS implementation will facilitate their recording and storage in clearly defined formats, with metadata and quality indications to enable search, retrieval, and archiving as accessible data sets. [...]
>
> To enable implementation of the GEOSS architecture, GEOSS will draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents in areas such as geodetic reference frames, common geographic data, and standard protocols. GEO Members and Participating Organizations and their contributions will be catalogued in a publicly accessible, network-distributed clearinghouse maintained collectively under GEOSS. The catalogue will itself be subject to GEOSS interoperability specifications, including the standard search service and geospatial services.

The Process for Reaching GEOSS Interoperability Arrangements document defines the steps by which an interoperability arrangement is determined including the activities of the Standards and Interoperability Forum (SIF).

2.2 Enterprise Components

Each Enterprise Scenario in AIP-3 seeks to use, adapt and/or advance various Earth Observation components contributed by GEO Members and Participating Organizations. Some of those components have already been registered in the GEOSS Components and Standards Registry (http://earthobservations.org/gci_cr.shtml). Others will be contributed and registered during AIP-3. In particular, AIP-3 will encourage the registration of new components and will especially welcome components that have high reuse potential (as in being reused across AIP-3 scenarios and communities, as well as outside of the AIP-3 context).

Indeed, as a federated system, GEOSS grows more useful over time as more GEOSS components are contributed. Example types of components include observing systems, data processing systems, dissemination systems, capacity building or other initiatives. The GEOSS Strategic Guidance Document (GEO Task Team AR-06-02, 14 Dec 2006) sites several examples of components already contributed to GEOSS:

- **Components to acquire observations:** based on existing local, national, regional and global systems to be augmented as required by new observing systems;

- **Components to process data into useful information:** recognizing the value of modeling, integration and assimilation techniques as input to the decision support systems required in response to societal needs; and
- **Components required to exchange and disseminate observational data and information:** including data management, access to data, and archiving of data and other resources.

The focus of AIP is primarily on the exchange and dissemination components. According to the Tactical Guidance for Current and Potential Contributors to GEOSS (GEO IV- 28-29 Nov 2007, Document 24), components may be initiatives, programmes, or systems of varying complexity. They can be comprised of an entire end-to-end system or its smaller parts. All GEOSS components (and services) need to be registered in the GEOSS Components and Services Registry (http://earthobservations.org/gci_cr.shtml). Component registration is open to all GEO Members and Participating Organizations.

2.3 Enterprise Actors including Users

Each scenario provides a framework for various Enterprise Actors to interact with each other within the GEOSS Architecture. Actors are not restricted to human users but also include software components or other systems that can interact with other actors or initiate activities.

Based on the AIP-2 results, Table 2 summarizes the main Actors used in the Enterprise Scenarios.

Table 2 – Enterprise Actors

Enterprise Actor	Description
GEOSS User	The GEOSS User spans a wide range of user types that continue to be challenging to distinctively categorize and describe. The GCI Concept of Operations provides two categories: - The GEOSS-Experienced users, who understand the concepts of GEOSS and seek registered resources through the GEO Web Portal or other applications - The Issue-Oriented user, such as researchers and science-to-policy analysts who work on specific issues that fall within one or more SBAs The AIP-2 summary report recommends further clarification, elaboration and description of the GEOSS User (in collaboration with the GCI Task Force and the User Interface Committee).
GEOSS Integrator	The GEOSS Integrator uses the GCI and Community Resources to deliver solutions for the GEOSS User or to create value-added Community Resources. This is consistent with the GCI Concept of Operations definition of Software and services integrator as a class of users typically engaged in support of one or more application areas who is able to use GEOSS to locate suitable services, data, and related resources, and to develop and deploy integrating software solutions that cater to a specific context or subject area.
Community Resource Provider	Resources provided by a Community Resource Provider include services, models, tools, community catalogs, community vocabularies, community portals/clients, etc.
GEOSS Common Infrastructure (GCI) Operator	The GCI currently consists of the following elements: the GEO Portal, the Clearinghouse, the Components and Services Registry, the Standards and Interoperability Registry, the Best Practices Wiki and the User Requirements Registry. This Actor category also incorporates the entities responsible for overseeing the above GCI elements (such as the SIF). In the future, the GCI could be coupled with a Test Facility/Tool to support Community Resource Providers and Integrators in testing their resources prior to registration in GEOSS

2.4 Enterprise Scenarios

The Enterprise Scenarios for the third Phase of the AIP have been developed in close coordination with the GEO User Interface Committee, relevant GEO tasks, and SBA domain experts. The Enterprise Scenarios described in this CFP are associated with several SBAs and fall into two categories:

- Scenarios building on the AIP-2 scenarios and infrastructure:
    - Disaster Management Scenario
    - Air Quality Scenario
    - Biodiversity and Climate Change – Prediction of an Ecosystem Evolution Scenario
    - Biodiversity and Climate Change – Arctic Spatial Data Infrastructure – A Framework for Science
    - Energy Scenario
- Scenarios newly introduced to AIP-3:
    - Water – Drought Scenario
    - Water – Water Quality Scenario
    - Water – Extreme Precipitation Scenario
    - Health and the Environment Scenario – Early Warning of Malaria

Scenarios provide narrative descriptions of the functionality to be supported by the third Phase of AIP. Each scenario represents a starting point for its associated community of practice, and is expected to evolve based on the final make-up of the Pilot participants, the availability and/or implementation of components, and on interoperability agreements amongst Pilot participants. Each scenario is developed by SBA community experts focusing on narrative descriptions of processes in support of decision-making using Earth Observations in the context of GEOSS and with an understanding of the basic GEOSS architecture.

The AIP-3 process and community are expected to benefit considerably from having some of the AIP-3 scenarios building on the AIP-2 SBAs and Scenarios:

- The elaboration on AIP-2 scenarios showcases the continued commitment of the respective communities in further applying and evolving the GEOSS architecture within their communities, further highlighting the value of leveraging the AIP process to contribute to and become part of the GEOSS.
- The involvement of some of the AIP-2 participants (and their associated components) will ensure a smooth and productive transfer of knowledge (and best practices) to the newly introduced AIP-3 SBAs and communities of practice as those begin exploring how to contribute their components and link them to others via GEOSS interoperability arrangements.

It is envisioned that some scenarios will feed into each other in AIP-3 in various areas such as:

- One scenario triggering another scenario (e.g. extreme precipitation triggering disaster management).
- Resources contributed to a scenario can also be used in other scenarios (this is particularly true in the case of global datasets).

2.4.1 Disaster Management Scenario

To support the Disaster Management scenario, respondents to the AIP-3 are encouraged to become active participants in the Group on Earth Observations Task that is intended to deliver end-to-end disaster management societal benefits. That GEO task number is DI-09-02b and it contains two subtasks as regional pilot efforts - one for Sub-Saharan Africa and the other for the Caribbean region. Each of these geographic areas pose different functional needs in the disaster management arena, but at the same time are supported by similar tools and techniques available in the AIP-3 as supplied by participating international collaborators involved in implementing the scenario on a global scale, but in focused regional and national contexts.

2.4.1.1 Targeted or Supported Community

The Flooding and Coastal Hazards Community consists of national disaster management, meteorology, hydrology, and emergency response agencies supported by regional inter-governmental centers, universities, and institutes plus satellite data providers and value added services on a global scale integrated through the GEOSS interface standards and made accessible through common desktop tools.

The objectives of the Flooding and Coastal Hazards Community SBA are:

- To demonstrate the effectiveness of satellite imagery to strengthen regional, national and community level capacity for mitigation, management and coordinated response to natural hazards
- To identify specific satellite-based products that can be used for disaster mitigation and response on a regional level
- To identify capacity building activities that will increase the ability of each region to integrate satellite-based information into disaster management initiatives

Many of the collaborating satellite and value added providers are organized for this AIP-3 activity and for the GEO Task DI-09-02B through the international Committee on Earth Observation Satellites (CEOS). Satellite data coordination for flooding and coastal hazards is managed by the CEOS Strategic Implementation Team (SIT) subgroup for disaster management. The CEOS Working Group on Information Systems and Services (WGISS) supports advanced inter-operability demonstrations in this setting through their Flood Sensor Web activity. The CEOS Working Group on Calibration and Validation (WGCV) supports intercomparison campaigns as part of the Quality Assurance for Earth Observations (QA4EO) program.

GEO Task DI-06-09 is also a related activity that is looking at use of satellites for risk management.

UN-SPIDER: Platform for Space-based Information for Disaster Management and Emergency Response – Bonn Workshop in 2007 identified the need for a demonstration showcase to highlight space contributions to Disaster Management.

2.4.1.2 Context and pre-conditions

2.4.1.2.1 Actors

The mains actors are

- Decision makers who need to affect resources (e.g. International Disaster Charter)
- Regional civil protection officials preparing to face a natural disaster or looking for information on a daily basis to react.
- The public looking for information either to face the situation or to find out what can be done to help

2.4.1.2.2 Information Assumed to be Available

The table hereafter has shown the general requirements for flood analysis using the EO data.

Table 3 – Flood Analysis Requirements

Phase Requirements	Mitigation	Warning	Response	Recovery
Target/data	Topography Hydrological models Historical atlas of floods Flood models/simulations New infrastructure, houses Land-use classification Monitoring of dikes and dams	Precipitation Water level (rivers, lakes) Weather forecast Soil moisture Snow-water equivalent Signs of catastrophic infra failure	Water level (rivers, lakes) Extent of flood Status of critical infrastructure Weather forecast	Status of critical infrastructure Damage assessment Flooded areas
Revisit	1 to 3 years (imagery) 5 to 10 yrs (topography)	Daily or better during high risk period	Daily in early morning; twice daily if possible	Weekly (major floods) for several weeks to several months
Timeliness	Weeks	Hours	Hours (2-4 max)	1 day
End use	Integration in land use planning/zoning Baseline for response	Decision support for warnings & evacuation	Situational awareness Resource allocation support Initial damage assessment	Tracking affected assets Charting progress

The major gap identified during AIP-2 was the link between observations collected during the Warning phase and the observations collected during the Response phase. This gap concerns both Satellite and In Situ observations. For the Warning phase, mainly In Situ are used for flood and earthquake events while Satellites are used for Hurricane events. However in both cases, there is no direct alerting system used to insure a link with the next Response phase.

2.4.1.2.3 Processing and Collaboration Functionality Needed

There is a need for a better integration between Warning and Response phases. The current situation shows that dedicated satellite observation acquisition is decided after the event. One consequence is that observation is more often used for the recovery phase than response phase.

In AIP-3, harmonization between services used to access observation (e.g. SOS) for the Warning phase and Response phase needs to be demonstrated. The link between each phase could be achieved by using services such as SAS for alerting and WPS for processing.

Respondents will need to supply satellite, in-situ and modeled data, tasking and custom data processing capabilities, rapid map creation, advanced publication and subscription services for notification and data sharing that are GEOSS best practice examples. Instrument types include radar, optical, thermal infrared, and possibly LIDAR. In-situ data includes local and regional holdings in various formats and accessibility, some static and some direct readouts from buoys, Doppler ground radar, and other gauges. Modeled data includes digital elevation models, precipitation nowcasts and forecasts, and other drainage and flow rate models in various resolutions.

Map construction automation is key to rapid dissemination and is needed to support this scenario. Tasking request services that enable submittal of targets and modes by browser-based GUI and by API interface are envisioned for implementation under the AIP-3 time frame. Sensor Tasking interface will provide feasibilities for future collection opportunities viewed on GIS-based maps or Google Earth. Target selection tools provide swath depictions, view angle, acquisition time, and other parameters that need to be made available to all participating organizations under the AIP-3 umbrella as shared resources. Open security solutions need to be explored by respondents to ensure identity authorization and authentication between participating organizations.

Rapid mapping derived data products should be customizable by end users in the field as well as analysts in the office. Prediction of vector borne disease outbreaks can be informed by remote sensing solutions. Connections between environmental health, air quality, and climate can be explored by the most novice users with ease using desktop standard tools available on PC, Mac, and unix/linux platforms.

2.4.1.3 Scenario Description

The Disaster Management Scenario describes the integration and utilization of GEOSS standard components and services to supply forecasts, a stream of satellite and in-situ observations, and derived maps integrated with local and regional data sets to support all phases of the disaster cycle. The scenario is applied to flooding disasters caused by tropical storms, hurricanes, cyclones, and tsunamis in particular, but can be easily re-cast to cover other disaster types such as earthquakes, wildfires, landslides, volcanoes, tornadoes, and many more.

2.4.1.3.1 Scenario Events

Legend:
Services in blue
Products in red
Actors in orange

Table 4 – Disaster Management Scenario Events

Step	Description
00	The Initiator is in charge of searches for warning services that provide events or predictions about potential flood on a given area. These services should be discovered by accessing GEOSS Portals.
01	Based on services found at Step 0, the Initiator identifies areas where monitoring is needed and asks Actuator (Regional civil protection) to activate services that offer Early Warning (e.g. based on modeling such a Global Flood Potential Model) to monitor AOIs. Then the monitoring action proceeds to activate some Early Warning service and possibly subscribe to any related Alert service.
02	When an alert is raised, Actuator (Regional civil protection) requests multiple Processors (Data Providers) to activate monitoring services.
03	A Processor configures/sends an event notification to Actuator (Regional civil protection) when monitoring detects upcoming disaster conditions. The notification can be send by using Sensor Alert Service (SAS).
04	Based on Alert issuing by a Processor, the Actuator (Regional civil protection) accesses the result of observations using WCS or SOS (e.g. Daily Flood Map Prediction). Based on the map analysis, the Actuator (Regional civil protection) sends back to Initiator a demand for activation of new data acquisition.
05	Based on Initiator acknowledgment, the Actuator (Regional civil protection) activates a feasibility request for a new data acquisition to multiple Processors (Data Providers) through SPS.
06	The Actuator (Regional civil protection) receives back from multiple Processors (Data Providers) feasibility sensor acquisition results. The Actuator analyses feasibility study, both from SPS output to a dedicated SPS client application and from SPS KML output.
07	Based on existing feasibility studies, the Actuator (Regional civil protection) sends a request for acquisition (tasking) through SPS. If possible the acquisition should be for data before, during and after event.
08	In parallel with acquisition request, the Actuator (Regional civil protection) request data from catalogue before event for a pre-damage analysis.

09	Once data is acquired, a Processor sends notification to Actuator (Regional civil protection) via WS Addressing or WS Notification. One or more Processors (Data Providers) make ortho-image available (pre and after). Geometric processing / Ortho-processing can be activated via WPS. Publication is made through WCS / WMS.
10	Actuator (Regional civil protection) accesses the data via WCS or WMS and should start the analysis process. The Actuator can submit such results to an Hydrology/Meteorology Disaster Management domain experts (e.g. the Caribbean Disaster Response Agency) and ask for 'near real time' feedback on the produced maps.
11	In parallel, Actuator (Regional civil protection) should request thematic processing from Processors (Map producer). This would involve the WPS running a classification or detection algorithm, and production of PNG and KML overlays on the raster result (GeoTIFF) from the WPS
12	The result of processing is released and make available through WCS or WMS. Depending on when the data is acquired, and whether the Alert was issued quite early before event, the data should be thematically processed to update the state of road network, and publish that map via WMS. The WMS is used on-the-field by Actuator (Regional civil protection), e.g. for building an evacuation plan. Whether data is acquired but delivered too late during or after event, the Actuator should provide damage map after event. This information should be available through WMS and used for assessing damage by insurance company or by NGO organization to help Public.
13	All maps produced are released for public communication and accessible via mass-market products such as KML.

2.4.1.4 Enterprise Model

This section defines an Enterprise Model for a specific disaster scenario of flooding caused by a hurricane. The Flooding scenario context diagram below depicts the external interactions of external classes and actors to the GEOSS Class and all external inputs, outputs and ports.

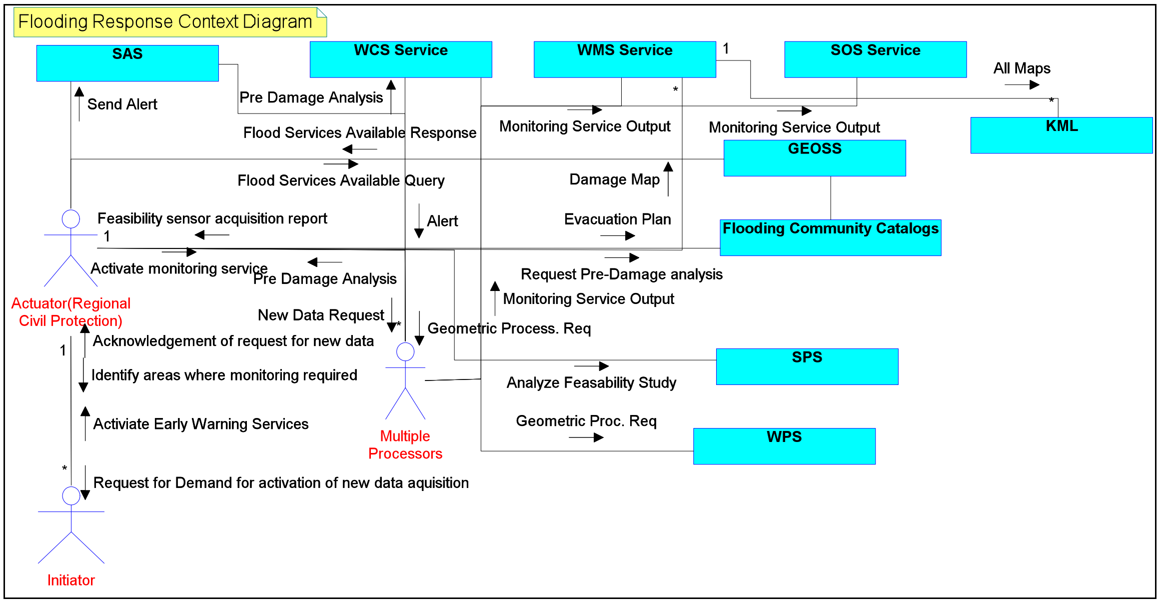


Figure 4 – Flooding Scenario Context Diagram

The Enterprise Specification below describes the properties that the environment of the ODP system must have for the specification to be used. A community is a collection of entities e.g. human beings, information processing systems, resources of various kinds, and collections of these. Community objects are included in the package names as Enterprise Global objects.

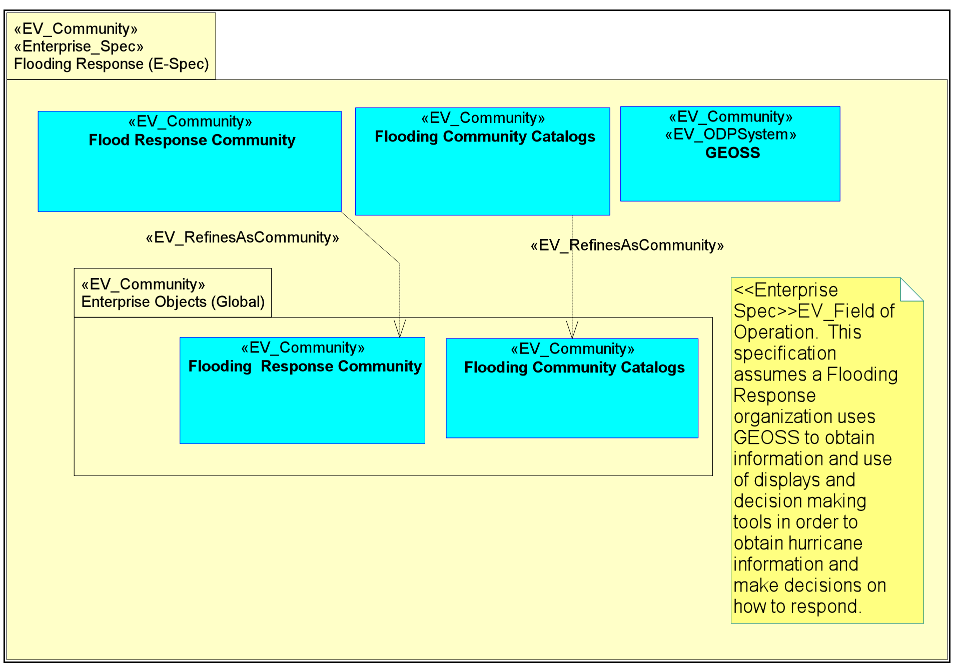


Figure 5 – Flooding Scenario Enterprise Specification

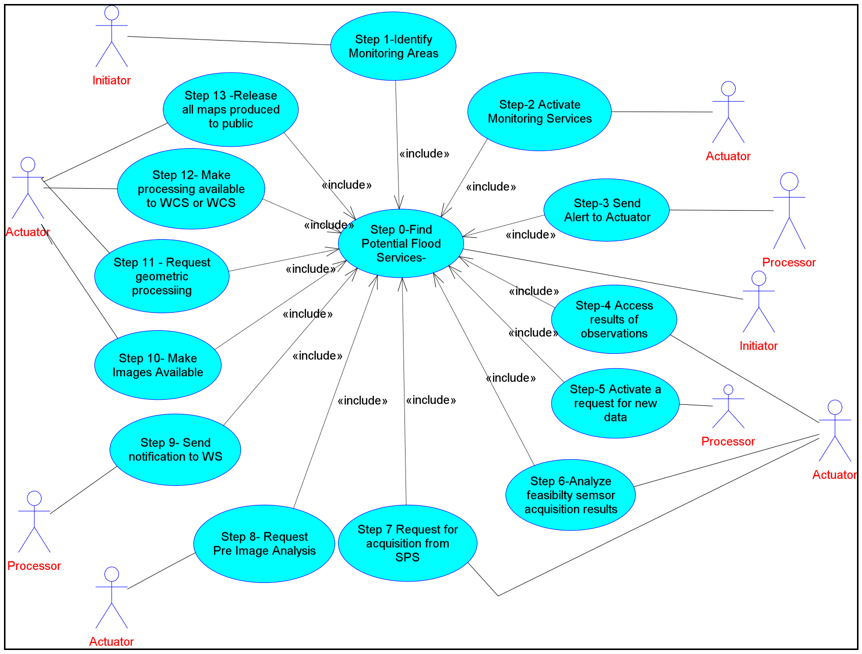


Figure 6 – Flooding Response Use Case Diagram

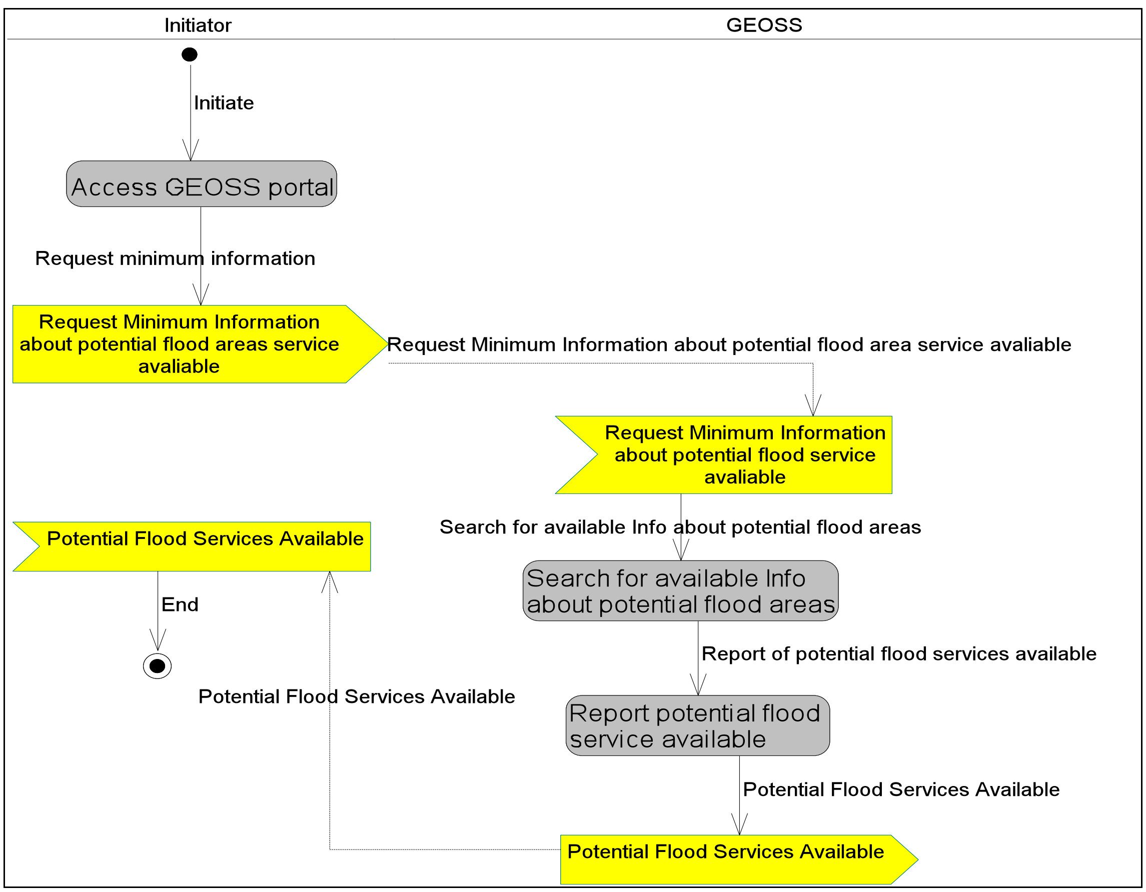


Figure 7 – Finding potential flood services Activity Diagram

2.4.1.5 References

- The UN, World Bank, WHO, and other agencies are all involved in steering the GEO Task.
- The GEO Regional End-to-End Disaster Pilot projects under Task DI-09-02b.
- The Regional End-to End Disaster Management Pilots are headed by Stuart Frye of Goddard Space Flight Center/SGT Inc. The Pilots evolved as a CEOS input to a subtask under the Group on Earth Observation (GEO) Societal Benefit Area (SBA) task DI-06-09 entitled "Use of Satellite Data for Risk Management" and headed by Guy Seguin of the Canadian Space Agency (CSA).
- CEOS-led task entitled "Flood Sensor Web Emergency Response Prototype" (task number AR-09-02c_2) is headed by Terrance Van Zyl of the Council for Scientific and Industrial Research (**CSIR**) in **South Africa** and identifies needed architectures and technologies to accomplish flood emergency response.
- The International Disaster Charter. The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users. Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property. (www.disasterscharter.org)
- Safer project: In the frame of the GMES initiative (Global Monitoring for Environment and Security), SAFER project aims at implementing preoperational versions of the Emergency Response Core Service. www.emergencyresponse.eu

2.4.2 Air Quality Scenario

Overview – Air Quality in the Context of GEOSS

The air quality community spans efforts to monitor the atmosphere (surface, satellite and aerial systems), model future atmospheric behavior and air quality conditions, measure and estimate emissions of pollution and pollution forming gases and particles, and combine earth observations with socio-economic data for decision-making analyses. The vision is to have these data available through an interoperability framework that allows them to be used via various subsets and combinations to support specific research and decision applications.

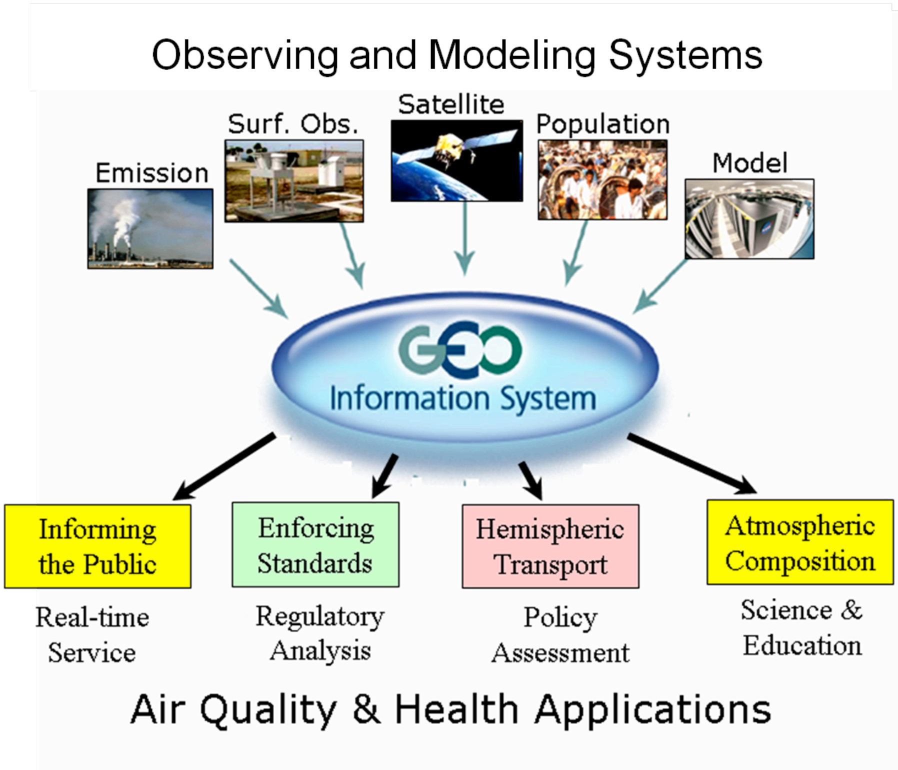


Figure 8 – Air Quality Community

Objectives for AIP-3

The objectives for AIP-3 will be finalized by the AIP-3 Air Quality & Health Workgroup Participants during the AIP-3 kick-off meeting. However, based on the work and experience gained during AIP-2, the following provides an initial set of goals for enhancing the use of the GEOSS Common Infrastructure (GCI):

- **Increase the number of data providers with web services registered in GCI**

  While AIP-2 defined an initial process and some of the infrastructure components needed for registering air quality web services in the GCI, the implementation was limited mostly to OGC WMS services and most of those services were provided through DataFed. The GCI service registration process defined during AIP-2 should be tested and used by a broader set of data providers in order to achieve a more robust and usable process for the air quality community. The availability of a variety of services will allow for refinement of the other, "down-stream" components of the GCI and Air Quality Community Infrastructure.

- **Enhance the Air Quality Community Infrastructure**

  Increasing the number and diversity of air quality data services accessible through the GCI will identify deficiencies in the current air quality community infrastructure. These gaps will be reviewed and modified and the overall infrastructure strengthened. Of particular importance is the robustness of the Air Quality Community Catalog and decisions on its underlying standards and processing for registering services. An example activity for AIP-3 is the development of processes to support registration of

OGC Web Coverage Services in the Air Quality Community Catalog. This objective will involve close collaboration with others advancing the AIP through the Transverse Working Groups.

- **Relate the GCI to air quality decision processes**

  As the Air Quality Community Infrastructure is enhanced, opportunities will be pursued to connect the GCI to use cases involving air quality research and decision-making. This objective can be achieved by organizations with existing decision support systems exploring the use of the GCI in their systems or by organizations developing new decision support systems to include use of the GCI in their designs.

A key to achieving these primary objectives is active participation in the AIP-3 by groups and individuals representative of the data providers and users who are envisioned to benefit from the GCI. Multiple systems serve or are targeting particular user communities within the air quality domain and their participation in AIP-3 will help define a common set of GEOSS-related processes and best practices across the community. Some of these existing systems are summarized in the list below (note the list is not comprehensive and others are invited to extend the list in their responses to the AIP-3 CFP).

- Related interoperability efforts, including
  - HTAP Network (long range transport)
  - CEOS Atmospheric Composition Portal (ACP)
  - Community Initiative for Emissions Research and Applications (CEIA)
  - GEO India Air (India Air Quality Community of Practice)
  - Others as defined by AIP-3 participants
- Information providers and decision support systems, including
  - AIRNow (US near real time monitoring and forecasting)
  - AIRNow-International
  - VIEWS (regional US air quality decision tools)
  - MACC (Europe atmospheric information services)
  - SERVIR (Central America monitoring and forecasting)
  - Bluesky Framework (US wildfire smoke forecasting and analysis)
  - Others as defined by AIP-3 participants
- Systems that established connections during AIP-2, including
  - DataFed
  - Giovanni
  - SEDAC

2.4.2.1 Targeted or Supported Community

The scenario is focused on three types of end users:

- A policy-maker, needing synthesized information on the importance of intercontinental pollutant transport
- An air quality manager, who needs to assess whether a regional pollution event was caused by an “exceptional event"
- The public, needing information about air quality now and in the near future to make activity decisions

While the scenario describes three distinct sets of end users, each depends upon common upstream actors and synthesized Earth observations. In fact, the common need for these synthesized atmospheric observations is a primary motivation for the structure of this scenario.

Given the wide variety of atmospheric processes at many scales, each of the above decisions needs an array of observations and models (listed below). Each type of data is significantly limited and not able to broadly document the state of the atmosphere. Synthetic fusion and inter-comparison of the data will allow analysts to produce a far more complete and accurate description of the atmosphere than obtainable from any one type of data. There are a number of scientific approaches to this challenge, but technical tools for inter-comparison, fusion, and processing of air quality data are not operationally available.

This scenario is consistent with GEO project HE-07-03: Integrated Atmospheric Pollution Monitoring, Modeling, and Forecasting in the GEO 2007-2009 Work Plan, and with the efforts of the CEOS Atmospheric Composition Constellation, the development of the GMES Atmospheric Service, and other major international collaboration efforts.

Participation in the scenario definition, development, and implementation can involve a range of activities. The following role definitions are intended to provide context to potential participants in the AIP-3 Air Quality Workgroup. However, CFP responses are welcome to define other roles that may not fit the given definitions.

Data provider

Provide access to data and information products that are used in air quality related science and applications. Data providers can make data available at multiple levels for use in AIP-3:

- Web accessible data – provide a persistently available source for data that can be used by another AIP-3 participant to create a standard web interface for registration in the GCI
- Standard web service – Data access though the implementation of a GEOSS recognized standard web service
- Standard web service with core metadata – provide information for the minimum set of metadata requirements for the GCI
- Standard web service with full metadata – provide information for a complete air quality metadata record.

Infrastructure developer

Contribute to the development of the Air Quality Community Infrastructure and its interfaces to the GCI and systems outside of the GCI. Apply existing services and capabilities to the air quality domain and develop new capabilities where needed.

Data consumer

Work with the user interfaces, applications and portals built on top of the GCI in order to find, understand and access data for particular uses in air quality science and management.

Domain community expert

Provide community perspective, insight and feedback to the design, development, implementation and use of the Air Quality Community Infrastructure. Expertise is useful from any related discipline but particularly from air quality data providers, scientists, managers and policy-makers, information scientists working on interoperability, and others with experience with GEOSS and other environmental information systems.

2.4.2.2 Context and pre-conditions

2.4.2.2.1 Actors

A number of actors process earth observations information upstream of the decision makers, who base their decisions on highly synthesized data. They are described in more detail in the full scenario (http://wiki.esipfed.org/index.php/AIP_AQ_Unified_Scenario).

Actors Processing and Using Data: Intercontinental Pollutant Transport Example

For illustration, a "value chain" of actors involved in the Intercontinental Pollutant Transport events is listed here; similar chains for the other events are described in the full scenario.

- End use decision maker: Policy maker negotiating an agreement on intercontinental pollutant transport
  - Information needed: Synthetic assessment reports quantifying the impact of long-range pollutant transport
- Upstream information processor: Scientific advisory group
  - Information needed: Technical assessments of model experiments and synthesized datasets to assess transport
- Upstream information processor: Scientific task force assessing long-range transport
  - Information needed: Synthetic description of the atmosphere, using multiple observations and models
- Upstream information processor: Air quality data analysts
  - Information needed: Wide variety of atmospheric observations, *synthetic integrations of this data*

Other Actors: Earth Observations Providers

The earth observations required are generally needed for each set of scenario events.

- Government agencies (National, State/Provincial/Tribal, and/or Local):
  - Environmental, Meteorological, Land management, Space agencies
- Industry, Consultants
- Academic and Other Research Institutes
- International cooperative fora (e.g. WMO, CEOS, EEA)

2.4.2.2.2 Information Assumed to be Available

Below is an initial list of information needed to support a realistic Air Quality and Health scenario. Note that most are not yet accessible through the GCI.

- Meteorological data, such as observations from ground-based networks, satellites, radiosondes, and forecasts from numerical models at various geographic and time scales

- Geographical data (land use, demographics, emissions-related activity, etc.)
- Atmospheric composition (air quality) observations such as surface monitoring networks, satellite observations, radiosondes, ground-based remote sensors, and aircraft measurements
- Numerical air quality chemical transport models (at regional to global scales)

2.4.2.2.3 Processing and Collaboration Functionality Needed

The main functionality needed to support a realistic Air Quality and Health scenario in AIP-3 include:

- Community Catalog(s) for registering data and services to be harvested by the GCI
- Community Portal(s) for finding, accessing the data and services from the GCI,
- Functionality for standard-based access to spatio-temporal data and metadata, and workflow software for service orchestration
- Processes and guidelines for implementing standards and using the GCI
- Community of Practice Workspace(s) where the actors in the scenario can communicate and coordinate their activities.

Additional functionality and facilities specific to the Air Quality Scenario should include tools for visualizing, and processing observational and modeling data for near real time and for historical analysis. These tools should facilitate:

- Integration of multiple observational data sets to create rich n-dimensional descriptions of the atmosphere to improve understanding of atmospheric processes;
- Comparison of observational data to numerical model estimates to improve numerical model descriptions of historical conditions (events or long-term trends);
- Real-time assimilation of observational data into numerical models to improve numerical forecasts;
- Effective mechanisms for distributing (in near real time) maps/images, descriptive information, and processed data to health, emergency response, and air quality management authorities; to mass media; other research and assessment communities (e.g., health); and the general public.

One of the main objectives of AIP-3 is to build on the Air Quality Community Infrastructure developed in AIP-2 to provide, evolve or contribute some of the above functionality. The Air Quality Community Infrastructure from AIP-2 is summarized below.

Air Quality Community Infrastructure from AIP-2

The AQ&H WG activities during AIP-2 were captured on the collaborative site used during the Pilot (https://sites.google.com/site/geosspilot2/air-quality-and-health-working-group). In preparation for AIP-3 the results from AIP-2 are being summarized on a newly formed GEO Air Quality Community of Practice site (http://geo-aq-cop.org).

The following two figures summarize the infrastructure used during AIP-2 and represent a starting point for AIP-3. Data access services are registered into an Air Quality Community Catalog. Registration entails the process of making metadata describing the web service available to the Air Quality Community Catalog. To aid the process of making the metadata available, a web tools was created that extracts metadata information from OGC WMS GetCapabilities and allows data providers to enter information to complete the metadata record in ISO 19115 format. The Air Quality Community Catalog is registered in the GEOSS Registry, meaning information describing the catalog, its type, and location is recorded in the GCI Registry. The GEOSS Clearinghouses retrieve metadata from the Air Quality Community Catalog and provide programmatic search interfaces to the metadata that are used by GEO Web Portals and air quality related web applications and portals.

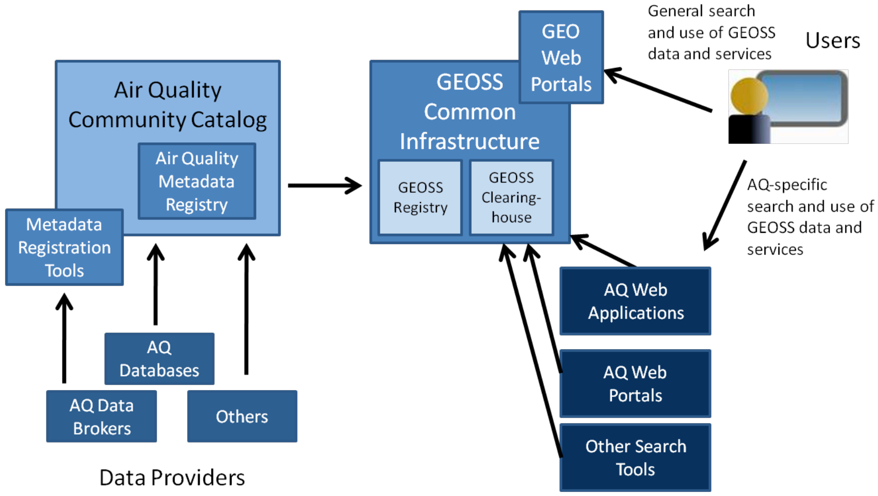


Figure 9 – AIP-2 Air Quality Community Infrastructure

Data Providers: AQ databases, data brokers, others – Multiple sources of air quality related data are provided through standard web interfaces.

Air Quality Community Catalog – The Air Quality Community Catalog stores metadata records. The primary AQ Community Catalog was a Web Accessible Folder of ISO 19115 metadata records.

Metadata Registration Tool – A web form based tool was created that

GEOSS Registry – The Air Quality Community Catalog is registered with GCI Registry that provides the sources of the underlying metadata used by the rest of the GCI

GEOSS Clearinghouses – The GCI Clearinghouses read the records in the GCI Registry and query the Air Quality Community Catalog for metadata records that are stored in the Clearinghouses. Regular harvesting of the Air Quality Community Catalog is conducted to ensure the latest information is reflected in the GCI.

GEO Web Portals – The three GEO Web Portals are designed to provide a graphical user interface to the GCI. They query one or more of the GEOSS Clearinghouses for metadata records that meet a set of search criteria and present the results.

AQ Web Applications, Portals, and other – Tools developed for particular air quality data searching, visualization and analysis that are able to query the GEOSS Clearinghouses.

Users – Depending on their need**,** users of the GCI either use the general search and visualization tools provided in the GEO Web Portals or the air quality tailored tools provided through web applications, portals or other mechanisms.

Some level of implementation for each of the infrastructure components was achieved during AIP-2 (summarized in Figure below). Web links to each of the components are available on the GEO AQ Community of Practice site (http://geo-aq-cop.org).

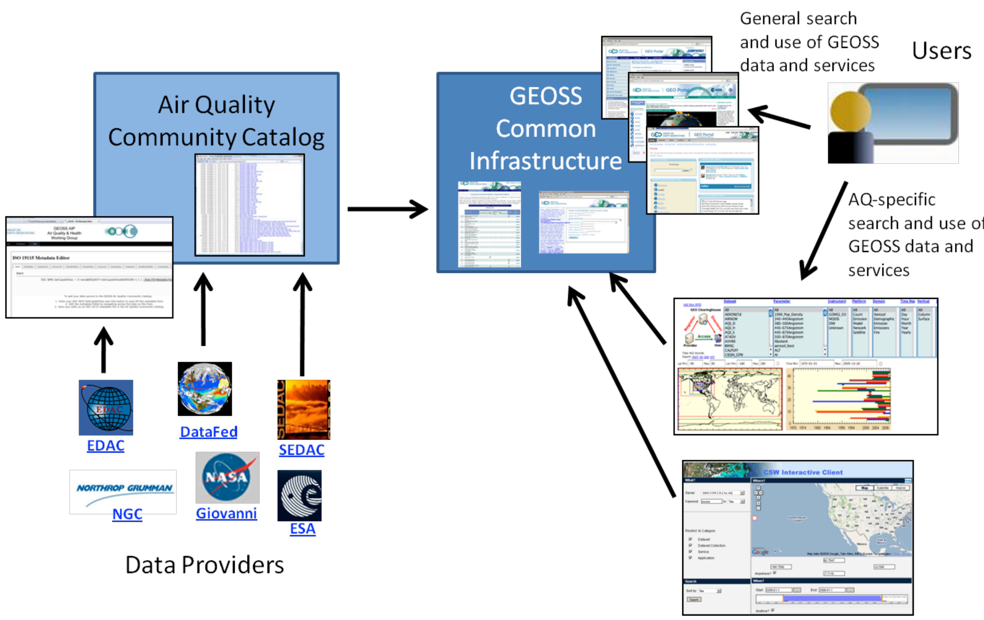


Figure 10 – Implementation of AIP-2 Air Quality Community Infrastructure

2.4.2.3 Scenario Description

The scenario described in this section builds on the AIP-2 Call for Participation which outlined a generic air quality scenario that serves as a framework for defining air quality related objectives, use cases and activities during the AIP. The scenario represents a future end-state that supports multiple uses and applications of the GCI for the air quality community. The goals during the AIP processes are to incrementally develop the infrastructure and content needed to achieve the envisioned end-state. It is likely that only a portion of the scenario and use cases described below will be addressed while working to the objectives of AIP-3. The scenario is expected to be refined based on the experiences and implementations during the AIP.

The air quality scenario envisions GEOSS facilitating two broad goals: building connections to facilitate movement of data between actors, and developing interoperable tools for intercomparison and fusion of a wide variety of atmospheric data. Readers are referred to the full version of the scenario for more details: http://wiki.esipfed.org/index.php/AIP_AQ_Unified_Scenario

2.4.2.3.1 Scenario Events

The interoperable infrastructure envisioned by this scenario will enable analysts to combine wide range of air quality observations, models, and other information, which will ultimately be used to produce a broad range of decision support products for a number of different audiences. Current air quality related projects (see full version of the scenario) are significant building blocks along with the evolving data mediators of the needed networks and tools.

Assessment of International and Intercontinental Transport of Air Pollution

Assessment of this phenomenon is currently underway by several bodies. GEOSS can assist these efforts by constructing linkages between the various databases and other existing air quality-related data hubs and by developing and linking tools to facilitate comparison of models, observations, and emissions data.

These capabilities are used to form a more complete and accurate description of the atmosphere than currently available from any one type of atmospheric observation. Researchers will use these datasets and models to quantitatively assess the importance of long-range pollutant transport. Research efforts will then be compiled into a detailed report of the task force. This report is then used as the basis for an synthesis report and executive summary which will finally be delivered to policymakers to inform their decision making process, as international conventions consider initiatives to address long range pollutant transport.

The connectivity and tools developed as part of this effort will be applicable to model evaluation and analysis at the regional scale as well, ultimately benefiting a large community of air quality managers and researchers.

Exceptional Event Analysis

Air quality is periodically influenced by natural and anthropogenic events, such as wildfires and dust storms. For regulatory purposes in several countries, pollution episodes can be flagged as 'exceptional events' if an area would not have exceeded the pollution standard without the occurrence of an uncontrollable and unusual natural or anthropogenic event.

An event might be obvious or subtle, so the impetus to examine a given event could come from air quality managers or the wider community. Analysts at air management agencies or elsewhere would use models and ambient and satellite observations to identify potential events. Once an event is proposed, relevant data is compiled from those data sources to explore the origin and evolution of the pollution, with data and developing analysis shared in a virtual workspace. Synthesizing data from the various sources, analysts quantify the effect of the event on the receptor regions, and then compile this information into a report submitted to air quality managers.

Providing Near Real-Time Air Quality Reports and Forecasts to the Public

Real-time and forecasted air quality information plays a very important role in informing the public about potentially harmful conditions. This information allows individuals to take precautionary measures to avoid or limit their exposure to predicted unhealthy levels of air quality. Information is needed in a central, accessible, and understandable format.

While air quality report and forecast systems exist in many countries, they depend on ambient monitors. Such an approach does not utilize many types of Earth observations, and will be less fruitful in many parts of the world due to geography and the expense of a network of real-time monitors.

These systems depend on continuous air quality and metrological monitoring network, including data and information from other jurisdictions (other regions or nations). Capabilities for fast assimilation of satellite observations and products are needed. These observations must be automatically ingested, formatted, and processed (for example, quality assurance) into a database. Forecasts and reporting are produced from the integration of these datasets. Current conditions and forecasts are then disseminated to give the public high spatial and temporal information about the location and duration of unhealthy air. Information is tailored, in some cases, to particular audiences such as emergency managers and health providers.

The continuous monitoring and high-frequency reporting, distribution, and forecasting in this scenario event facilitate frequent evaluation of the entire system. Insights from these checks will not only improve forecasting techniques, but are also useful for improving understanding of the input data and models.

2.4.2.4 Enterprise Model

The Enterprise Model will be developed later depending on the final composition of the Air Quality and Health Working Group and their associated components.

2.4.2.5 References

Air Quality Tasks in the GEO 2009 – 2011 Work Plan related to this part of AIP-3 include:

- HE-09-02a: Aerosol Impacts on Health and Environment
- HE-09-02b: AQ Observations, Forecasting & Public Info
- HE-09-02c: Global Monitoring for Persistent Organic Pollutants
- HE-09-02d: Global Monitoring for Atmospheric Mercury
- DA-09-02d: Atmospheric Model Evaluation Network
- US-09-01a: Earth Observation Priorities for Air Quality & Health
- AR-09-02b: Atmospheric Composition Portal
- DA-09-01b: Data, Metadata and Products Harmonization
- DA-09-02a: Data Integration and Analysis Systems Alliance

2.4.3 Biodiversity and Climate Change- Prediction of an Ecosystem Evolution Scenario

The objective of this scenario is to develop a framework that aids scientists in predicting the impact of climate change on ecosystems and biodiversity species distribution, and assess projections achieved through environmental models.

The Biodiversity and Climate Change scenario builds on and extends the experiences developed in the context of GEOSS AIP-2.

2.4.3.1 Targeted or Supported Community

This scenario aims to demonstrate how the GEOSS Common Infrastructure (GCI) facilitates interoperability between the resources (i.e. data, services, models, semantics, best practices, etc.) managed by three important communities: Climate, Biodiversity, and Ecosystem Communities (GEOSS themes).

Therefore, supported communities include climate, biodiversity and ecosystems scientists. This scenario is extremely useful to predict and assess how future environmental changes will affect ecosystems and species distribution at local, regional, and global scales. Thus, policy makers and environmental decision makers are targeted communities. Finally, this scenario can contribute to more complex and multi-disciplinary frameworks (e.g. applying the Model Web approach).

2.4.3.2 Context and pre-conditions

Predicting how biodiversity will change with climate is critical to understand the implications of climate change; one of the key biodiversity alterations will be how the regional and local ecosystems change in relation with climate variation. This is currently a topic of great interest and many studies have been done looking at such changes. The value of these studies covers part of the continuum from pure research to pure applied work. The research end includes understanding what factors actually control the ecosystems, such as physiological limitations relative to weather and climate. Moving further towards the applied end of the continuum, then includes developing approaches that allow the implications of changing climate to be assessed.

2.4.3.2.1 Actors

The main involved actors in this Scenario are:

- **Scientist**: end user of the developed system;
- **Environmental, Climate, Ecosystems, and Biodiversity Data/Service Providers**:
    - Government Agencies (e.g. environmental protection agencies);
    - Academic and Other Research Institutes;
    - International (non-governmental) Organizations;
- **Model Providers**
    - Academic and Other Research Institutes;
    - Government Agencies (e.g. environmental protection agencies);
    - International (non-governmental) Organizations.
- **Multi-disciplinary interoperability experts**

2.4.3.2.2 Information Assumed to be Available

One type of critical data is the observation biodiversity data. This data can be provided by international information framework (e.g. GBIF), researchers and researching projects (e.g. ALTER, ALTER, etc.), or other sources (e.g. governmental agencies). The availability of good data over a range of dates may be of particular value because they can support model validation.

Another type of critical data involves environmental and climate parameters important for ecosystems. Even though ecosystems evolution may be controlled by just a few environmental parameters, it is common to predict changes based on a variety of parameters because it is often not known a priori which parameters are most significant to that specific ecosystem. WMO, WorldClim, and IPCC are valuable examples of present and future climate data sources.

2.4.3.2.3 Processing and Collaboration Functionality Needed

Important processing functions fall into two main categories. The first one consists of the processes that elaborate climate, environmental and biodiversity data sets to generate more appropriate input data for ecological and environmental models (e.g. space and time scales processing, subsettings, coordinate transformations, statistical analysis, etc.).

The second important processing functions correlate biodiversity to climate and environmental parameters (e.g. Ecological Niche Models: ENMs).

Collaboration with domain experts is needed to enhance present resource discovery functionalities (e.g. catalog query functionalities) by supporting semantic based queries and model discovery. The aim is to allow scientists to select the most appropriate resources (e.g. data sets and environmental models) by means of precise taxonomies and by shielding the resources complexity.

2.4.3.3 Scenario Description

In this Scenario, Climate Change, Biodiversity and Ecosystems resources (i.e. datasets, services and models) are discovered, accessed, and chained in a homogeneous way. The goal is to use these resources for generating predictions of an ecosystem evolution by applying ecological and environmental modeling; the achieved predictions are published as new GEOSS resources.

From the GEOSS infrastructure perspective, an important objective is to investigate the multi-disciplinary interoperability process to determine valuable predictors for the impact of climate change on ecosystems and biodiversity.

2.4.3.3.1 Scenario Events

These are the preliminary Scenario’s steps:

1. The user accesses the GEO Portal to discover an appropriate “CC&Bio Application” to predict a specie distribution due to climate changes on a given area; all the following steps are performed through this “CC&Bio Application”.
2. The user discovers and accesses biodiversity datasets.
3. The user discovers and accesses historical environmental datasets.
4. The user discovers and accesses Climate Change datasets.

5. The user discovers and accesses the appropriate ENM for the context of his/her study.
6. The user runs the discovered ENM to generate the present ecological niches – ingesting the discovered present biodiversity and environmental data sets.
7. The user projects the generated ecological model by ingesting the discovered Climate Change datasets; biodiversity distribution projections are generated.
8. Biodiversity projections are published on an access service (e.g. WCS-T);
9. Scientist validates the projections.

2.4.3.4 Enterprise Model

The following Figure depicts the enterprise Model implemented by the Scenario.

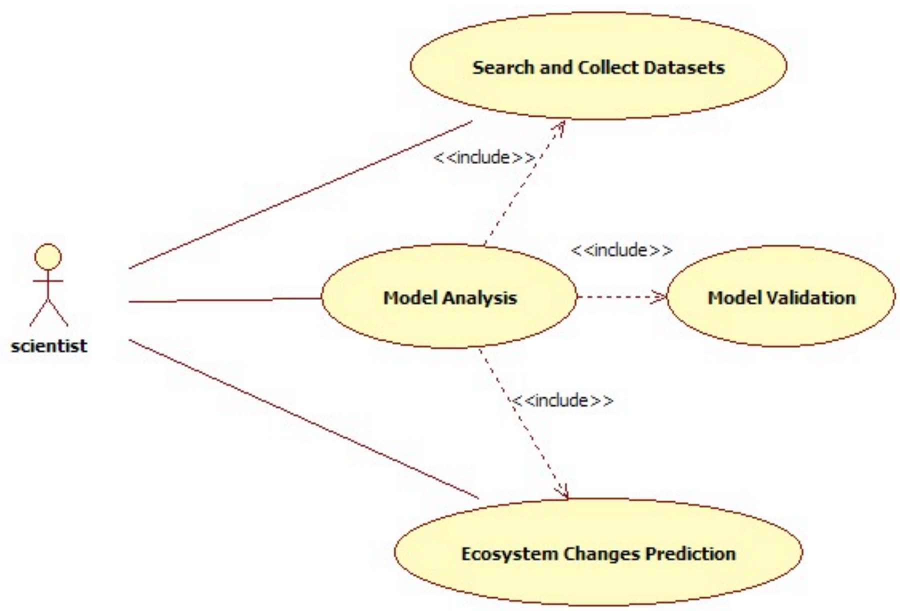


Figure 11 - Enterprise use case diagram for CC&Bio scenario

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2.4.4 Biodiversity and Climate Change – Arctic Spatial Data Infrastructure Scenario – A Framework for Science

The Arctic Council in November 2009 approved a new initiative for the eight Arctic nations to develop an Arctic SDI to host and serve basic and thematic geographic data in support of Arctic science initiatives. In addition to “base maps” served through OGC Web Map Services in a suitable polar projection and downloadable as data, scientific data sets are expected to include geologic, meteorological, climatic, land cover, built infrastructure, communities and related data. The intent of the Arctic SDI is to support the publishing of additional science and environmental data that are geographically referenced in order to create a geographic library and catalog that can be used by scientists and decision makers to visualize and/or access multiple data sets in their geographic and temporal context.

The objective of the scenario is for Council members to contribute data and services, register them with the ASDI catalog, and then use the geospatial portal interface to interact with the catalog and the data to support a number of scenarios.

2.4.4.1 Targeted or Supported Community

Working groups of the Arctic Council that are envisioned to use the Arctic SDI to post and access mappable data, include:

- Council on Arctic Flora and Fauna (CAFF)
- Arctic Monitoring and Assessment Programme (AMAP)
- Emergency Preparation, Preparedness, and Response (EPPR)
- Protection of the Arctic Marine Environment (PAME)

2.4.4.2 Context and pre-conditions

2.4.4.2.1 Actors

Scientific information provider is a governmental or academic organization that has developed an Arctic data set and/or Web service will use the ASDI to document and publish that data with a minimum of effort. National mapping agencies will take a lead in facilitating the hosting of the scientific data.

Geographic data service provider operates key Web Services or data download services, which may include Catalog, Web Map Service, Web Feature Service, or Web Coverage Service, or file-based data access (i.e. ftp, http, form selection interface)

Multi-participant responses are requested to include data providers, service providers, and end-users. Any individual organization may contribute one or more of these actors. Proposals of commitment to serve and register Arctic spatial data sets are also sought, that may be accessed and applied by others.

2.4.4.2.2 Information Assumed to be Available

Key data sets assumed to be made available in the Arctic SDI include the following base map layers for the region north of 60 degrees North. Initially, these may be at a small scale (low resolution) but will be supplemented by more detailed data as they become available.

- 30m Elevation from ASTER DEM
- Ortho-imagery
- Major transportation infrastructure
- Political boundaries
- Populated places and place names
- Land cover
- Major rivers and streams

Additional thematic layers of interest include:

- Population estimates
- Geologic map of the Arctic

- Shaded relief, aspect, slope, watershed boundaries
- Climate data for known periods
- Protected areas

Potential scientific geographic data of interest include:

- Observations and monitoring sites and linked data -- i.e. meteo sites and time series, river discharge, environmental sampling sites, species occurrence for flora and fauna,
- Environmental model outputs as maps over time

These lists represent a set of known data sets with unknown availability in the Arctic region. We are looking for proposals by participants to offer data or services on any of these or additional data for some portion of the Arctic region.

2.4.4.2.3 Processing and Collaboration Functionality Needed

The ability to integrate and visualize data in the same geographic and time context is crucial to the usability of this GEOSS Community Web Portal. If data are not available in the selected polar projection, then the ability to re-stage or re-project the data will be required on some data sets. No additional collaboration functionality is envisioned.

2.4.4.3 Scenario Description

Responses are encouraged to suggest scenarios that would exercise the availability and integration potential of diverse Arctic data that could be applied in decision support.

Possible scenarios being requested from participants that would exercise the ASDI include the following suggestions:

- Assessing the effects or dimension of climate change,
- Visualizing the extent of flora and fauna observations in the Arctic environment over time,
- Exploring correlations between terrestrial and vegetative conditions and meteorological or climatologic point and extrapolated data,
- Evaluating data collection networks and conducting interpolation of point data or performing gap analysis to motivate additional data collection sites,
- Providing hydrological modeling capabilities for Arctic Rivers,
- Assessing hazards and hazard response based on population, existing infrastructure, and environment

2.4.4.3.1 Scenario Events

The scenario events will be developed once the scenario(s) have been finalized based on the responses to the CFP.

2.4.4.4 Enterprise Model

The Enterprise model will be developed based on the scenarios suggested in the CFP responses.

2.4.4.5 References

Arctic Council papers:

- 2008 proposal: http://arctic-council.org/filearchive/ac-sao-nov08-final_agenda_v1.pdf
- 2009 approval: http://arctic-council.org/filearchive/SAO%20Meeting%20nov09-%20FINAL.pdf

2.4.5 Energy Scenario

Production and use of energy are major contributors to Greenhouse Gases (GHG). Decision makers and policy planners need a better knowledge of the impacts on environment induced by the various technologies used for energy production, in order to select the most appropriate technologies. The Energy scenario in AIP-3 focuses on the assessment of such impacts by a proper exploitation of data available within GEOSS. It should benefit from already existing energy related services including those that have been developed within the AIP-2. Databases related to technologies and emissions will be made available as GEOSS-compatible services during the AIP-3 time frame. Quality assessment and management of Intellectual Property Rights (IPR) using GEOSS recommendation will also be considered.

As with the energy AIP-2 CFP, several energy domains can be considered such as solar, wind, biomass, fossil fuel, etc. For the AIP-3 scenario, the addition of environmental impact assessment is of crucial importance.

The scenario described here aims first and foremost at enriching the existing GEOSS Common Infrastructure (GCI) by enrolling as much as possible providers of data and services relevant to energy and environmental impact assessment. This first step will promote distributed interoperable approach allowing search, discovery and use of these data and services. Then, based on existing and newly deployed resources, several scenarios focused on end-users concerns will be developed. This second step aims at providing visualization and analytic tools and services.

The work carried out in the AIP-2 has paved the way from a data provider perspective towards interoperability. Key elements of the GEOSS Common Infrastructure (GCI) have proven their usefulness to implement interoperability and should be considered within AIP-3. Each AIP-3 data provider wishing to promote data and services in energy and/or environmental impact assessment within the GCI should consider the following steps:

- Creation of Web Service allowing access to the resources using GEOSS standard recommendations (OGC WMS, W3C WSDL, etc)
- Creation of Metadata using recognized international standards (ISO 19115, 19119, etc)
- Creation of catalogues of Web Services using GEOSS recommendations (UDDI, Web Accessible Folder (WAF), etc)

- Registration of catalogues and resources into the GEOSS Registry allowing the "Search & Discovery" of deployed resources within the GCI.

Each data provider is encouraged to investigate and document the quality of the data, what best practice or standard approach is used to assess this quality parameter and how it could be spread along the GEOSS information chain for the benefit of the end-users. A similar approach should be applied to data license and Intellectual Property Rights (IPR).

For the end-user scenarios, value-added visualization and analytic tools based on existing or newly deployed Web Services are considered. The AIP-2 scenario has offered various web-based solutions (Web 2.0 Mash-up) for visualization, analysis and data retrieval process. Though no mandatory framework for such development is promoted within GEOSS, the use of open, standards, community driven and publicly available solutions are recommended.

2.4.5.1 Targeted or Supported Community

The energy scenario aims at developing a global observation strategy for the monitoring and the prediction of the impact of the exploitation of energy resources on the environment. Various energy resources may be consequently addressed such as solar, biomass, wind, fossil fuel, etc.

While the scenario will benefit from existing AIP-2 energy and environmental data sets made available by both communities, additional data sets and models providing access to energy-related parameters and environmental impact assessment indicators should be made available within AIP-3.

The scenario will ease the flow and the combination of those data sets and models in order to propose relevant indicators qualifying environmental impacts of the energy use ranging from production to consumption.

Three different types of beneficiaries of this scenario have been identified:

- **Policy planners**, who need general and global trends of the assessment of environmental impacts of the various energy technologies in order to produce global recommendations and rationalize decision making based on scientific assessment
- **Energy operators**, who face the challenge of selecting the relevant technology for a given site according to possible environmental impact for the given energy production source
- **Installers of Renewable Energy systems**, who will benefit from having global environmental impact indicators for a given source of energy for marketing towards environment-conscious customers and the public

2.4.5.2 Context and pre-conditions

2.4.5.2.1 Actors

Actors of the scenario are directly derived from the Enterprise Actors described in Section 2.2.2. From a bottom up perspective, the energy scenario starts with:

- **Community Resource Providers**: for the energy scenario, they include data providers in energy or environmental impact assessment. They will provide the raw or transformed Earth observation components (data, metadata, catalogue, model, services, tools…) in a GEOSS interoperable compliant form for the realization of the scenario.
- **GEOSS Integrators**: The scenario aims at providing value-added indicators of the environmental impact of the use of energy by combining the distributed needed resources coming from GEOSS members. Based on the use of the GCI and Community Resources, the GEOSS Integrators will develop and deploy persistent application needed to achieve the scenario goals.
- **GEOSS Users**: from high end-users like **policy planners**, who need synthetic assessment and report, **energy operators**, who conduct top level studies and **installers of renewable energy systems**, for large dissemination activities, the scenario will tackle a wide range of different users and needs.

2.4.5.2.2 Information Assumed to be Available

In order to derive a consistent set of environmental indicators for monitoring the impact of energy production, transport and use, various global and regional data sets need to be accessible:

- Energy-related Earth observation data have been made available in a GEOSS interoperable compliant form in the framework of AIP-2. The Web Service Energy Community Portal (www.webservice-energy.org) gives access to several resources through GEOSS compliant Web Services,
- Life Cycle Inventories (LCI) data sets in the energy sector are needed in order to derive environmental impact indicators for the associated energy production, transport and use possibly over its whole life cycle.

2.4.5.2.3 Processing and Collaboration Functionality Needed

The GEOSS Common Infrastructure (GCI) components should be the foundation of the overall data flow and data processing. The Energy scenario will leverage and enrich the following existing components:

- Community of Practices (CoP) portal(s) that gather the various actors for scientific and public knowledge dissemination purpose
- Community Catalogues exposing standard metadata through catalogues service interface empowering registration into the GEOSS Registry and allowing harvest by the GEOSS Clearinghouses
- Community Portals(s) providing standard access to data and services for the execution of the scenario

Specific processing should be considered for providing a human user interface (Web 2.0 Mash-up) for visualization, handling and download in a suitable format of the final computational results. This specific processing hosted at a Community Portal will benefit from chaining and processing of Web services in energy and environment provided by GEOSS partners.

2.4.5.3 Scenario Description

The description of the Energy Scenario requirements provided in this CFP has been kept as general as possible in order to raise the most interest among a wide variety of providers of energy-related data (in various domains) in providing information on the environmental impact of the production, transportation and use of energy to leave open any specific need for their own sectors and technology specificities.

One of many possible scenarios is described below focusing to the environmental impact assessment of the photovoltaic system considering the above general objectives. Other scenarios are encouraged based on different energy domains, user communities and related projects.

2.4.5.3.1 Scenario Events

Environmental impact assessment of the photovoltaic sector (Example Scenario).

As photovoltaic sector development is extensively growing, environmental concerns according to technologies and systems are not yet well assessed. Expert needs to provide answers to various questions like: *Regarding environmental impacts, what is the most favorable material for photovoltaic panel construction? What are the environmental performances of PV systems? What is the carbon footprint of a PV system according to its lifecycle?*

Being able to assess scientific, technical parameters will allow characterizing the environmental impact of the photovoltaic sector. The assessment of the carbon footprint of a PV system according to its lifecycle implies to deal with various data sets that perfectly fit into the GEOSS interoperable approach:

- Solar radiation (kWh/m2) is a key parameter with a tremendous impact of PV electricity production
- Geo-localization (lat. long. or Area Of Interest AOI) where such PV systems will be installed is consequently of major importance.
- The type of material and technology of the PV system (a-si, multi-Si, mono-Si)
- The total primary energy that has been needed for the PV system construction depending on the electricity mix used for its production

As a final results a map of carbon footprint according to PV life cycle assessment can be produced. An example of a recent study (ESPACE Project http://www.espace-pv.eu/resultats.html) illustrates this scenario.

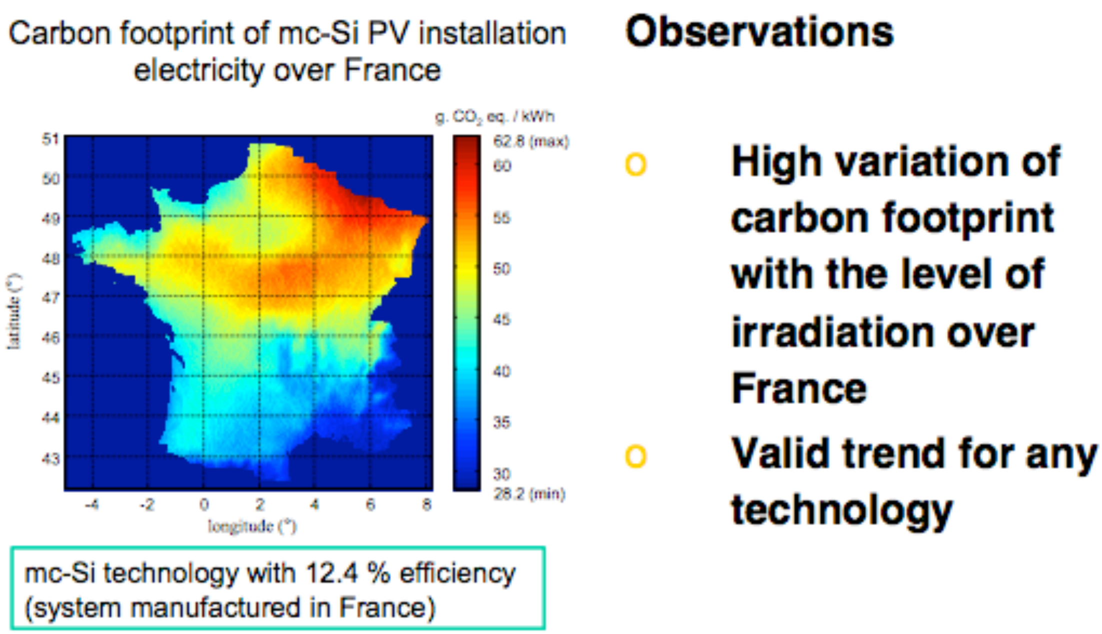

Figure 12 – Carbon footprint Example

The generation of such map could be made available as an on-line accessible specific processing thanks to the GEOSS interoperability approach of chaining and combining distributed Web Service having access to the needed data sets.

2.4.5.4 Enterprise Model

The Enterprise Model will be developed later depending on the final scenario(s) selected.

2.4.5.5 References

This scenario is directly linked to the GEO 2009-2011 Work Plan:

GEO Task EN-07-02 - Energy Environmental Impact Monitoring

Promote the development of Earth observation systems for the monitoring and prediction of environmental impact from energy resource exploration, extraction, transportation and/or exploitation. Build upon the contribution of the European project EnerGEO (Earth observation for monitoring and assessment of the environmental impact of energy use).

It also foster the activities of the following GEO tasks

- GEO Task EN-07-01 - Management of Energy Sources
- GEO Task EN-07-03 - Energy Policy Planning

A selected and non-exhaustive list of relevant resources for the energy scenario includes:

- GEOSS Energy Community Of Practice (COP): http://www.geoss-ecp.org
- Web Service Energy Community Portal: http://www.webservice-energy.org
- GEOSS AIP-2 Energy Scenario:

  - Engineering report: http://www.ogcnetwork.net/AIP2ERs#energy
  - Web 2.0 Portlet Client: http://project.mesor.net/web/guest/geoss_re_scenario
  - Promotional video: http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP2/index.html
- ESPACE Project: http://www.espace-pv.eu/index_eng.html
- Ecoinvent: http://www.ecoinvent.org/home/
- European platform on LCA: http://lct.jrc.ec.europa.eu/eplca

2.4.6 Water- Water Quality Scenario

The objective of the scenario is to assist decision-making in the Water Societal Benefit Area and provide information for the benefit of the public on water quality. Collecting in situ observations of water quality, the biogeochemical constituents of waterways, and the physical processes of freshwater continental drainage is labor-intensive and generates huge amount of data. Unlike other areas, such as drought forecasting, which rely on relatively mature meteorological and climatological practices, utilization of space-borne satellite observations to complement in situ observations is in its infancy (although coastal, satellite-based water quality techniques have been developed for a longer period of time, including harmful algal blooms and coral reef protection).

2.4.6.1 Targeted or Supported Community

- Riparian owners, state natural resources agencies, US Department of Interior Geological Survey (in the case of the USA)(nutrient and flow data) and US Environmental Protection Agency (in the case of USA).
- County extension agents, lake associations, etc.
- Users who can access visualized products from the portal on the Web (or users receiving alerts during waterway or beach “closings.”

2.4.6.2 Context and pre-conditions

2.4.6.2.1 Actors

- Decision makers and data providers at various national levels including
  - Riparian owners,
  - State natural resources agency,
  - US Department of Interior Geological Survey (in the case of the USA)(nutrient and flow data)
  - US Environmental Protection Agency (in the case of USA).
  - County extension, lake associations, etc

2.4.6.2.2 Information Assumed to be Available

The information assumed to be available is that provided by national environmental protection agencies, which systematically collect multiple chemical composition and streamflow data within their jurisdictions. Note that not all of this information is yet accessible via the GCI.

2.4.6.2.3 Processing and Collaboration Functionality Needed

Within the USA, the National Aeronautics and Space Administration (NASA) has only recently begun funding projects to develop water quality space applications (excepting open ocean and coastal ocean applications, which are a more mature technology).

Nutrient transport algorithms are now being included in some global water transport models (such as WBM/WTM), which have daily time steps. At the same time, nutrient models are being coupled with carbon models within land surface models (although such land surface models do not carry out water routing, except in specialized cases of post-processing). These techniques identify source strength for such nutrient concentrations, which are then added to river networks. These modeling techniques need to be integrated with space-born Earth Observations.

Improved information infrastructure and cyberinfrastructure are required to integrate the huge numbers of data hubs and data holdings existing among innumerable national environmental protection agencies, as satellite observations become increasingly blended with these in situ observations in the future.

2.4.6.3 Scenario Description

Below are four possible scenarios that can be exercised during AIP-3. The final scenario(s) and their associated steps will be determined based on the CFP responses.

Possible Scenario 1

This scenario is focused on a single large water body (as in the case of a large lake system or coastal bay) and its surrounding watershed up to the water divide (mountain chain separating drainage basins). A policy maker within a state or national environmental protection organization is charged with responsibility in preparing annual reports on progress having been made towards targeted restoration of a coastal bay or large lake, including

- Water Quality (Dissolved Oxygen, Mid-channel water clarity, Chlorophyl-a, Chemical contaminants, etc)
- Habitat and Lower Trophic-Benthic Community (Benthic index of Biotic Integrity, Phytoplankton, Submerged Aquatic Vegetation abundance, etc)
- Total Maximum Daily Load (TMDL) for the entire coastal bay or lake water body
- Changes in land use within the upstream watershed upon these coastal bay or large lake indicators

Landsat and MODIS satellite can be blended with in situ observations of water clarity, while Landsat and MODIS time series can be used to track changes in land use and linked to predictive values in numerical models used to simulate water quality and water nutrient loads. Surface water based buoys deployed as a sensor web can also provide in situ data streams that are inputs to a visualization of total water body health. The combination of multiple sources of information—including visualized information accessible through the portal—decreases the labor required to prepare the progress report on progress made towards restoration of the coastal bay (or other water body). The visualization can be more rapidly updated during the course of the year, allowing state government officials and the public to participate in restoration over shorter time scales than the yearly time scale over which formal reports on progress towards reaching restoration goals are published. Conditions may include protecting members of the public utilizing the beaches, fringing a coastal bay.

Possible Scenario 2

An water manager or an official in a public health agency (a decision maker) has the responsibility of issuing alerts warning the public, as during extreme precipitation events (flooding), when the aging, leaking storm drain infrastructure capacity of a city is exceeded, resulting in flooding of waters, including sewage, into flood waters filling city streets, to which the public will be exposed. A range of such conditions can be found in Midwest USA, Louisiana in the USA, Europe, monsoon India, China, Taiwan, and elsewhere.

Possible Scenario 3

A policy maker manages a decision support system that sends alerts to the academic marine science community to dispatch university marine scientists to investigate conditions of possible coral reef bleaching. This system is automated, and is based upon processing input data, such as high-resolution sea surface temperature (SST), wind from buoys, downwelling solar radiation from satellite and buoys, and Photosynthetic Active Radiation (PAR) from satellite (and buoy), combined with decision rules, which mimic the threshold beyond which email alerts are triggered. Pylons and buoys can be linked together as a sensor web, combined with satellite-based Earth Observations. For example, the US National Oceanic and Atmospheric Administration (NOAA) Integrated Coral Observing Network (ICON) is such a system.

Possible Scenario 4

In addition to anthropogenic water uses (such as agriculture and power generation), water is also required to maintain the normal functioning of ecosystem services, maintaining high biodiversity. For example, water will be withdrawn by root systems of riparian vegetation or wetland vegetation. At the same time, besides the water directly consumed in evapotranspiration of natural land cover (and maintenance of soil fauna), water is required to sustain fish migration and to provide certain habitats during low flow and flood conditions. This "allocated use" of the environment constitutes "environmental flow requirement."

This scenarios focuses on a decision maker who is reconciling water scarcity and water availability against water uses must include water required to maintain high biodiversity, as well as water required for other anthropogenic uses and the other societal benefit areas.

2.4.6.3.1 Scenario Events

The scenario events will be determined upon selection of one or more scenarios to focus on during AIP-3, based on the CFP responses.

2.4.6.4 Enterprise Model

The Enterprise Model will be developed upon selection of one or more scenarios to focus on during AIP-3, based on the CFP responses.

2.4.6.5 References

IGWCO- Water Quality http://www.earthobservations.org/wa_igwco_th_wq.shtml

GEO Task 09-01-a Water Societal Benefit Area
http://sbageotask.larc.nasa.gov/water.html

2.4.7 Water- Drought Scenario

The objective of the Drought Scenario is to support the development of a Global Drought Early Warning System capability, permitting users to visualize the impacts of drought and drought forecasts, including the role of water on famine and the cross-cutting societal benefit area of sustainable agriculture.

2.4.7.1 Targeted or Supported Community

The targeted and supported community includes water planners, drought management agencies, and members of the public who wish to find out information on their water supplies, with such information being provided through the portal and through targeted cell phone alerts during emergencies

2.4.7.2 Context and pre-conditions

2.4.7.2.1 Actors

1. End use decision maker at the local and state level, having the jurisdictional authority to authorize the rationing of water;
2. A utility who has the authority to set ceilings on water use;
3. Emergency support personnel who have the financial resources to authorize emergency delivery of food packages to a community suffering from catastrophic famine due to drought.

2.4.7.2.2 Information Assumed to be Available

Below is a list of information assumed to be available in order to support the scenario. This information has to be spatially of sufficiently high enough density to be useful at application scales and permit reliable estimation of water supply (and reduce uncertainties in estimating the water budget). Some of this information is acquired, processed and accumulated by national governments, such as the National Integrated Drought Information System (NIDIS), in the case of the USA, the Drought Management Center for Southeast Europe, the USA NASA/Goddard Global Land Data Assimilation System, NCEP drought monitor, the Australia Ministry of Water Resources, and multiple other organizations. Some academic institutions also carry out regional (and some experimental global) drought forecasting, such as Princeton and the University of Washington in the USA.

Note that most of the information resources are not yet accessible via the GCI.

1. Distributed information on available water supply must include measures of the accumulation of snowpack during the winter season (where mountainous terrain or high latitude locations are found), since during the winter season, lower surface temperatures and lower surface evaporation rates, allow accumulation of water to take place; this water supply melts in spring recharging the unsaturated vadose zone and groundwater table—providing water for the remainder of the year.
2. Distributed, high-resolution information on precipitation, as determined by multiple observables, including radar (such as Doppler radar), rain gage network, and satellite-monitored precipitation
3. Synoptic station measurements of wind speed within the planetary boundary layer (at anemometer level), air temperature, atmospheric humidity, incoming solar radiation, and measured terrestrial (infra-red) radiation are required to estimate: 1) evapotranspiration from Land Surface Models; or 2) sensible heat flux (and soil storage flux), so that evapotranspiration may be derived as a residual from the surface net energy equation, using satellite observations of radiation budget components. Much of the synoptic meteorological station and short-range forecast information is provided by the US National Oceanic and Atmospheric Administration (NOAA) National Center for Environmental Prediction (NCEP) models or the European Union European Community Medium Range Forecasting modeling suite.
4. Groundwater observations are also required, to ascertain whether groundwater supplies may compensate for surface water scarcity and drought (on agricultural crop production and other water uses).
5. Additional required information: water surface elevation of reservoirs and lakes and rivers (including discharge of rivers)
6. Reliable estimation of water usage and consumption is required so that the consumption of water can be compared against available water supply using tools.
7. Reliable monitoring of water usage and consumption through evapotranspiration by crops is required, at different rates for different types of crops and over different types of natural land cover (wetland, urban surfaces, desert, etc). This requires high-resolution spatial data on agricultural acreage and crop type.
8. Reliable knowledge of the population of farm animals, to account for water consumption by animals, including both direct consumption and water consumption growing crops fed to animals as foodstuffs or forage. This also allows the “water footprint” to be estimated for beef production and processed foods.
9. Accurate, high-resolution topography is required in order to model streamflow within a drainage basin, as provided by, for example HydroSHEDS or the Aster digital elevation model.
10. Most commonly used routing algorithms (such as the Muskingum method or the 1D St. Venant equation) are too crude to directly use HydroSHEDS and Aster topography, so that such very high-resolution topography must be resampled to reduce it to a coarser resolution to use the routing algorithms (and, by doing so, dropping out fine river network details such as river meander bends).
11. A streamflow gauging network is required, such as the national Ministry of Water Resources or hydrometeorology authority, and the Global Runoff Data Center.

12. Seasonal forecasts are available from the NCEP Climate Forecasting System (CFS) or the European Union, from which estimates are made on the prolongation or abatement of a drought, providing some additional lead-time for mitigation measures to protect the population and water users.

2.4.7.2.3 Processing and Collaboration Functionality Needed

The following are the processing and collaboration functionality needed to best leverage and grow the GCI within the context of the Drought scenario:

- Community Catalog for registering data and services
- Community Portal for finding and accessing data and services needed for the execution of the scenario.
- Additional functionality and facilities include tools for processing, analyzing, and visualizing observational and modeled data for near-real time (NRT), historical analysis (to derive soil moisture anomalies, for example), and for seasonal forecasting.
- Real-time assimilation of observational data into numerical models (direct insertion or ensemble Kalman Filter) is carried out to improve forecasts in Land Surface models, including the US National Center for Atmospheric Research (NCAR) Community Land Model (CLM), the Noah land model, the Variable Infiltration Capacity (VIC) model, WBM/WTM, Matsiro-TRIP, JULES, etc.
- Effective mechanisms for distributing in NRT maps/images and alerts to emergency response and water management authorities, to mass media, and the general public.

2.4.7.3 Scenario Description

Drought indices are based upon *meteorological drought, agricultural drought* (soil moisture anomalies), and *hydrologic drought* (areas where snowmelt-runoff are important, as in the Western USA, parts of South America, Himalaya and Tibet meltwater production regions, and Central Asia).

Drought is determined as water scarcity from the amount of water (for example, snowfall or incoming precipitation) customarily received. This must include “latency,” i.e., winter water storage as snowpack which melts and recharges soil in spring, affecting late spring and summer available water supplies. Soil Moisture anomalies provide one index of drought; soil moisture anomalies require long-term statistical distributions of Soil Moisture (SM). These products are modeled data, created using multi-model ensembles run using 60 year to 100-year driving data (precipitation, temperature, etc) and stored as gridded statistical distribution data. The modeled data are based upon observations of temperature and precipitation which are used as forcing variables with land surface models in order to estimate soil moisture within the limits of model error and observational errors. Models are used, because *in situ* observational data over a 50-year period or longer are temporally-coarse and spatially-coarse. The produced modeled fields are spatially high-resolution and temporally high-resolution, but model errors introduce uncertainties.

There are four types of time scales on which different global drought forecasting systems may be based:

(1) "Nowcasting" system;
(2) Short-term forecasting
(3) Seasonal forecasting; and
(4) Climate change forecasting.

Forecasts work by applying precipitation and meteorological forecast fields (such as temperature) to land surface models and hydrological models.

The seasonal forecast models may include forecast models, such as the USA NOAA NCEP CFS seasonal model or EU or Japanese seasonal forecast systems.

The short-range forecasting systems may include as forecast components the USA NCEP Global Forecasting System or European Community Medium Range Forecasting model forecasts.

Forecast soil moisture conditions are produced from Land Surface Models or Hydrological Models (or a multi-model ensemble MME*), and the forecast soil moisture can be compared with historical soil moisture for the same time of year* to prepare a drought forecast.

A *climate change* forecast is made using Global Climate Models (General Circulation Models or GCMs), but the precipitation must be derived from cyclonic and convective precipitation estimated within the GCM, which is subject to considerable uncertainty. There is also uncertainty regarding the accuracy of the ranges of IPCC scenarios. Considerable progress is being made in Japan (and elsewhere) developing a new generation of 10 km (or finer) GCMs, which may alleviate the need for downscaling precipitation fields to application scales (i.e., agricultural scale) (although the convection parameterization problem remains).
A GEO global drought forecasting system might be based upon combining multiple regional drought forecasts.

Beyond two weeks, hydrological forecasts degrade rapidly. This suggests segregating nowcasts and short-term forecasts from the longer range seasonal and climate change forecasts. Obviously, the longer the lead-time, the more time to prepare remedial efforts to mitigate drought or catastrophic crop failure.

2.4.7.3.1 Scenario Events

1. A policy officer is trying to locate where water is geographically scarce, so that remedial efforts may be launched and initiated in a timely fashion, if warranted. He combines various sources of data within the decision support system (possessing user-friendly visualization). The data combined include the forecasts described above in addition to

    a. House household data (organization such as Oxfam, Red Cross and Red Crescent, US-AID, etc) on the ability of households in the region to survive drought (*along with the resources of the household in providing ability to* *substitute foods*, given local crop failures due to drought). This is important because S*usceptibility* is a critical factor determining *drought vulnerability*.

b. Information retrieved and processed from satellite systems, such as the Soil Moisture and Ocean Salinity (SMO(S) and Soil Moisture Active and Passive (SMAP) that provide the spatial coverage, encouraging the development of corroborative in situ soil moisture networks. In addition to radar and microwave estimation of the upper soil column soil moisture, SEBAL (Surface Energy Balance Algorithm), Simplified Surface Energy Budget (SSEB), ALEXI, and dis-ALEXI data also estimate evapotranspiration from the entire root zone using satellite measured radiances from pixels derived from Landsat and MODIS imagery (but with errors using the surface energy balance equation and estimated sensible heat flux and soil heat fluxes). The combination of evaporation of water by vegetation and measurement of water held in the upper soil column—when combined with land surface models—may reduce the errors accumulating in using the land surface models and meteorological data, by themselves. *Such satellite-based information can be effectively applied in nowcasts or to provide data assimilation within short-term forecasts.*

2. Research staff who assist the policy officer are tasked to map the *intensity* and *spatial extent* of the incipient drought—as displayed in the high-resolution distribution of soil moisture, indicating severity, area, and duration.
3. These preceding steps produce a data product that can be displayed using a geographic information system—a visualized product—such as high-resolution maps of soil moisture anomalies.
4. The gridded soil moisture data—in nowcasts and short-term forecasts—is compared with high-resolution distributed crop distribution and crop type data, which is maintained by the GEO Global Agricultural Monitoring System (and other organizations), and this crop acreage and crop type information is updated with crop vitality data from satellite systems, such as fused Landsat-MODIS data. Crop vitality information is derived by *comparing the current condition of the crop with the previous states of the crop at the same time of growing season* (the basis for the.
    a. An *agricultural production* estimate per pixel (as partly determined by Landsat-MODIS fused data)(kg per square meter) may be *divided by crop water use* (cubic meters of water per square meter) to *derive water productivity* (kg of crop per cubic meter of water). Such an Agricultural Water Productivity Mapping system will display where water use is wasteful or where particular crops (such as biofuels) are wasteful for purposes of conserving water.
5. Assessment of drought requires a surface water appraisal and a groundwater appraisal. Agricultural areas of declining soil moisture may be sustained by surface irrigation canals drawn from tanks or rivers or reservoirs or sustained by wells appropriating groundwater. Models employed by the national meteorological services, such as NOAA National Weather Service Community Hydrologic Prediction Service Flooding Early Warning System (FEWS) and MIKE provide,

along with models such as VIC and WBM/WTM and Matsiro-TRIP, some estimates of *surface* water availability. Areas where snowmelt-runoff is important may also use the Surface Water Supply Index as a drought indicator. Post-processing routing of land surface models is also possible and provide estimates of surface water imports. In addition to these *surface water* models, *ground water* models, combined with groundwater table measurements, have to be consulted, such as MODFLOW.

a. Gridded site information (for example, station data) is cross-listed with the water cycle ontology and the agricultural ontology and the geographical ontologies, reducing the semantic heterogeneity found among multiple countries and sites, following the practices of the Asian Water Cycle Initiative and the East Asia water cycle community of practice.

b. Web services, such as an upgraded version of WaterML, can update catalog data and station data, such as the time series of point streamflow property data, including the data contained within the Global Terrestrial Network on Hydrology global data sets, such as Global Runoff Data Center and International Ground Water Resources Assessment Center, supplemented by additional data to close the inputs required by models. The virtual observatory reduces semantic heterogeneity which complicates data integration. The surface water models (used for surface water assessment) include modules within their code ("frameworks") that automate the process of calling web services to update model user variables, including the use of ontologies. These ontologies will be registered with the GEO geophysical variable ontologies and geographical ontologies.

6. The officer preparing a drought forecast or a drought alert may integrate different drought forecasts or may choose different systems to produce multiple lines of evidence for synopsis and prediction

7. Based on this assessment, the policy officer will provide stakeholders with advice on possible mitigation strategies, which are *based upon* the combination of *severity, area, duration, and susceptibility*, for which the extreme case is water rationing or famine relief. Triggers are based on thresholds that are used to send automated email alerts (or cell phone alerts) to listed decision making bodies, such as NIDIS and the Drought Center for Southeast Europe, etc.,

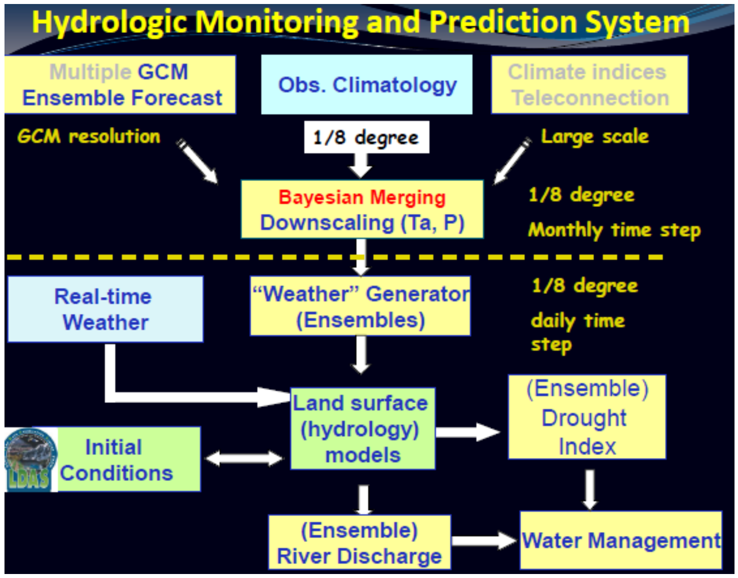

Figure 13 - An Example of a Global Drought Prediction System

Figure from Wood, Luo, Sheffield, and Li 2010

2.4.7.4 Enterprise Model

An Enterprise Model will be developed later depending on the responses to the CFP.

2.4.7.5 References

GEO Task WA-06-02: Droughts, Floods and Water Resource Management includes *a) Forecasting and Early Warning Systems for Droughts and Floods* and *b) Impacts from Drought*

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Wood, E., L. Luo, J. Sheffield, H. Li, 2010: Towards a Global Drought Monitoring, Forecasting, and Projection Capability, presentation

2.4.8 Water – Extreme Precipitation Scenario

Extreme precipitation is hard to manage due to its characteristics of high uncertainty and high dependency on local atmospheric and terrain condition. Often, extreme precipitation is associated with a disaster such as flood, landslide, debris flow, avalanche, etc. By their own very nature, extreme precipitation events do not follow administrative or any other artificial boundaries. Their impacts range from local villages to several countries. Unfortunately, the frequency, intensity and impact coverage of extreme precipitation in the world has been increasing due to global climate change.

Consequently, it is increasingly critical to be able to efficiently integrate and fuse global distributed information (including global observations data) to manage the prior or posterior events associated with of extreme precipitation in order to increase the accuracy of forecasts and support the design of hydrology engineering or other decision-making.

The AIP-3 extreme precipitation scenario envisions GEOSS facilitating two broad goals:

- Building connections to facilitate movement of data between actors,
- Developing interoperable tools for inter-comparison and fusion of a wide variety of atmospheric climate data.

The main goal of this scenario is to verify that the GEOSS GCI can be treated as a platform of providing historical meteorological data, extreme precipitation events and satellite imagery to support the research and governmental decision support for researchers and governmental agencies, respectively.

2.4.8.1 Targeted or Supported Community

There are two types of end users in this scenario:

- Decision makers: mainly governmental agencies officers who may need the historical meteorological data such as temperature, precipitation in order to gather information about extreme precipitation and to support policy-making decisions affecting extreme precipitation classification, disaster managements and responses, engineering design standard, etc.

- Researchers: researchers need to integrate distributed data (such as meteorological data) to analyze the causes of extreme precipitation and its trends and intensity in a specific area.

2.4.8.2 Context and pre-conditions

2.4.8.2.1 Actors

This scenario depicts how earth observations and standard-based technologies could be used to inform a wide spectrum of extreme precipitation decision-making or research. Three actors are identified:

- Data (and service) providers, who provide atmospheric data and frequency, location, intensity, disaster of extreme precipitation locally.
- GEOSS integrators, who are the software and service integrator, have ability to discover various services and bind them to their specific software.
- Data consumers, who are the researchers, governmental officers, can manipulate software, which is developed by GEOSS integrator to do the research of extreme precipitation event.

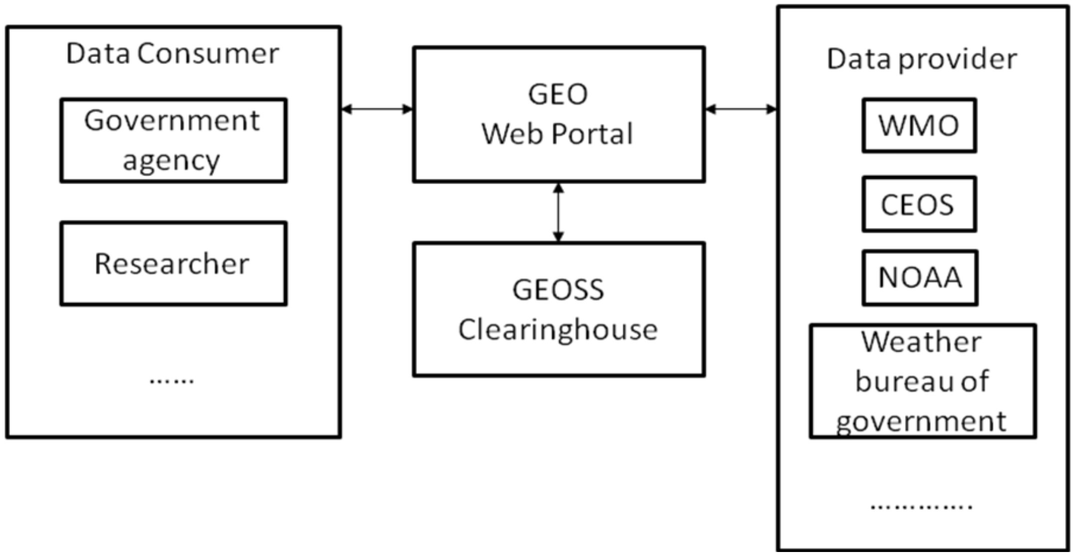

Figure 14 – Extreme Precipitation event scenario community

2.4.8.2.2 Information Assumed to be Available

- Extreme precipitation data, for example, frequency, location and intensity.
- Ocean current data
- Geo-location data, for example, base map, DTM, etc.
- Meteorological data, for example weather forecasts, weather observations, etc.
- Satellites imagery

2.4.8.2.3 Processing and Collaboration Functionality Needed

Exercising the following GCI elements (directly or via a GEOSS Integrator) provides the main functionality needed in support of the scenario:

- GEOSS Component Registry Service Registry
- GEOSS Clearinghouse
- GEOSS Portal

2.4.8.3 Scenario Description

The problem of extreme precipitation is challenging for several reasons:

- The causes of extreme precipitation are complicated and hard to predict because of multiple effects of temperature, terrain, circulation, temperature of ocean current and atmospheric pressure
- Addressing an extreme precipitation event requires cooperation amongst several entities and countries and hence requires exchange of information (including global) across boundaries

This scenario depicts how earth observations and standard-based technologies could be used to inform a wide spectrum of extreme precipitation decision-making or research with a focus on

- **Extreme precipitation event analysis**
  - Supporting a research group in getting data/resources related to precipitation location, duration, intensity, digital terrain model, inter-annual variation, etc.
  - Encouraging the contribution of the above resources to GEOSS via registration in the GCI
  - Wrapping up the results of the analysis as a service or component that can be registered in the GCI for reuse by other researchers and users.
- **Disaster scenario simulation and assessment of an extreme precipitation event**
  - Identifying the scale and damage extent after an extreme precipitation event (especially given that such events often lead to several disasters such as landslides, debris flows, etc)
  - Providing advanced modelling and assessment tools to evaluate the impacts of extreme precipitation events (given that disasters caused by extreme precipitation can lead to serious tremendous damages to the ecology, environment and can have social economic impacts

2.4.8.3.1 Scenario Events

The events will be determined based on the final scenario as shaped by the CFP responses with the following steps in mind

- Using the GCI to discover precipitation-related data provided by various entities and countries
- Using the GCI to discover supplementary services and data resources
- Using a GEOSS integrator/mediator to integrate and orchestrate the services
- Provide a client application (or web service) to share the results with other GEOSS users

2.4.8.4 Enterprise Model

The diagrams below capture the components and interactions among the diverse set of users/actors, and may be revised depending on the CFP responses.

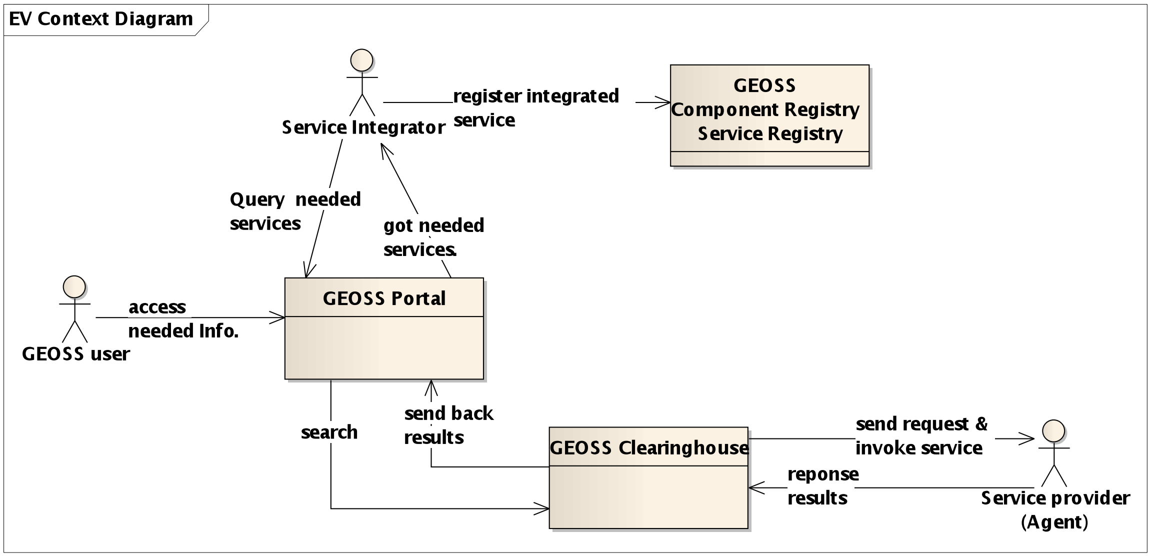

Figure 15 – Extreme Precipitation Scenario Context Diagram

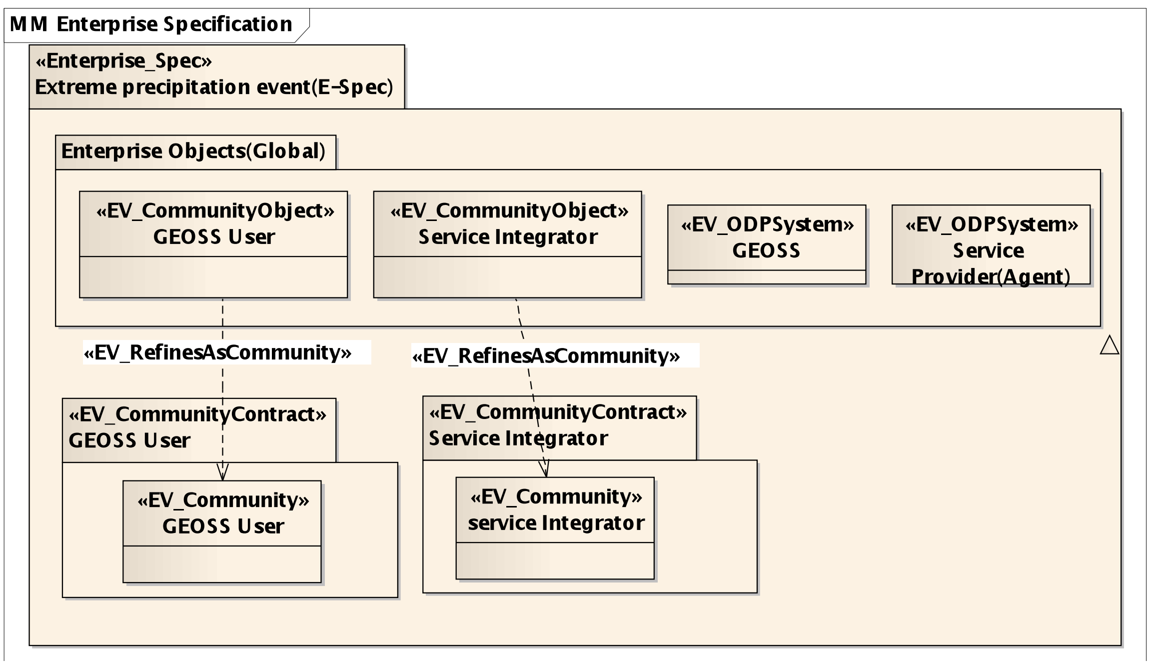

Figure 16 – Extreme Precipitation Scenario Enterprise Specification

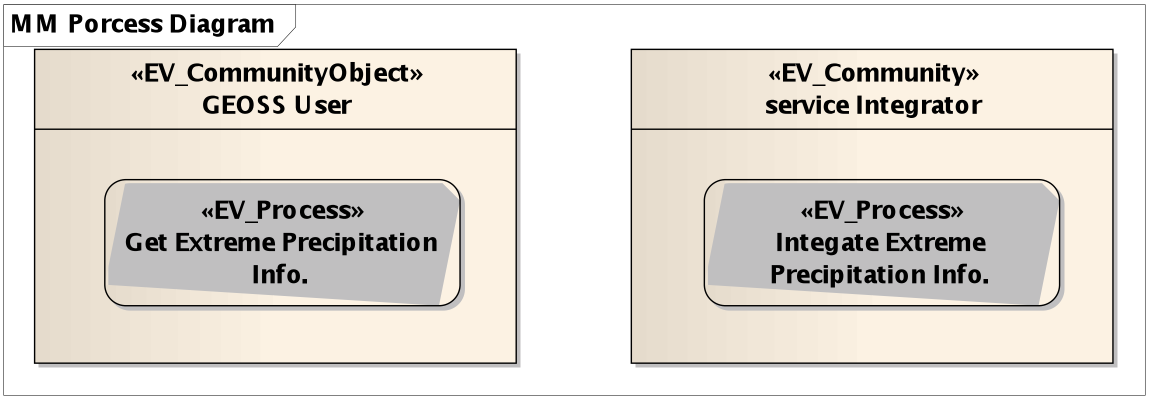

Figure 17 – Extreme Precipitation Scenario Process Diagram

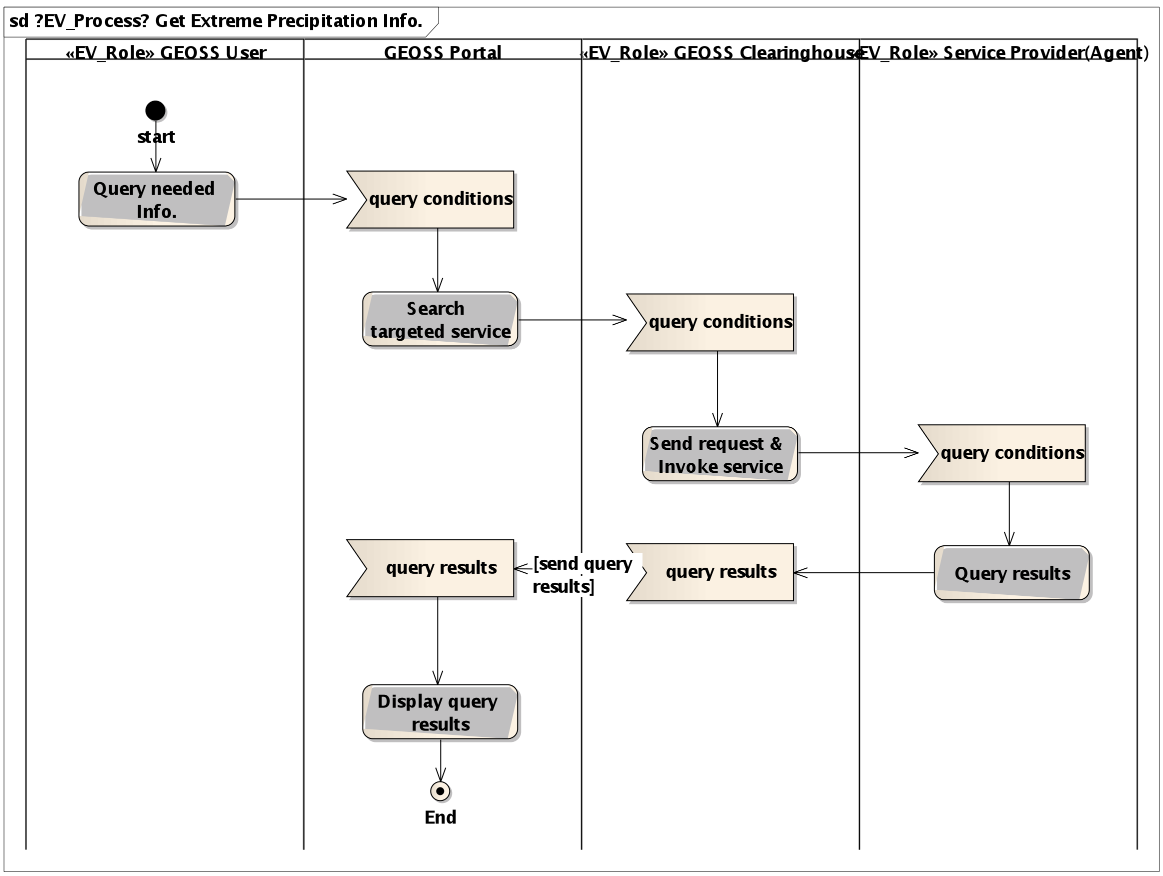

Figure 18 – Extreme Precipitation Scenario Activity Diagram

2.4.8.5 References

GEO Task WA-08-01 Integrated Products for Water Resource management and Research

2.4.9 Health and the Environment Scenario – Early Warning of Malaria

About half of the world's population is at risk of malaria and an estimated 247 million cases led to nearly 881 000 deaths in 2006. Lots of people die during outbreaks, which occur due to various reasons including meteorological ones. Rainfall, temperature and humidity are considered important indicators for prediction of malaria outbreaks and seasonal incidence increase in areas where it is stable. Regional forecasts based on rainfall, epidemic figure and socioeconomic indicators were made in Punjab way back in 1923 and 1946 (Gill, 1923 and Yacub and Swaroop, 1946). Based on rainfall estimates, forecasting of malaria outbreaks is being done in some parts of Africa (Abeku et al 2004; Cox and Abeku, 2007; Da Silva et al 2004; Ceccato et al 2007). After independence, the relationship between rainfall and malaria incidence has also been analyzed in different parts of India but with varying results (Singh and Sharma, 2002; Dhiman et al 2003; Dev and Dash, 2007; Devi and Jauhri, 2006).

There is inconsistency, lack of uniformity and data gaps encountered in using meteorological data sets collected from different sites. Recently, vegetation index, a biological indicator of rainfall, which indicates the occurrence of rainfall, stagnation of water on ground for sometime resulting in growth of vegetation can be monitored through satellite, has been found useful in prediction of malaria outbreaks in Africa (Thomson et al 1996, 1997). The southern and east Africa experience is mainly based on rainfall anomalies and temperatures being the reason of having epidemic occurring in the desert and altitude fringes. However, it has not been easy to obtain temperature forecasts.

NDVIs from FEWS are shared with programs as proxies however we do not have reports of how they are actually used for operational malaria control in Africa or India. The National Oceanic Atmospheric Administration (NOAA), through Advanced Very High Resolution Radiometer (AVHRR) sensor of USA has been monitoring global temperature condition index and vegetation condition index (VHI) from which a more robust cumulative indicator, Vegetation Health Index has been found useful in prediction of malaria in Bangla Desh (Rahman et al 2006). A preliminary analysis using VHI and malaria incidence has been attempted in three districts in India and found that VHI may be used as an indicator for early warning of malaria with one to two months in advance (Dhiman et al 2006). In order to establish and implement the usefulness of VHI for EWS for malaria, analysis needs to be done in all districts of a malaria outbreak prone state.

The integration of satellite and epidemiological data for development of Early Warning System (EWS) often fails due to lack of fusion of multidisciplinary fields. It is therefore envisaged to utilize and validate the usefulness of rainfall/SST/VHI as an indicator for EWS for malaria in outbreak prone areas in and to expand the existing system of EWS in southern parts of Africa like Zimbabwe. Any system of EWS would save human life from malaria due to timely preparedness and response.

Although the importance of advancing the research to refine the use of these risk factors is of high value, the focus of the AIP-3 scenario is on discovery, processing, integration and presentation of the information in a ready-to-use fashion by the user community, with an emphasis on demonstrating uptake of that information within that community in support of decision making and prioritization processes.

The objective in AIP-3 is to leverage (and contribute when appropriate) meteorological, satellite-derived vegetation indices and sea surface temperatures, sociological attributes and other data sources available through GEOSS to support a tool for early warning of malaria outbreak, that can provide adequate time for preparedness and response to imminent outbreak.

The application of such a tool for EWS for malaria outbreaks has been put into practice/demonstrated potential (Gill,1921, Yacob and Swaroop, 1946;WHO,2002; Thomson et al 2005 and Cox and Abeku, 2007). The feasibility of using indicators like rainfall/ SST/and/or VHI will be explored in AIP-3 so that the same may be transferred to user community i.e. District malaria Officer level in affected parts of the countries.

2.4.9.1 Targeted or Supported Community

The targeted community is the one inhabiting in outbreak prone areas of Africa and India who are end beneficiary of the proposed tool. End users of the tool are vector borne disease control programmes in districts and at the national level.

2.4.9.2 Context and pre-conditions

2.4.9.2.1 Actors

The main actors in the process would be Meteorology department, National Vector Borne Disease Control Programme, Researchers from NOAA, CNES, WHO- AFRO, IRI and NIMR. The GEOSS Common Infrastructure will act as the mediator in the process.

2.4.9.2.2 Information Assumed to be Available

- Monthly data on rainfall, temperature and Relative Humidity for the past 20 years for selected sites in India and Africa. Data on temperature and rainfall may be downloaded from MODIS(http://www.edcdaac.usgs.gov/dataproducts.asp) and NASA (http:// precip.gstc.nasa.gov.) or Meteorological departments at national level.
- Monthly epidemiological data of malaria of past 20 years for above selected sites.
- Extraction of Data on vegetation Health indices.
- Extraction of Data on sea surface temperature
- Satellite images for the outbreak period if required.

Note that most of this data are not yet accessible through the GCI.

2.4.9.2.3 Processing and Collaboration Functionality Needed

Various processing and collaboration functionality is needed and are encouraged to be contributed as part of the CFP responses in the following areas:

- For extraction and processing of monthly data on Vegetation Health indices and Sea surface temperature, collaboration with NOAA;
- For processing of satellite images collaboration with CNES and for playing the role of mediator/coordinator of the scenario collaboration with GEOSS;
- For procuring meteorological and epidemiological data, collection of sociological attributes/health system's capacity and ground truth of study area collaboration with user country e.g. WHO-AFRO, NIMR

- For integration of meteorological, epidemiological, sociological, health system's capacity- IRI
- User agency- National malaria control programme- e.g. NVBDCP in India and Selected NMCPs of Southern Africa.

2.4.9.3 Scenario Description

The scenario is related to a GEO activity being proposed as a Ministerial Summit Showcase under the "from science to decisions: air, land and water" proposal from EPA.

2.4.9.3.1 Scenario Events

1. Data discovery: using the GCI to discover data resources that can be leveraged
2. Data collection/extraction: collection of monthly data on rainfall, temperature, monthly incidence of malaria for 20 years or more; VH1 and SST. This step may include registration of some of the data sources as GEOSS resources in the GCI
3. Determination of relationship between meteorological parameters and malaria incidence
4. Validation though field-collected data prospectively (at sites where such activities are already ongoing)
5. Collection of data on capacity of health systems and communities vulnerability
6. Integration of feasible indicators in ready-to-use mode. This step also may include providing access to some of the data as mappable resources accessible and viewable via the GEOSS GEO Portal.

2.4.9.4 Enterprise Model

The Enterprise Model will be developed later depending on the responses to the CFP in this area.

2.4.9.5 References

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3 Information Viewpoint – Earth Observations

3.1 EO Information Topics

The Information Viewpoint focuses on the semantics of the information and information processing performed, by describing the structure and content types of supporting data. This viewpoint describes topics in Earth Observation information without regard to how the information is distributed between GEOSS system components.

The EO Information Viewpoint provided in the following is organized in to four major groups of topics (Figure 19). The basis for all EO information is well-understood location including reference frameworks. The main information about our Earth can be characterized as of three types: Geophysical Observations, Geographic Features, and Environmental Models. Each of these three provide an understanding of the Earth from the perspectives of different communities. A challenge in GEOSS is to have a harmonized architecture that enables cross-communication in information technology of these three communities. Metadata and Registries allows for description and discovery of information across the GEOSS. Harmonization of data policy, rights management and licenses for data enable Data Sharing. And lastly, the focus of GEOSS is providing users with the information that they need for decision support.

For AIP-3, an objective is to move from a collection of EO Information topics toward a consistent cohesive and comprehensive architecture for EO information.

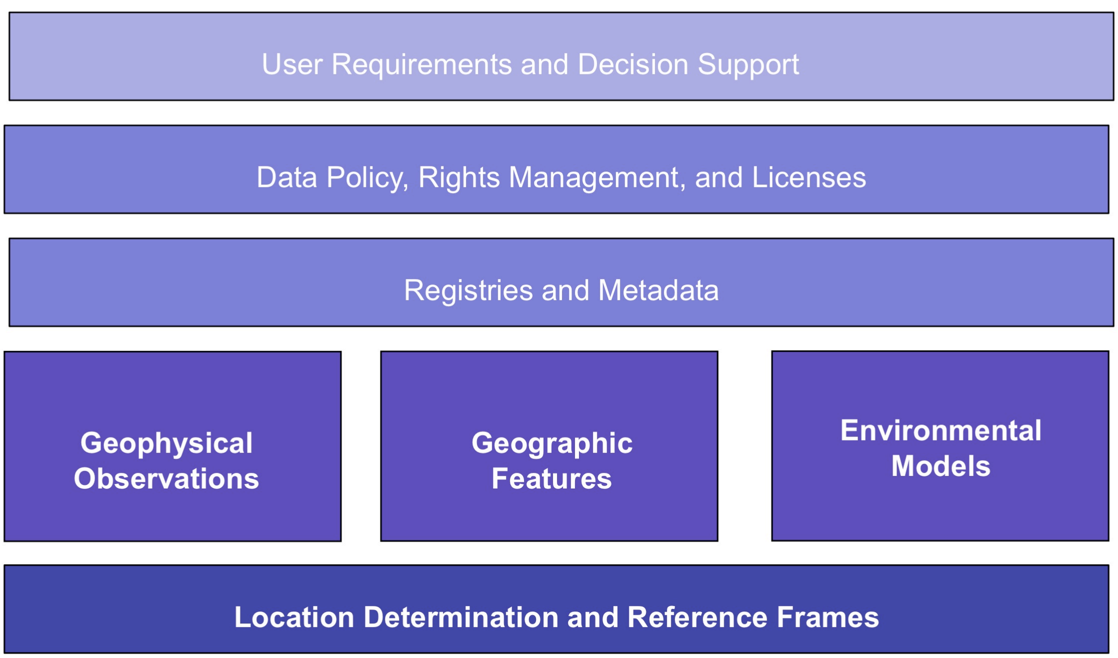

Figure 19 – EO Information Viewpoint Topics

3.2 Location and Reference Frames

Spatial Referencing is accomplished in several ways including

- Terminology with spatial reference
- Coordinate reference systems

Many **terms** refer to locations near the surface of the earth, e.g., identifiers and place names. Spatial referencing with identifiers is when an identifier uniquely indicates a location, e.g., a postal code. Place names may be ambiguous, e.g., Springfield, requiring additional information to be resolved into a specific location. Gazetteers and geocoding are used to resolve the ambiguity.

Coordinates are unambiguous only when the **coordinate reference system** to which those coordinates are related has been fully defined. A geospatial coordinate reference system is a coordinate system that has a reference to the Earth. A coordinate reference system consists of a coordinate system and a datum. Types of coordinate reference systems include: geocentric, geographic (including an ellipsoid), projected, engineering, image, vertical, temporal. The datum defines the origin, orientation and scale of the coordinate system and ties it to the earth, ensuring that the abstract mathematical concept "coordinate system" can be applied to the practical problem of describing positions of features on or near the earth's surface by means of coordinates. Thousands of coordinate reference systems have been defined for various applications. The World Geodetic System (WGS) defines a coordinate reference system that is used with Earth Observation data. The latest revision is WGS 84.

An International Standard for defining the information model of CRSs is provided by ISO 19111, Geographic information — Spatial referencing by coordinates (also available as OGC Abstract Specification Topic 2 – Spatial Referencing by Coordinates). In order to achieve interoperability of data, it is anticipated that example CRSs that are relevant to GEOSS should be identified and discussed as common. Descriptions of CRSs can be exchanged using the OGC Geography Markup Language (GML). For on-line interoperability, identifiers for CRSs need to be agreed and used, e.g., "urn:ogc:def:datum:EPSG:6.3:6326" identifies the WGS 1984 datum defined in the EPSG v6.3 database. GEOSS should consider its interactions with registries and registers for CRSs that are being established consistent with ISO 19135. For example ISO TC211 is working with the Geodesy community, e.g., IAG, to establish a Geodetic CRS register.

An element of AIP will be to increase the coordination of AIP with the GEO Task on coordinate reference systems. For example the developments of GGOS have been identified as relevant to this coordination.

3.3 Geophysical Observations

Observations of the Earth available in GEOSS encompass all areas of the World, and cover in situ, airborne, and space-based observations. GEOSS primarily focuses on issues of regional and global scale and cross-sector applications, while also facilitating, if so invited, the operation and enhancement of Earth-observing systems that are focused on national, local and sector-specific needs. [GEO 10 Year Plan]

Through GEOSS, organizations share observations and products with the system as a whole, and take the necessary steps to ensure that the shared observations and products are accessible, comparable, and understandable, by supporting common standards and adaptation to users' needs. [GEO 10 Year Plan]

To meet these objectives of sharing and fusing information from diverse sensors and organizations, harmonized concepts of information are needed. This section defines geophysical observations in the context of international standards and globally coordinated project results.

3.3.1 Observations and Measurements

Geophysical observations are the beginning point of our knowledge of the Earth. An **observation** is an act of observing a property [OGC and ISO]. For GEOSS the properties are geophysical phenomenon that can be measured by sensors. The goal of the measurement is to produce an estimate of a geophysical parameter.

Measurements are direct observations of specific geophysical parameters [CEOS SEO paper]. These correspond to corrected and calibrated data or retrieved environmental variables. Some examples include radiance, ocean height, soil moisture, and relative humidity.

A controlled vocabulary of **geophysical parameters** will support achieving GEOSS objectives for fusion and comprehension of observations across the various GEOSS systems and users. Below, Table 1 provides a listing of geophysical parameters as defined and managed by CEOS and WMO.

During AIP-3 a controlled vocabulary for geophysical parameters will be used in development of a User Requirements Registry (See Section 5.4.1) and for the Semantic Mediation use case (See Section 5.6.2).

References:

- CEOS SEO paper
- OGC O&M part 1
- ISO 19156 DIS
- CEOS MIM database (URL http://database.eohandbook.com/)
- The Space-Based Global Observing System in 2009 (GOS-2009), compiled for WMO by B. Bizzarri

Table 5- Geophysical parameters from CEOS and WMO databases

Aerosol absorption optical depth (column)	Cloud mask	Oil spill cover
Aerosol effective radius (profile)	Cloud optical depth	Outgoing long-wave radiation at Earth surface
Aerosol Extinction / Backscatter (profile)	Cloud top height	Outgoing long-wave radiation at TOA
Aerosol optical depth (column)	Cloud top temperature	Outgoing short-wave radiation at TOA
Atmospheric Chemistry - BrO (profile)	Cloud type	Outgoing spectral radiance at TOA
Atmospheric Chemistry - C2H2 (profile)	Color dissolved organic matter (CDOM)	Ozone profile
Atmospheric Chemistry - C2H6 (profile)	Crustal Motion	Permafrost
Atmospheric Chemistry - CFC-11 (profile)	Crustal plates positioning	Photosynthetically Active Radiation (PAR)
Atmospheric Chemistry - CFC-12 (profile)	Diffuse attenuation coefficient (DAC)	Precipitation index (daily cumulative)
Atmospheric Chemistry - CH2O (profile)	Dominant wave direction	Precipitation Profile (liquid or solid)
Atmospheric Chemistry - CH3Br (profile)	Dominant wave period	Precipitation rate (liquid) at the surface
Atmospheric Chemistry - CH4 (profile)	Downwelling long-wave radiation at the Earth surfa	Precipitation rate (solid) at the surface
Atmospheric Chemistry - CHOCHO (profile)	Downwelling short-wave radiation at the Earth surf	Sea level
Atmospheric Chemistry - ClO (profile)	Downwelling solar radiation at TOA	Sea surface temperature
Atmospheric Chemistry - ClONO2 (profile)	Earth surface albedo	Sea-ice cover
Atmospheric Chemistry - CO (profile)	Electron density profile	Sea-ice sheet topography
Atmospheric Chemistry - CO2 (profile)	Fire area	Sea-ice surface temperature
Atmospheric Chemistry - COS profile	Fire temperature	Sea-ice thickness
Atmospheric Chemistry - HCFC-22 (profile)	Fractionally absorbed PAR (FPAR)	Sea-ice type
Atmospheric Chemistry - HCl (profile)	Freezing level height	Short-wave cloud reflectance
Atmospheric Chemistry - HDO (profile)	Geoid	Short-wave Earth surface bi-directional reflectanc
Atmospheric Chemistry - HNO3 (profile)	Glacier cover	Significant wave height
Atmospheric Chemistry - N2O (profile)	Glacier motion	Snow albedo
Atmospheric Chemistry - N2O5 (profile)	Glacier topography	Snow cover
Atmospheric Chemistry - NO (profile)	Gravity field	Snow detection (mask)
Atmospheric Chemistry - NO2 (profile)	Gravity gradients	Snow melting status (wet/dry)
Atmospheric Chemistry - OClO (profile)	Height of the top of the Planetary Boundary Layer	Snow surface temperature
Atmospheric Chemistry - OH (profile)	Height of tropopause	Snow water equivalent
Atmospheric Chemistry - PAN (profile)	Ice sheet topography	Soil moisture at the surface
Atmospheric Chemistry - PSC (profile)	Iceberg fractional cover	Soil moisture in the roots region
Atmospheric Chemistry - SF6 (profile)	Iceberg height	Soil type
Atmospheric Chemistry - SO2 (profile)	Land cover	Temperature of tropopause
Atmospheric pressure (over land surface)	Land surface imagery	Total electron content (TEC)
Atmospheric pressure (over sea surface)	Land surface temperature	Turbulence
Atmospheric specific humidity (at surface)	Land surface topography	Vegetation Canopy (cover)
Atmospheric specific humidity (profile)	Leaf Area Index (LAI)	Vegetation Canopy (height)
Atmospheric stability index	Lightning detection	Vegetation Cover
Atmospheric temperature (at surface)	Long-wave cloud emissivity	Vegetation type
Atmospheric temperature (profile)	Long-wave Earth surface emissivity	Visibility
Bathymetry	Magnetic field (scalar)	Volcanic ash
Cloud base height	Magnetic field (vector)	Water vapour imagery
Cloud cover	Melting layer depth in clouds	Wave directional energy frequency spectrum
Cloud drop size (at cloud top)	Normalized Differential Vegetation Index (NDVI)	Wind profile (horizontal)
Cloud ice (profile)	Ocean chlorophyll concentration	Wind profile (vertical)
Cloud ice content (at cloud top)	Ocean dynamic topography	Wind speed over land surface (horizontal)
Cloud ice effective radius (profile)	Ocean imagery	Wind speed over sea surface (horizontal)
Cloud imagery	Ocean salinity	Wind stress
Cloud liquid water (profile)	Ocean surface currents (vector)	Wind vector over land surface (horizontal)
	Ocean suspended sediment concentration	Wind vector over sea surface (horizontal)

3.3.2 Sensors and Missions

In addition to having a shared and controlled understanding of type of geophysical observations, users and consuming systems must have an understanding of the sensor systems that have made the observation in order that the results may be fused with other observations.

Sensors are entities capable of observing a phenomenon and returning an observed value. [SensorML]. Instrument and Sensor are terms used nearly synonymously in many occasions. Sensors are attached to a **platform**, e.g., satellites or in situ stations. A platform has an associated local coordinate frame that can be referenced to an external coordinate reference frame and to which the frames of attached sensors and platforms can be referenced.

The CEOS Mission, Instrument, and Measurements (MIM) database is a compilation of space mission, instrument, and measurement information contained in the CEOS Earth Observation Handbook. The CEOS MIM database is updated annually from formal surveys of CEOS members, which includes 28 international space agencies and 20 other national and international organizations, which are currently operating and planning over 240 Earth observation satellites in the next 15 years. The MIM database contains the following tables:

- Mission Table Mission: information such as launch and end-of-life dates, mission descriptions, the primary and contributing agencies, and specific information regarding the orbital parameters (repeat cycle, LST, orbit type, etc). The mission table is linked to the instruments.
- Instruments Table: Instrument information such as the instrument names, instrument status, instrument geometry (conical, cross-track, nadir, etc), the instrument type, and additional text fields describing the spatial resolution, wavebands, etc.
- Measurements Table: A list of 146 measured geophysical parameters that are linked to individual instruments (See Table 5). These geophysical parameters are consistent with level 2 type retrieved mission data and are considered the minimal set to represent the needs of the nine societal benefit areas.

The MIM database is comprehensive in meeting its objectives of providing this information in human readable form. In order that software can use a description of a sensor for processing the observations, additional information beyond that contained in MIM database is needed. A full description of the sensor geometry and measurement characteristics needs to be available in a machine-readable format.

Based on common understanding among Earth observation scientists that data from space-borne sensors is neither adequately nor easily georeferenced to meet processing requirements, a markup language has been developed that allows the description of the dynamic, geometric, observational characteristics of sensors. Sensor Model Language (SensorML) defines models and XML Schema for describing any process, including measurement by a sensor system, as well as post-measurement processing. SensorML supports a variety of needs within the sensor community, including discovery of sensor, sensor systems, and processes, on-demand processing of observations, lineage of observations as well as plug-and-play, auto-configuration, autonomous sensor networks, and archiving of sensor parameters.

References:

- CEOS MIM database (URL http://database.eohandbook.com/)
- SensorML

During AIP-3 the MIMS database can be used to support requirements planning and investigation by GEOSS users through the variety of clients. In AIP-3 investigations could be undertaken to add SensorML descriptions to the MIM Database. The SensorML descriptions are then available to be used by Processing Services to create information beyond the direction measurement of the sensor.

3.3.3 Quality Assurance for Observations

The Quality Assurance Framework for Earth Observation (QA4EO) was established and endorsed by CEOS as a direct response to a call from GEO. GEO had identified the requirement to establish an internationally harmonised Quality Assurance (QA) strategy to enable interoperability and quality assessment "at face value" of EO data. QA4EO encompasses a framework and set of ten key guidelines, derived from best practices and with example templates included to aid implementation. Each GEO stakeholder community is responsible for its own overall governance within the framework. QA4EO provides guidance to enable individual organisations to document, in a consistent manner, the necessary evidence of compliance, thereby allowing those commissioning the work to assess its adequacy and "fitness for purpose". QA4EO-compliant processes would un- equivocally assure data quality and would encourage harmonisation across the whole GEO community.

The QA4EO framework is based on the adoption of guiding principles, which are implemented through a set of key operational guidelines derived from best practices, for implementation by the GEO community. QA4EO consists of ten distinct key guidelines linked through an overarching framework document. The top-level requirements expressed in these documents drive the need for community references, indicate critical generic deliverables for bias evaluation through comparisons and act as a starting point for more detailed technical procedures to underpin the top level requirements.

References:

- Quality Assurance Framework for Earth Observation (http://QA4EO.org/)

AIP3 pilots are invited to contribute to formulation, discussion and implementation of such community references During AIP-3 , QA4EO information can be made available through the AIP service oriented architecture, including the registries and metadata mechanisms.

3.3.4 Global Observation Products

Increasing access to data is a high priority for achieving the goals of GEOSS. Several GEO tasks are relevant to identifying observation products to be made more accessible through GEOSS:

GEO Task DA-09-03, "Global Data Sets" aims to provide a suite of global datasets based on improved and validated data sources. Initiate regular analysis and reporting. The task will facilitate interoperability among data sets using the framework, structure and methodologies of the GEO Architecture. These observation products are currently under development:

- Global Meteorological and Environmental Data
- Global DEM

Development of many more Global Data Sets is needed, e.g., infrastructure, administrative boundaries, demographics.

The GEO 2010 Baseline Initiative is a coordinated effort to call on GEO Members, Participating Organizations and the public to assemble shared, inter-operable products that will be used to establish a baseline for the year 2010 of bio-environmental conditions, as well as indicators of ecosystem functioning and services. An important aspect of the initiative is to ensure that the data are inter-operable and accessible, which will enhance their use by reducing pre-processing time, cost and redundancies.

3.4 Geographic Features

To enable implementation of the GEOSS architecture, GEOSS will draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents in areas such as geodetic reference frames, common geographic data, and standard protocols. [GEO 10 Year Plan]

The starting point for modeling of geospatial information is the geographic feature. A **feature** is an abstraction of a real world phenomenon. A geographic feature is a feature associated with a location relative to the Earth. A digital representation of the real world can be thought of as a set of features.

Any feature may have a number of properties that may be operations, attributes or associations. Any feature may have a number of attributes, some of which may be geometric and spatial.

Geographic phenomena fall into two broad categories, discrete and continuous. Discrete phenomena are recognizable objects that have relatively well-defined boundaries or spatial extent. Examples include buildings, streams, and measurement stations. Continuous phenomena vary over space and have no specific extent. Examples include temperature, soil composition, and elevation. A value or description of a continuous phenomenon is only meaningful at a particular position in space (and possibly time). Temperature, for example, takes on specific values only at defined locations, whether measured or interpolated from other locations.

These concepts are not mutually exclusive. In fact, many components of the landscape may be viewed alternatively as discrete or continuous. For example, a stream is a discrete entity, but its flow rate and water quality index vary from one position to another. Similarly, a highway can be thought of as a feature or as a collection of observations measuring accidents or traffic flow, and an agricultural field is both a spatial object and a set of measurements of crop yield through time.

A **coverage**[ix] is a feature that associates positions within a bounded space (its spatiotemporal domain) to feature attribute values (its range). Examples include a raster image, a polygon overlay, or a digital elevation matrix. Commonly used spatiotemporal domains include point sets, grids, collections of closed rectangles, and other collections of geometric objects. The range of a coverage is a set of feature attribute values. The attributes of a coverage, i.e., its range, are homogeneous across its domain. A Geographic imagery scene is a coverage whose range values quantitatively describe physical phenomena.

3.4.1 Application Schemas Methodology

Standardized conceptual schemas for spatial and temporal characteristics increase the ability to share geographic information among applications. These schemas are used by geographic information system and software developers and users of geographic information to provide consistently understandable spatial data structures.

GEOSS might consider developing a methodology for development of application schemas. For consideration, an INSPIRE Drafting Team has developed "Data Specifications" Methodology for the development of data specifications

http://www.ec-gis.org/inspire/reports/ImplementingRules/inspireDataspecD2_6v2.0.pdf

GML Application Schemas have been developed for several communities:

- GML Application schema for Earth Observation products
- GeoSciML

For additional GML Application Schemas: http://www.ogcnetwork.net/node/210

3.4.2 Global Feature Datasets

Increasing access to data is a high priority for achieving the goals of GEOSS. Several GEO tasks are relevant to identifying observation products to be made more accessible through GEOSS:

GEO Task DA-09-03, "Global Data Sets" aims to provide a suite of global datasets based on improved and validated data sources. Initiate regular analysis and reporting. The task will facilitate interoperability among data sets using the framework, structure and methodologies of the GEO Architecture. These observation products are currently under development:

- Global Land Cover
- Digital Geological Map Data
- Global Soil Data

Development of many more Global Data Sets is needed, e.g., infrastructure, administrative boundaries, demographics.

The GEO 2010 Baseline Initiative is a coordinated effort to call on GEO Members, Participating Organizations and the public to assemble shared, inter-operable products that will be used to establish a baseline for the year 2010 of bio-environmental conditions, as well as indicators of ecosystem functioning and services. An important aspect of the initiative is to ensure that the data are inter-operable and accessible, which will enhance their use by reducing pre-processing time, cost and redundancies.

3.5 Environmental Models

Environmental models and related techniques provide another source of information relevant to Earth Observations. There are many types of models including:

- Geophysical Models
- Data Assimilation
- Ensemble Techniques
- Information Fusion
- Data Mining

GEO Task AR-09-02d, "Model Web Development" aims to 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. Such an approach has many advantages over tightly coupled, closed, integrated systems, which require strong central control, lack flexibility, and provide limited access to products.

3.6 Registries and metadata

Registries and metadata form the neural network on which GEOSS runs. Metadata about provided resources are essential for efficient resource discovery and evaluation. The metadata themselves can be found because they are organized and referenced in a set of interconnected GEOSS registries such that other GEOSS infrastructure components can use them to provide end user services.

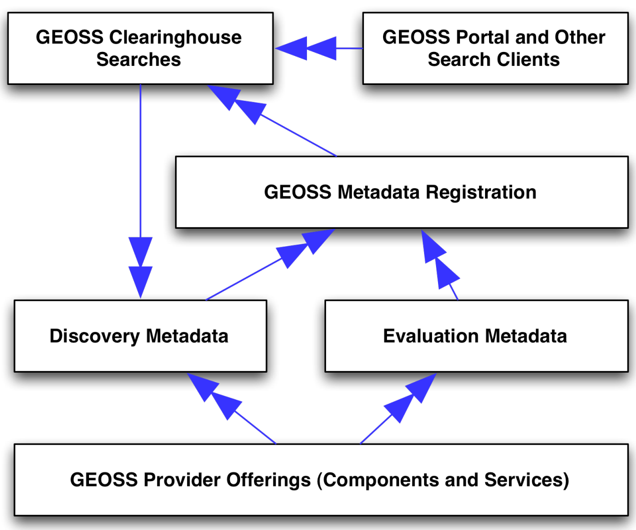

Figure 20 – GEOSS Metadata Registration and Discovery

According to ISO 19135, a registry is an information system on which a register is maintained. A register is a controlled list (a store or a database) of information. A registry system acts as a hub within a distributed data & services infrastructure, and ultimately provides an aggregated (and to the extent possible–integrated) view of content from numerous, heterogeneous information resources. In this approach, standards for describing, registering and querying resources are essential. For example, the standard ISO/IEC 11179, Information Technology--Metadata Registries, provides guidance on representing data semantics in a common registry[x].

Registries themselves need metadata standards for management of the metadata artifacts they hold. The OASIS Consortium standard "ebXML Registry Information Model (regrep-rim-3.0)" is a standard that defines the types of objects and items that can be stored in an (ebXML) Registry to describe and organize its holdings. OGC Catalog profiles extend ebRIM specifically for use in geospatial registries. An upcoming version 4.0 of regrep-rim is expected to include geospatial-temporal capabilities in its core specification.

The standard for geospatial metadata is ISO 19115: Geographic Information--Metadata. This standard facilitates the exchange and integration of data and information by giving a standard description of the identification, extent, quality, spatial and temporal scheme, spatial reference and distribution specifics of geospatial data[xi]. ISO 19119 provides additional service metadata elements and ISO 19139 adds XML encoding rules. Dublin Core is also an international standard, although less specific to geospatial data. Following the two international standards, National standards and profiles, such as FGDC, should be considered.[xii]

3.6.1 GEOSS Registry Model

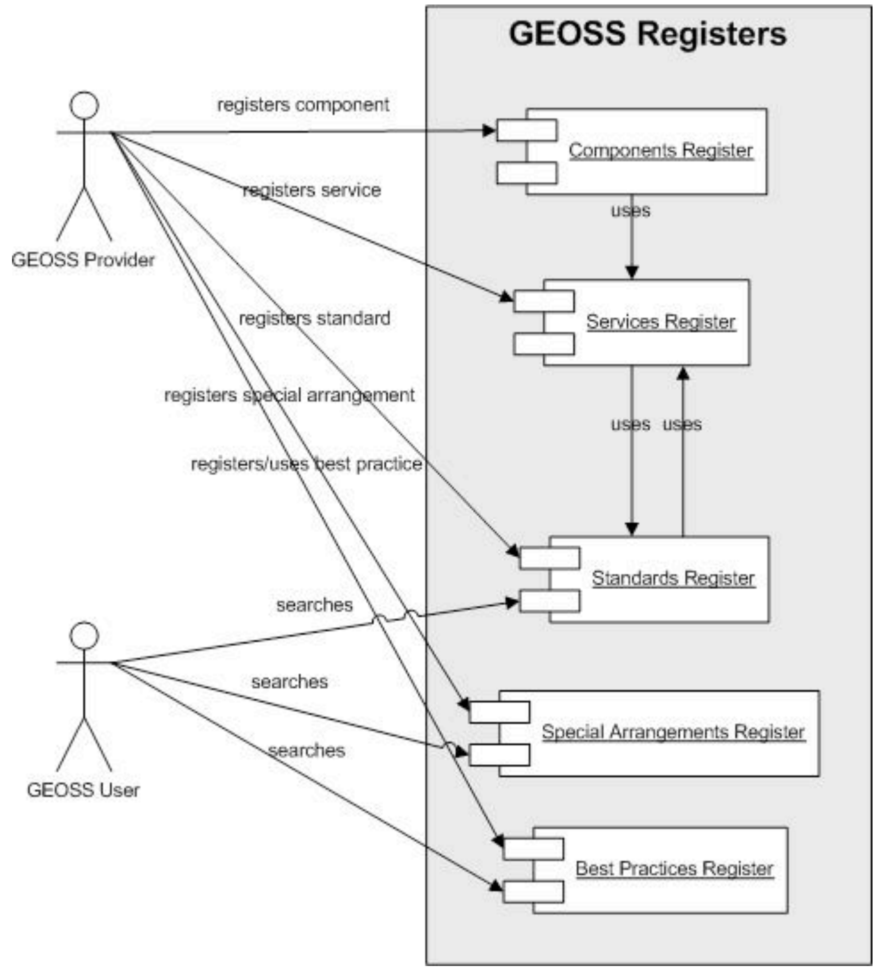

Figure 21 – GEOSS Registers Use Case Model

The current GEOSS registries and typical usage are shown in Figure 21. They support the registration, management, and discovery of GEOSS resources. GEOSS providers register components and services that define the manner in which data can be accessed in an interoperable way. Registered services reference standards and special arrangements that are used to implement the services. The GEOSS provider also registers these standards and special arrangements, either directly at the register web interface, or indirectly via the service registration process, whereby the Services Register interoperates with the Standards Register or Special Arrangements Register. The Best Practices Register holds descriptions of best practices that provide insight into data access using the registered services, standards, and special arrangements. GEOSS providers register best practices.

GEOSS users will typically discover available data, and the services to invoke in order to access the data, through the GEO Portal. They can also search the Standards Register, Special Arrangements Register, and Best Practices Register directly in order to gain information that will assist them in data access and use.

3.6.2 Dataset metadata – search and suitability

Metadata standards such as ISO 19115 offer a very small number of mandatory elements and an overwhelming number of optional elements. Neither element set is particularly useful in itself. A focus on metadata applications in the 2nd phase of AIP showed that these fall into two general categories. A small common set of elements is generally useful for **discovery** of resources, while larger and more specific sets are needed in order to evaluate the **suitability** of resources for a particular use.

In the discovery case, not only do a few common elements (e.g. title, author, subject, date, and place) suffice, but they are generally accessible through a variety of catalog search interfaces, including widely used ones such as ISO 23950, OGC CS/W and OpenSearch. Search interoperability for discovery purposes is also less impacted by the variety across standards in structures of metadata and their particular elements. The various metadata schemas don't need to be fully mapped each to each other for purposes of discovery. Only a small number of “queryable” elements have to be mapped to a common syntactic and semantic type. The harder work of mapping other elements for the evaluation case can be informed by the particular application suitability for which it is intended

3.6.3 Profile for GEOSS metadata

The initial focus for common discovery metadata (core queryables and common responses) in AIP-2 was recommended to be the OGC CSW:Record, based on Dublin Core metadata elements with a handful of extension elements. Dublin Core defines a minimal set of metadata elements that can be supported by almost all communities. Experience so far with implementation of discovery within GEOSS indicates that there are additional “queryable” metadata elements important for discovery, that are particular to earth observation data. Precisely what elements should be defined and included is an appropriate goal for the upcoming work; they include at a minimum the temporal and spatial extent of an observation (collection) feature of interest and the phenomenon (phenomena) being observed.

Consideration of a profile for GEOSS metadata will also build on the experiences of searching GEOSS community catalogues. This experience can be informed by existing metadata profiles that are relevant to the GEOSS communities. For example, the following OGC CS/W profiles have been developed[1]:

- **ebRIM Application Profile of CSW**: defines a profile on the use of the OASIS ebXML Registry Information Model (ebRIM) for CSW part (Clause 10) of the OGC Catalogue Services 2.0.2 specification. It makes use of the OASIS ebXML Registry Information Model (ebRIM) to define a geospatial catalogue service that can be extended by multiple domain-specific extension packages (see Bibliography item[xiii]).

- **BASIC package**: defines a general utility CS/W-ebRIM extension package that shall be supported by all conforming catalog services, with a focus on service-oriented metadata management, for cataloguing OGC Web Services (OWS

[1] Complete citations for the profiles is provided in the Bibliography

Common), WSDL Service descriptions, and some basic ISO 19139 (XML encoding) data descriptions (see Bibliography item[xiv])

- **CIM package**: defines a Core ISO Metadata (CIM) extension package, for the cataloguing of ISO 19115 and ISO 19119 compliant metadata record, including templates for interoperability with ISO Application Profile (see Bibliography item [xv])

- **EO (Earth Observation) package**: defines an Earth Observation Products extension package based on HMA EO product metadata (see Bibliography item[xvi])

Note: work is ongoing at OGC technical committees for providing other extensions package specifications (portrayal rules, units and measures…) and in particular a CRS extension package.

- **ISO Metadata Application Profile of CSW**: defines a non-ebRIM-based profile of CSW 2.0.2 for ISO 19115 and 19119 metadata records with support for XML encoding per ISO/TS19139 (see Bibliography item[xvii]).

In order to look for Earth Observation resources (collections, services, or products) a two level discovery mechanism can be used first using the Cataloguing of ISO Metadata (CIM) extension package, and then looking for the specific Earth Observation products via the Earth Observation extension package.

3.6.4 EO Metadata

This section describes an approach for metadata used to describe products of earth observation satellites. Ref xx[xviii] This metadata specification is a potential source or inspiration for metadata elements useful in both discovery and evaluation of earth observation data.

From an end user point of view, an EO data product can be naturally described by a spatial extent (e.g. the geographic footprint of a satellite acquisition) and several attributes describing the metadata (e.g. date of acquisition, etc.)”.

The encoding language for describing geographic features is the Geography Markup Language as standardised by the OGC and further adopted as ISO19136. The GML application schema for Earth Observation Products was developed during a consensus process in which a mapping was done between metadata elements from the different partners on to a harmonised set of elements. Where possible, the element names were taken from corresponding element names within the ISO19115 and ISO19115 Part 2 (Draft) standards. The metadata was initially modelled as features (extending <gml:AbstractFeature>) and later on refined as gml:Observation.

However in the near future it will be necessary to investigate the effects of the adoption of Observation and Measurements O&M (ISO 19156) that deprecates gml:Observation The issue may be solved using the O&M Observation which links Feature Type and Observed Property, thus establishing the link with GML.

Since different EarthObservationProduct element formats will be returned from a catalog search depending on the supported schema, the catalogue profile for this metadata schema allows clients to first retrieve the list of supported schemas (either eop, opt, sar, or other ones defined on them) and then access the metadata at the level in the hierarchy that best fits their needs.

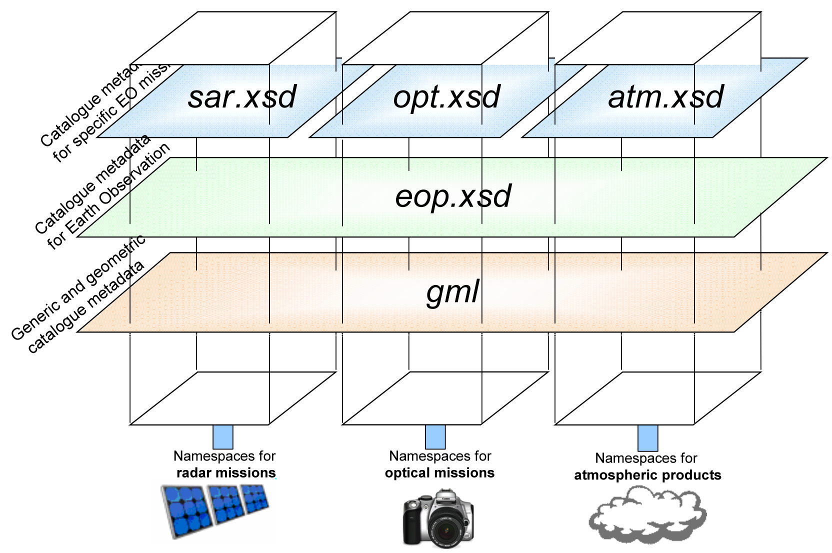

Figure 22 – EarthObservationProduct type hierarchy

3.7 Data Policy, Rights Management, and Licenses

The GEO Data Sharing Task Force (DSTF) has worked to develop a set of Implementation Guidelines that reflect the GEOSS Data Sharing Principles. These guidelines cover many areas, including:

- User registration
- Licenses for access and use of data
- Licenses for access and use of data provider services
- Billing
- Attribution
- Provenance
- Data access conditions

AIP-3 will focus on user registration and data access conditions. Although GEOSS strongly encourages full and open access to, and sharing of, data, there are inevitable instances where data providers will need to require user registration and adherence to access conditions. There exists overlap between user registration, licensing, and data access conditions, but AIP-3 will primarily consider user registration as a separate activity to licensing and data access conditions. User registration will only involve user identification, while data access conditions will involve licensing.

Data providers may wish to capture usage information as to who is using the data and what it is being used for, as well as requiring that the data accessed by data consumers be used in only certain ways. Having data consumers satisfy the data providers in this regard can be realized in a variety of ways, spanning the spectrum from very passive mechanisms to very aggressive mechanisms. This spectrum also is associated with the complexity spectrum of implementation. The more aggressive a data provider wishes to be in implementing policies and licenses for data access and control, the more difficult the implementation. Whichever mechanisms are used, it is important to understand that for data made available through GEOSS with restrictions, the license selected applies to, and travels with, the data and therefore all persons and organizations using the data are required to adhere to the license selected by the data provider. The language of the license does not change with each person or organization using the data.

The implementation of user registration and data access conditions by data providers must satisfy the interoperability framework that is realized by the GCI. This will be discussed in more detail in the Engineering Viewpoint section, but one of the goals is to make any implementation of policy compliance, whether implemented by the GCI or the individual data providers, as uniform as possible with a minimum impact on the data consumers. An issue that immediately arises with regards to policy compliance is that, even if the GCI and/or GEOSS-registered data providers satisfy a GCI supported mechanism, there are a multitude of community catalogs searched via the GEOSS clearinghouse that exist outside the GCI and provide access to many data providers that may have taken no position with regards to licensing and policy compliance. When a data provider takes no position on licensing, and provides no metadata describing any conditions on the use of the data, the presumption will be that there is no full and open access to the data, and that the data are not available for use until appropriate permissions are obtained directly from the source. In this case, the GCI, if possible, can alert the data consumer to this situation. For more information and insight into data access conditions and digital rights, see [1] and [2].

3.10.1 User Registration

User registration is a way for data providers to accomplish two main goals: 1) control access to data, and 2) record information regarding the use of the data. In both cases, the mechanism used can be applied once or applied each time data access is requested. Since one of the goals of GEOSS is to provide full and open access to data, minimizing the impact on data consumers to access and use data is a primary objective. The focus of AIP-3 is to have user registration required once, resulting in some kind of digital identification to be used repeatedly by the registered data consumer. This strategy may have an expiration date associated with the digital identification, requiring some sort of renewal process.

User registration involves the collection of information from data consumers that identifies the user and may include contact information, the type of user, the reasons for wanting access to the data, and the category of data usage. Under AIP-3, any information about the user collected during user registration will be used for authentication purposes only, and not for licensing or any other data access conditions.

User registration will ultimately involve some mechanism related to a login scenario. Login mechanisms are utilized to deal with authentication, access, and accounting (AAA). Authentication refers to the recognition of a valid user, access refers to which data are accessible by a user based upon licensing or other data access conditions, and accounting refers to costs and information captured from the user for use of the data. Within the GEOSS context, authentication, access, and accounting may be implemented, but AIP-3 will only focus on authentication. Authentication of GEOSS users can be managed by the GCI or by the data providers. AIP-3 encourages a single-sign on solution that is managed as a federated process between data providers. Some examples of open source solutions for this include OpenID[2], OAuth[3], and Shibboeth[4].

3.10.2 Data Access Conditions

Data access conditions require data providers to implement mechanisms that either actively control, or passively inform, how data is to be accessed and used. If active measures are taken, then data providers may implement mechanisms that collect data consumer acknowledgement of the data access conditions imposed. These conditions can address usage of data by a direct data consumer, downstream access to data by indirect data consumers that a direct data consumer makes available, generation of merged data sets from multiple data providers, and the generation of derivative data sets or data products. AIP-3 is focused on data access conditions that are not active mechanisms, but based on open access licenses. A highly recommended coordinated suite of licensing categories for GEOSS that address data access conditions for AIP-3 is:

- Dedication to the Public Domain (CC0, i.e. *Creative Commons Zero*)
- Creative Commons Licenses (limited to the *Attribution Required* and *Non-Commercial Use* Creative Commons licenses)
- Specialized GEOSS Open Access Licenses (limited to one for *GEOSS Societal Benefits Areas Only*)
- Non-Standard Open Access License

Only the Specialized GEOSS licenses would have to be developed by GEO and made available for use. The others are either publicly available or the responsibility of the data provider. Each of these categories includes many options, but only the options referred to in parentheses will be focused on for AIP-3.

It is quite common for multiple data sources to be used in order to result in a merged or derivative data set, or data product, by data consumers. In these instances, for open access licenses, the most restrictive license prevails as to the new license that is carried forward with the merged or derivative data set, or data product. However, if even one of the licenses of the multiple original data sets is not a standardized open access license,

[2] OpenID can be found at http://openid.net

[3] OAuth can be found at http://oauth.net

[4] Shibboleth can be found at http://shibboleth.internet2.edu/

then any published non-standard license must be investigated and/or negotiations must take place to come to an agreement on the licensing conditions.

Data access conditions will be made available in the GEOSS CSR and the data provider's metadata. The metadata will be used for the mining of data access, and related licensing, conditions in order to support automated data access and use. The manner in which this information is to be used will be discussed in the Engineering Viewpoint section.

References:

[1] "Towards Voluntary Interoperable Open Access Licenses for the Global Earth Observation System of Systems (GEOSS)," Harlan Onsrud, James Campbell, Bastiaan van Loenen, International Journal of Spatial Data Infrastructures Research, under review

[2] "DRM Policies for Web Map Service," Alban Gabillon, Patrick Capolsini, ACM SPRINGL '08, 2008

3.8 User Requirements and Decision Support

3.8.1 Information for Decision Support

Previous sections of the Information Viewpoint have presented a structured description of the data available in GEOSS. For many users, this wealth of EO data will be unusable. Information for decision support by many users needs to be in form of maps, graphs and messages.

A **map** is a portrayal of geographic information. While a map may be a digital image file suitable for display on a computer screen, a map is not the data itself. A **map projection** is a coordinate conversion from a geodetic coordinate system to a planar surface. The result is a two-dimensional coordinate system called a projected coordinate reference system. To portray data on a map, choices must be made about **symbols** for the features of the data, e.g., icon for a hurricane, line width for roads.

For certain decisions, a simple concise **alert** message containing location information is the optimal information for a user to receive. The Common Alerting Protocol (CAP) is a simple but general format for exchanging hazard emergency alerts and public warnings over networks. CAP allows a consistent warning message to be disseminated simultaneously over many different warning systems, thus increasing warning effectiveness while simplifying the warning task.

3.8.2 User Engagement and Support

The User Interface Committee (UIC) is conducting several tasks to gather information that will allow GEOSS users to make better use of GEOSS. Structuring this user engagement information will enable it to be shared amongst the GEOSS information system components.

GEO Task US-09-01, "User Engagement" involves users in reviewing and assessing requirements for Earth Observation data, products and services. The task creates an appropriate mechanism for coordinating user requirements across societal benefit areas.

The UIC is developing a User Requirements Registry to make this and other information available on-line. The URR will publish User Types, Activities and Requirements. The URR will support activities analysis of:

- User Types, Activities and value chains linked to a Requirement
- Activities and Requirements of a User Type
- Activities and User Types down a value chain/network that benefit from an Activity/Requirement/Specification.

4 Computational Viewpoint – Systems of Systems

4.1 Service oriented architecture (SOA)

The Computation Viewpoint defines mainly a Service-oriented approach to enable distribution through functional decomposition of the system into objects that interact at interfaces. There are GEOSS elements beyond the services approach, e.g., direct satellite broadcast, delivery of data on media, but the predominant discussion in this viewpoint concerns a Service-Oriented Architecture (SOA).

GEOSS interoperability arrangements are to be based on the view of complex systems as assemblies of components that interoperate primarily by passing structured messages over network communication services. By expressing interface interoperability specifications as standard service definitions, GEOSS system interfaces assure verifiable and scalable interoperability, whether among components within a complex system or among discrete systems in a federated "system of systems"[xix].

The OASIS Reference Model for Service Oriented Architecture[xx] defines SOA as a paradigm for organizing and utilizing distributed **capabilities** that may be under the control of different ownership domains. The value of SOA is that it provides a powerful framework for matching needs and capabilities. Visibility, interaction, and effect are key concepts for describing the SOA paradigm. **Visibility** refers to the capacity for those with needs and those with capabilities to be able to see each other. Whereas visibility introduces the possibilities for matching needs to capabilities (and vice versa), **interaction** is the activity of using a capability. The purpose of using a capability is to realize one or more **real world effects**. At its core, an interaction is "an act" as opposed to "an object" and the result of an interaction is an effect (or a set/series of effects). This effect may be the return of information or the change in the state of entities (known or unknown) that are involved in the interaction. **Service** combines the following related ideas:

- The capability to perform work for another
- The specification of the work offered for another
- The offer to perform work for another

Visibility is promoted through the **service description** which contains the information necessary to interact with the service and describes this in such terms as the service inputs, outputs, and associated semantics. In general, entities (people and organizations) offer capabilities and act as **service providers**. Those with needs who make use of services are referred to as **service consumers**. The service description allows prospective consumers to decide if the service is suitable for their current needs and establishes whether a consumer satisfies any requirements of the service provider.

The Publish-Find-Bind use case (Figure 23) is a basic building block of a service-oriented architecture.

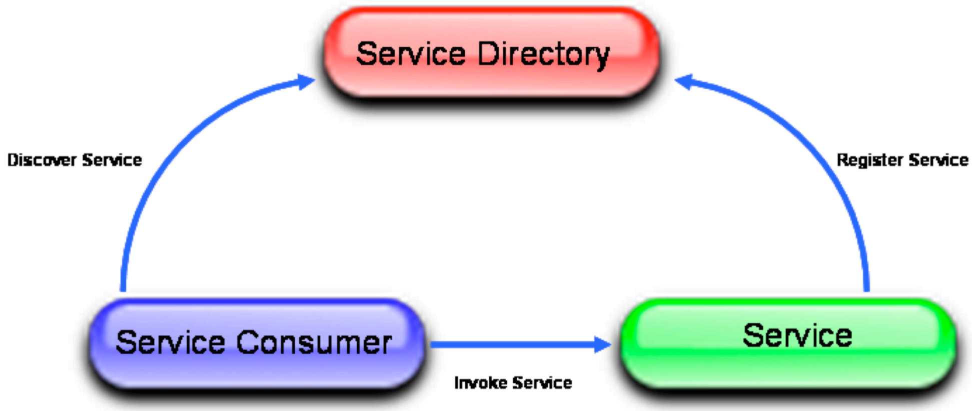

Figure 23 – Publish-Find-Bind Sequence

The archetypal SOA "triad" does presume that a direct connection between a service and client (service consumer) is feasible; that the components share both a distributed computing protocol and a knowledge community / domain. In heterogeneous or federated systems, this is may not be the case, and a fourth component role needs to be invoked, that of broker or mediator:

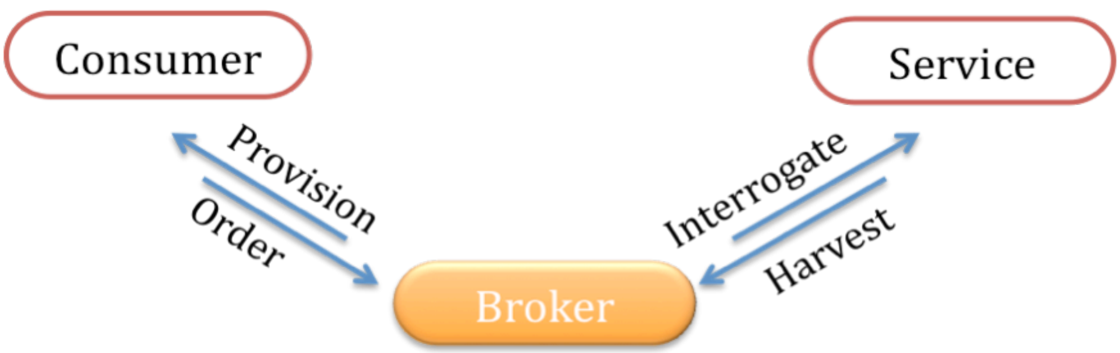

Figure 24 – Broker Role in SOA

A broker implements one or more mediation functions (protocol, interaction style interface type, information model) through the same service interfaces which would be invoked in its absence, or may support extended interfaces such as ordering or harvesting.

Experience with initial implementations of the GEOSS Clearinghouse has demonstrated the importance of this broker role in facilitating discovery across the GEOSS Federation. The mediation role filled by the Clearinghouse applies particularly to interoperability across catalog services provided by the various GEOSS communities and is described in more detail in following sections.

4.2 GEOSS functions via SOA

4.2.1 Catalog/registry services

Interoperability arrangements for catalog search are key to service oriented architectures. This section describes several catalog service standards that support one or more of the required catalog functions. These standards are used for catalog and registry services in GEOSS

- ISO 23950 Protocol for Information Search and Retrieval.
- Profiles of the OGC CSW specification namely the ebRIM, ISO 19115/19119, and Earth Observation application profiles
- Cataloguing of ISO Metadata Extension Package
- OASIS UDDI
- OpenSearch

The GEOSS Clearinghouse is a client to community catalogue servers implemented in accordance with multiple catalog service standards; at a minimum these include ISO 23950 and OGC CSW.

The metadata supported in the AIP Architecture is described in Section 3.6, "Registries and metadata."

4.2.2 Portrayal and display services

4.2.2.1 Web Map Service

A Web Map Service produces spatially referenced maps dynamically from geographic information. It specifies operations to retrieve a description of the maps offered by a server, to retrieve a map, and to query a server about features displayed on a map. OGC Web Map Service is used by many components in GEOSS. OGC Web Map Service (WMS) version 1.3 (OGC06-042) is identical with ISO 19128:2005, Geographic information – Web map server interface.

OGC Web Map Service provides a choice of "style" options that can be used in rendering the selected "Layers", but there is only the name of each style is available. To provide a general definition of map styling, and to even enable style customization in WMS, a Symbology Encoding language is defined in the *Styled Layer Descriptor profile of the Web Map Service Implementation Specification* (OGC 05-078r4).

The WMS profile for Earth Observation products (OGC 07-063) is intended to support the interactive visualization and evaluation of Earth Observation (EO) data products. The profile describes a consistent Web Map Server (WMS) configuration that can be supported by any content providers (satellite operators, data distributors …), most of whom have existing (and relatively complex) facilities for the management of these content. In addition, this profile is intended to compliment the EO Products Extension Package for ebRIM Profile of CSW 2.0 (OGC 06-131) by showing how WMS servers may be used to evaluate products identified through catalogue discovery prior to their ordering.

4.2.2.2 OGC Web Map Context Documents

OGC Web Map Context (WMC) Documents (OGC 05-005) is a companion specification to the aforementioned Web Map Service (WMS) specification. It states how a specific grouping of one or more maps from one or more Web Map Services can be described in a portable, platform-independent format.

WMC Documents provide a practical way to reconstruct the web-mapping context in the same WMS clients where they were generated or the other WMS clients that support this WMC Documents specification.

4.2.2.3 KML

KML is an XML grammar used to encode and transport representations of geographic data for display in an earth browser, such as a 3D virtual globe, 2D web browser application, or 2D mobile application. It is an XML language focused on geographic visualization, including annotation of maps and images. Please note that, geographic visualization includes not only the presentation of graphical data on the globe, but also the control of the user's navigation in the sense of where to go and where to look.

Though KML is not a visualization service itself, it promotes the interoperable geospatial data visualization by defining how the visualization of geospatial data in 2D or 3D environments could be formally described. KML documents authorized by one person can be directly shown up in others' KML browsers. From this perspective, KML is complementary to the key existing OGC/ISO Web Map Service standard and OGC Web Map Context Documents, where only 2D geospatial data visualization is considered.

KML (formerly Keyhole Markup Language) was submitted by Google to the OGC. It has been evolved within the OGC consensus process, and finally results in two approved OGC standards, KML version 2.2 (OGC 07-147r2) and KML 2.2 – Abstract Test Suite (OGC 07-134r2).

4.2.3 Data access services

4.2.3.1 Web Feature Service

The OpenGIS Web Feature Service (WFS) allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services. The specification defines interfaces for data access and manipulation operations on geographic features, using HTTP as the distributed computing platform. Via these interfaces, a Web user or service can combine, use and manage geodata -- the feature information behind a map image -- from different sources.

The following WFS operations are available to manage and query geographic features and elements:

* Create a new feature instance

* Delete a feature instance

* Update a feature instance

* Lock a feature instance

* Get or query features based on spatial and non-spatial constraints

4.2.3.2 Web Coverage Service

The OGC Web Coverage Service (WCS) supports electronic retrieval of geospatial data as "coverages" – that is, digital geospatial information representing space-varying phenomena.

A WCS provides access to potentially detailed and rich sets of geospatial information, in forms that are useful for client-side rendering, multi-valued coverages, and input into scientific models and other clients. The WCS may be compared to the OGC Web Map Service (WMS) and the Web Feature Service (WFS); like them it allows clients to choose portions of a server's information holdings based on spatial constraints and other criteria.

4.2.3.3 OPeNDAP

OPeNDAP is a software framework for scientific data networking, allowing access to remote data. Local data can be made accessible to remote locations using OPeNDAP servers. Data analysis and visualization applications can be used as OPeNDAP clients (i.e., applications able to access remote OPeNDAP served data).

OPeNDAP is a protocol for requesting and transporting data across the web. The current OPeNDAP Data Access Protocol (DAP) uses HTTP to frame the requests and responses.

4.2.4 Service Chaining and Workflow

ISO 19119:2003, Geographic information — Services, defines service chaining as the combining services in a dependent series to achieve larger tasks. ISO 19119 enables users to combine data and services in ways that are not pre-defined by the data or service providers. This level of data/service interoperability will be achieved in stages. Currently users can discover data that is provided by a service, i.e., "tight" data/service binding. We are beginning to see processing services offered that could bind to remote services that offer data. Processing services acting as clients to data services is an example of "loosely" coupled services.

There are many options for achieving service chaining. Several GEO Members have implemented workflow approaches using a workflow engine and a scripting language.[xxi] [xxii] Much of the workflow management for controlling the execution of a chain of web services has been done using OASIS Business Process Execution Language (BPEL). Other scripting languages are available.

A description of Service Chaining as applied to Earth Observations can be found in an HMA Architectural Design Technical Note.[xxiii]

A description of workflow applied to Earth Observations in combination with sensor web developments is provided in a recent NASA paper[xxiv].

4.2.5 Data transformation services

Earth Observation and other geospatial data will not always be well suited to a specific purpose and will need processing specific to the users needs. This situation is typical in environments were data is acquired and archived for one application but this is accessed for by a user with a different application than the original application.

Processing services are network accessible services that can process data provided by a separate service. Typically a processing service does not include capabilities for providing persistent storage of data.

The OGC Web Processing Service (WPS) defines a standardized interface that facilitates the publishing of geospatial processes, and the discovery of and binding to those processes by clients. Processes may include any algorithm, calculation or model that operates on spatially referenced data. A WPS can be configured to offer any sort of geospatial functionality to clients across a network, including access to pre-programmed calculations and/or computation models that operate on spatially referenced data. A WPS may offer calculations as simple as subtracting one set of spatially referenced numbers from another (e.g., determining the difference in influenza cases between two different seasons), or as complicated as a global climate change model.

The OGC Web Coordinate Transformation Service (WCTS), which can be used by geospatial applications and other services for the transformation of geospatial data from one coordinate reference system (CRS) to another. This is frequently required when using data from different sources in one application. To use together data stored in different CRSs, such data must be transformed into the same CRS.

Recent efforts are underway to provide Grid Computing as defined by the Open Grid Forum through a WPS interface. Extensive tests have been performed as well within the ESA Grid infrastructure leading to a preliminary definition of a Grid-based Processing Service. This with the objective of reducing the burden caused by the transfer of large EO coverages by transferring instead the processing algorithms on the Grid that hosts within its storage element the coverages to be processed.

4.2.6 Ordering services

This service provides a set of functionalities for the user/operator to place orders for the catalogued EO products and for adhere to subscriptions from the missions being part of the FedEO infrastructure.

This service allows the clients to perform the following activities:

- Get the service capabilities: retrieval of the supported version, the supported operations, etc.
- Order options retrieval (scene selection options, processing options, media definition, subscription sub-setting, etc.).
- Order Quotation: for getting a quotation of the order going to be submitted.
- Order submission
- Order monitor: to check the status of submitted orders.

- Order Cancellation: to cancel an on-going order.
- Retrieval of on-line available products.

During the order execution the user can query the status of his / her orders or also cancel the orders. The services should verify any constraints that may be imposed on users, and report status and relevant information back to the user

4.2.7 Sensor web services

The Sensor Web is a concept of achieving a collaborative, coherent, consistent, and consolidated sensor data collection, fusion and distribution system. Any kind of sensor, from a thermometer located at a fixed position to a highly complex hyper spectral sensor on board of an earth-orbiting satellite, are made available on a global level.

Sensor Web addresses information gathering from distributed, heterogeneous, dynamic information sensors and sources of different structure and aims at

- Describing sensors in a standardized way,
- Describing sensor data processing in a standardized way,
- Standardizing access to sensor data,
- Standardizing the process of what is commonly known as sensor planning, but in fact is consisting of the different stages planning, scheduling, tasking, collection, and processing,
- Building a framework and encoding for measurements and observations.

Two concepts of Sensor Web Enablement (SWE) were presented in the Information Viewpoint. Observations and Measurements describe a conceptual model for sensor web observations in Section 3.3.1. SensorML – an encoding for describing sensors – is described in Section 3.3.2.

Sensor Web services used in GEOSS include:

- The OGC Sensor Observation Service (SOS) provides access to observations from sensors and sensor systems in a standard way that is consistent for all sensor systems including remote, in-situ, fixed and mobile sensors. SOS provides information about the sensor itself encoded in SensorML and observation data encoded in Observation and Measurement (O&M).
- The OGC Sensor Planning Service (SPS) provides a standard interface to collection assets (i.e., sensors, and other information gathering assets) and to support systems that surrounds them. SPS supports different kinds of assets with differing capabilities, as well as different kinds of request processing systems, which may provide access to the different stages of planning, scheduling, tasking, collection, processing, archiving, and distribution of resulting observation data.
- The OGC Sensor Alert Service (SAS) provides a standard interface to subscribe to events generated on the basis of observations. The interface allows clients to subscribe to pre-defined events as well as to define specific event-criteria.

4.2.8 Event handling

Request-response styles of service interaction are useful for many applications, but a publication-subscription style is more suited to applications where quick response to significant observational events is needed. There are many approaches to "pubsub" but they generally share three elements:

1. Publication of (access to) events, or information changes which are deemed by the publisher to be significant.
2. Subscription by users to events that they consider by topic, magnitude, timing, location, or other attribute to be of particular interest to themselves (alerts)
3. Delivery of subscribed events by means of an agreed protocol or channel (notification)

Channels for notification involve a range of interaction styles and protocols, from repeated polling of a service through push messaging systems to news broadcasts. Of particular interest are:

1. Web feeds – a publisher provides a Web-accessible XML document of event entries, e.g. in Atom format. A subscriber re-reads this file whenever it changes. Alternately, a subscriber registers a subscription with an intermediary feed aggregator that reads some range of Web feeds and constructs a custom feed containing only those entries of interest to the subscriber.
2. Chat – a publisher sends a notification by way of an Instant Messaging protocol such as AIM or XMPP either to a pre-arranged list of chat listeners, or to a chat room that listeners have joined.
3. SMS (Short Message Format) is a means of sending short text messages to cellphone users who have subscribed for notifications and provided their cellphone numbers.
4. Social networks – a publisher posts a notification to a channel or channels supported by social network applications such as Facebook, MySpace, Flickr, etc. Twitter messages or "Tweets" have been particularly widely used to provide updates from both machine and human observers to many critical events such as the recent earthquake in Haiti.

Alert-specific information formats such as CAP (Sec. 3.9.1) can be exchanged by way of many of these channels in order to communicate more precisely whether a subscriber should take some defined action as a result of the alert.

4.2.9 User management services

User Management services provide the authentication and authorization capabilities in a service oriented architecture. AIP-3 will investigate the use of several standards in this area.

OpenID is an open and decentralized framework for authenticating users with the same digital identity on different web sites. Some of the organisations offering OpenID provider services include AOL, Facebook, Google, Yahoo!, Microsoft, MySpace, Sears, Universal Music Group, France Telecom, Novell and Sun. Each one of these providers issues a URL or XRI as the user's identifier. When logging into different websites, a user is able to enter the same identifier at login. The development of OpenID is led by an open source community, legally represented by the OpenID Foundation[5].

OAuth is an open protocol that enables websites or applications to access protected resources from a web service, without disclosing usernames and passwords. Instead of forwarding usernames and passwords, OAuth uses tokens generated by the Service Provider. The tokens are granted access to a specified resource for a specified duration[6]. OAuth is currently under development for submission to the Internet Engineering Task Force (IETF)[7].

Shibboleth is an open and standards-based system for single sign-on across or within organizational websites. It enables a user to authenticate at his organization, while accessing protected resources on another organization's website. Shibboleth benefits from interoperability with the Security Assertion Markup Language (SAML), developed by OASIS. SAML is an XML-based framework for communicating user authentication, entitlement and attribute information[8]. An example implementation of Shibboleth is the UK Access Management Federation that provides authentication for more than 700 organizations in the public, private and academic sectors [9].

4.3 GEOSS functions via broadcast

The GEONETCast concept is to use the multicast capability of a global network of communications satellites to transmit environmental satellite and in situ data and products from providers to users within GEO. Commercially available technology provides cost-efficient solutions with easy to implement terminals, which are widely used for direct to home digital television. The multicast capability allows different datasets to be handled in parallel, regardless of the source. The use of a key access capability enables the data policy of each data provider to be respected and the distribution at individuals or groups of users, as appropriate, to be targeted within the footprint of each satellite.

All data types (not the instances) that are disseminated on GEONETCast (regional and global) should be described with standardised Meta data information. The current standards are the series of ISO 19100 standards and WMO Core Metadata Profile of the ISO Metadata Standard.

The concept of GEONETCast is to use bandwidth on commercial satellites for the data broadcast using standard DVB-S broadcast.

The GEONETCast Implementation Plan[xxv] lists a number of standards have emerged as forming the baseline for dissemination systems which contribute to the GEONETCast infrastructure:

[5] http://openid.net/foundation

[6] http://oauth.net/documentation/spec

[7] http://tools.ietf.org/html/draft-hammer-oauth-08

[8] http://shibboleth.internet2.edu/Shibboleth-SAML-FAQ.html

[9] http://www.ukfederation.org.uk/

- Contributing dissemination systems should be generic, multi-service dissemination systems, based on standard Digital Video Broadcast (DVB) technology;
- Using commercial broadcast channels on television, direct-to-home (DTH) telecommunication satellites;
- Utilising commercial, off-the-shelf, commonly available reception equipment;
- Using Internet Protocol (IP) over DVB standard coding;
- Systems should support transparent transfer of files – files should be received exactly as sent;
- Use of standard, openly described file formats is encouraged – examples currently in use are L/HRIT, BUFR, GRIB, HDF, netCDF;
- Contributing systems should provide secure access control at individual file and User level;
- The systems should be open, flexible, and scalable at both the Network Centre and User Terminal level;
- Quality of service should be ensured and regularly monitored;
- Catalogues of transmitted data should be maintained and made available for consultation by Users in order to facilitate data discovery and subscription;
- Dissemination should be organised in multiple multicast channels corresponding to product categories, which are associated with Programme Identifiers (PID). User level;

4.4 GEOSS functions via media

There may be instances where digital transport either via Internet or broadcast is not possible, because either the data provider or the data consumer does not have satellite or Internet access. When either of these situations is true, the only means available for data transfer between data provider and data consumer will include mechanisms such as data disks, data tapes, CDs, DVDs, etc. that are sent via physical transfer. It will be assumed that there is local computing support to be able to use the media that is necessary for disseminating or receiving data.

4.4.1 Media Types

The media choices that are available for data encoding and data transfer are broad. Since GEOSS is based upon the utilization of open standards, the media choices shown will be those that are widely available and compatible between various computing systems.

Media Type	Existing Alternatives
Magnetic Tape Storage	Digital Linear Tape (DLT), Super Digital Linear Tape (SDLT), Linear Tape-Open (LTO)
Disk Storage	Universal Serial Bus (USB) drives, FireWire (IEEE 1394) drives

Optical Storage	Compact Disc (CD), Digital Video Disc (DVD), Universal Disc Format (UDF, also known as ISO/IEC 13346 or ECMA-167)

4.4.2 Registering and Utilizing Media Services

If a data provider wishes to disseminate data within GEOSS via physical media, the appropriate component, service, and standard or special arrangement must still be registered in the GEOSS registries so that data consumers can discover information about the data available and the service needed to consume it. Similarly, if a data consumer wishes to receive data within GEOSS via physical media, the search for the service must take place over the Internet using the Clearinghouse or registries. In both cases, if the data provider or the data consumer does not have Internet access, then a proxy must be used that has Internet access. The proxy can be a GEO Member representative or a GEO Participating Organization representative.

For registration purposes, the data service must have an Information URL that points to a document available online that describes how to request data, and how to access the data on the media (this includes file names and standards used for the data). This document will contain a form that can be used online or printed out. The form should include input fields that collect data consumer contact information (postal, phone, fax), the data requested, the date of request, and the media choice. If the data provider is not on the Internet, then the request form should specify where the data consumer should send it or fax it.

5 Engineering Viewpoint – Components Types

5.1 Engineering component tiers

The Engineering Viewpoint identifies component types in order to support distributed interaction between the components. The component types are to be consistent with the Enterprise viewpoint, e.g., GEOSS as a system of systems. The components are characterized as part of a service layer in a 3-tier model (Figure 25 and Table 6):

- The top tier is the only one with which clients (people or systems) deal directly. It provides the interfaces to describe and use the services offered;
- The middle tier embodies all the business processes required to respond to requests issued by clients. The services in general embody everything from authentication to complex geoprocessing on sets of data from various repositories and from generation of map views to statistical charts that the client gets back at the end of the process;
- The lower tier provides read and/or write access to data, whether its geospatial data, accounting records, or catalogue entries stored in any of a dozen different types of registries.

The component types interact based upon the services identified in the Computational Viewpoint. To limit the complexity of the diagram, interactions between components is not made explicit in Figure 25. Interoperability arrangements for the Component Types are listed in Table 6. The Test Facility is described in the Business Process Tier.

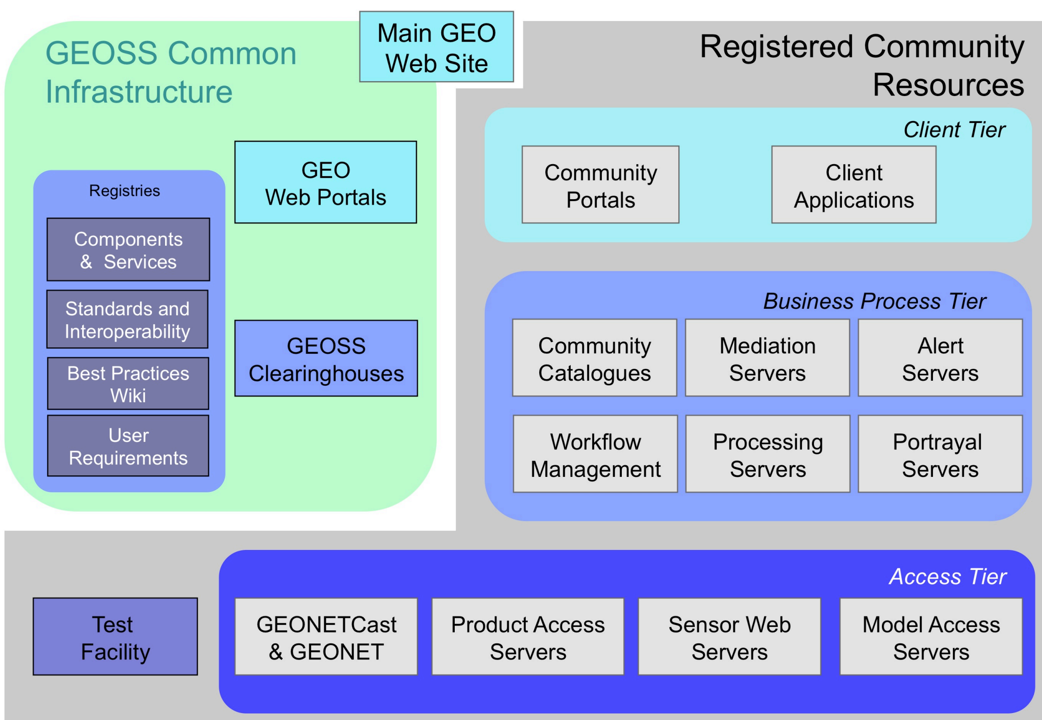

Figure 25 – Engineering Viewpoint Components

Table 6 – GEOSS Engineering Component Types

Component	Description	Example Interoperability Arrangements
Main GEO Web Site	Earthobservations.org	http
GEO Web Portals	A single point of access to information, internal or external to GEOSS, relevant to all SBAs and is of interest to various types of users	http, CSW, WMS, KML
GEOSS Registries	Component and Service Registry (CSR) Standards and Interoperability Registry (SIR) GEOSS Best Practices Wiki GEOSS User Requirements Registry	
GEOSS Clearinghouse	Provides search access to high-level metadata from all catalogs registered in the CSR through remote harvest of metadata or provision of distributed search. Indexes all CSR entries.	CSW, ISO 23950
Community Portals	A community-focused portal (website) that provides a human user interface to identified content	CSW, ISO23950, KML, WMS
Client Applications	Application hosted on users computer to access remote services and provide manipulation of the data in the client application. Clients may be specific to a user community or may be more generic geospatial data applications.	CSW, ISO23950, WMS, WFS, WCS, SOS, SPS, WPS, CAP, KML, RSS, GeoRSS
Community Catalogues	Collection of community-organized information descriptions (metadata) exposed through standard catalog service interfaces	CSW, ISO 23950
Mediation Servers	federates several catalogue services with differing vocabulary and offers results through a catalogue service.	CSW, ISO 23950
Alert Servers	Component provides feeds of alerts.	CAP, RSS, GeoRSS
Workflow Management	Encapsulates an engine capable of managing workflows, services, activities, and workflow execution instances.	BPEL
Processing Servers	Components that accepts requests to process data using an algorithm hosted in the component. The data is accessed from a remote service.	WPS
Test Facility	Provides persistent services to support the service registration and operational monitoring of services.	WMS, WFS, WCS, CSW
Product Access Servers	Services to access Earth Observation data. Typically hosted by a facility that provides redundant resources for both high availability and high performance.	WMS, WFS, WCS, ftp, OPeNDAP
Sensor Web Servers	Services to access sensors and sensors networks: e.g.; ground station and associated satellites; and in-situ networks of sensors.	SOS, SPS, SAS
Model Access Servers	Services to access outputs of predictive models of geospatial information, hosted by a simulation and modeling center.	WMS, WCS, WFS, SOS
GEONETCast	Global network of satellite-based data dissemination systems to distribute data via broadcast.	DVB-S

5.2 GEOSS Common Infrastructure

The GEOSS Common Infrastructure (GCI) (Figure 26) consists of web-based portals, clearinghouses for searching data, information and services, and registries containing information about GEOSS components, standards, best practices and requirements. The Initial Operating Capability (IOC) of GCI was declared established as of 1 May 2008. The GCI IOC baseline represents a significant milestone in the development of GEOSS. The Executive Committee and GEO Secretariat have now declared that GEOSS is "Open for Business". A GCI Coordinating Team is now established.

In Figure 26 the GCI is shown as being enclosed by a light green oval. Within the oval are the identified registries, the GEO Web Portal(s), and the GEOSS Clearinghouse(s). Key external interactions are with users, offered GEOSS registered resources (services, component systems, etc.), the GEONETCast satellite data broadcast service and other communication services, community resources not registered with GEOSS, and the main GEO web site.

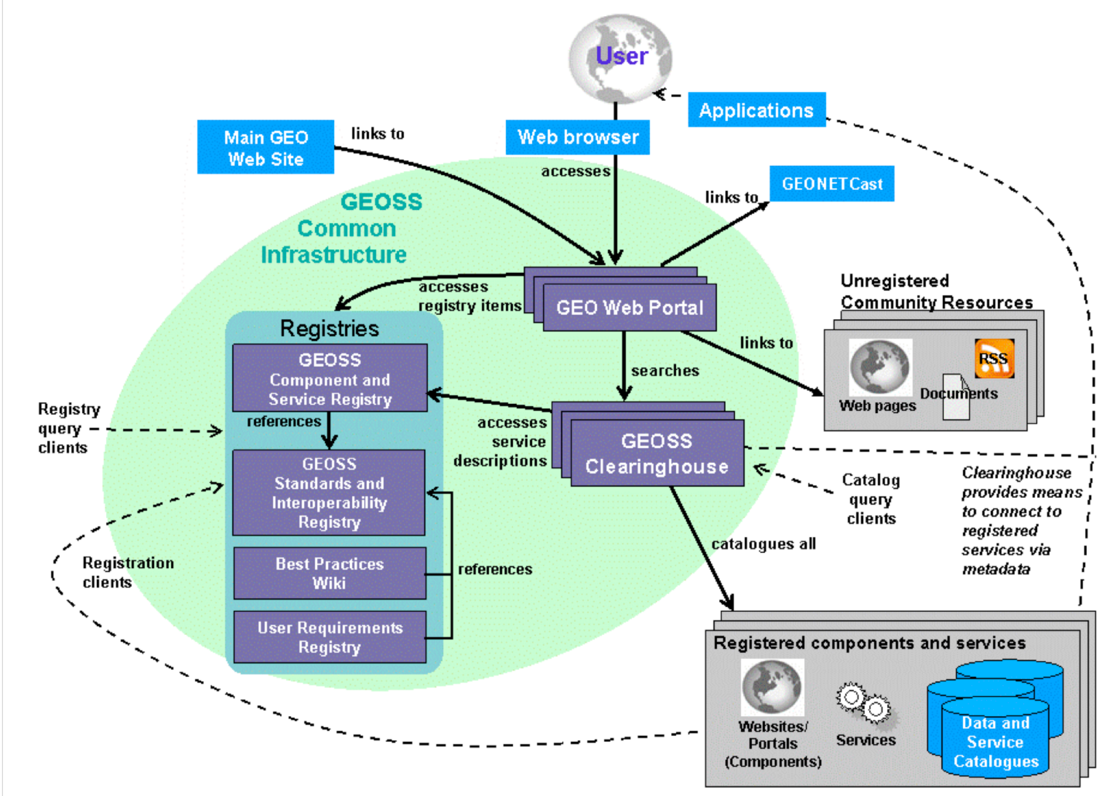

Figure 26 – GEOSS Common Infrastructure

The GCI Components are described based upon where they fit in the three-tier model. Several separate documents exist to describe the GCI[10]:

- GCI Consolidated Requirements
- The GCI Concept of Operations

5.3 User interface components

5.3.1 GEO Web Portal

A Web portal is a single point of access to information, which is linked from various logically related Internet based applications and is of interest to various types of users. The GEOSS architecture defines two types of portals: a GEO Web Portal and GEOSS Community Portals. Additionally the development of reusable portlets is envisioned.

Portals present information from diverse sources in a unified way; they provide a consistent look and feel with access control and procedures for multiple applications, which otherwise would have been different entities altogether. Since all the applications share information through portals, there is better communication between various types of users. Another advantage of portals is that they can make event-driven campaigns. Generally, a portal provides:

- Intelligent integration and access to enterprise content, applications and processes
- Improved communication and collaboration among customers, partners, and employees
- Unified, real-time access to information held in disparate systems
- Personalized user interactions
- Rapid, easy modification and maintenance of the website presentation

The GEO Web Portal enables discovery of many types of information and services. The GEO Portal is a client to some of the discovered services. For example, all the GEO Web Portal is a WMS client and so capable to execute a ServiceRequest of GetMap and process the response. It is not anticipated that the GEO Web Portal will be a client to every service type in the GEOSS registry. The AIP Architecture anticipates that "Application Client" components will serve as helper clients to services not supported by the Portal.

5.3.2 Community Portals

Community portals provide a user interface for a specific community. The user interface including the accessible information is tuned to the needs of the user community. User communities can be for a specific research interest, societal benefit area, etc.

The Pilot is anticipates two types of responses regarding Community Portals:

[10] http://www.earthobservations.org/gci_gci.shtml

1. Existing community portals that currently provide web access to a community of users. Participation in the Pilots will enable the participating organization to expand their portal by interoperating with additional web services. The Community Portals will also play a significant role in the demonstration of user scenarios.
2. Portal solutions are available for hosting by other organizations. Solutions will need to be freely distributed to any organization for hosting and populating by the receiving organization. Proposals should for portal solutions should not only describe what the portal can do but the methods by which other organizations can obtain and configure the portal solution at their sites.

Community Portals may provide a list of functionalities, either as direct components of the portal itself or linked from physically remote locations. All services seem to be part of the portal itself.

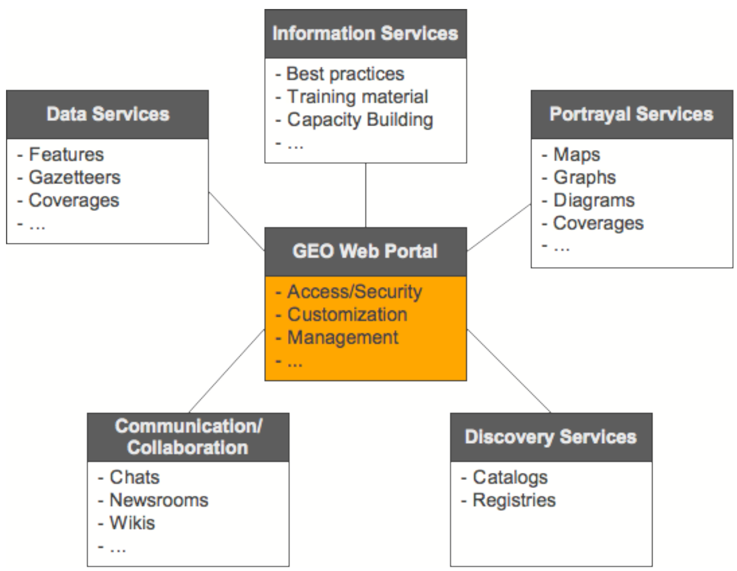

Figure 27 – Web Portal and integrated or linked services

5.3.3 Client Applications

Decision support client application components access remote data from one or more Web services and provide manipulation of the data in the client application. Decision support functionality may include filtering, aggregation, analysis, visualization, presentation, and interpretation of multiple sources of data. Decision support clients may be specific to a user community or may be more generic geospatial data applications. Client applications which can be distributed free of charge are desired, note that this does not necessarily require that the code be open source.

While this type of application is generally understood to be a user-facing component, this does not restrict the computing platform by which it is implemented. The application may be implemented in software running "standalone" on the user's desktop, or it may be generated by software running on a remote server and "delivered" through a Web browser.

Despite the range of technological and architectural possibilities, GEOSS client applications should facilitate consumption of GEOSS services by a wide range of users and support decisions needed for the societal benefit area scenarios detailed in this document.

5.3.4 Client Portlets

Client application generator components supporting the Portlet (JSR 168 specification) and/or WSRP (Web Service Remote Portlet, OASIS-approved network protocol) specifications facilitate both consumption of GEOSS services and incorporation of decision support / visualization functionality into the GEO portal as well as some community portals and should be considered.

5.4 Business process components

5.4.1 GEOSS registries

A registry is an information system on which a register is maintained; whereas, a register is a set of files containing identifiers assigned to items with descriptions of the associated items (definitions from ISO 19135). A registry provides access to the registers that it maintains.

The GEOSS registries and their current owners are:

- 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 crosscutting information and services. Contributors can also share ideas and proposals informally via the associated Standards and Interoperability Forum.
- The GEOSS Best Practices Wiki provides the GEOSS community with a means to propose, discuss and converge upon best practices in all fields of earth observation.
- GEOSS User Requirements Registry will publish User Types, Activities and Requirements to support identification of linkages between those items as well as down a value chain/network that benefit from an Activity or Requirement

The GEOSS Clearinghouse accesses these registers, and provides search and discovery for all catalogue records stored therein. Some registers, such as the Components and Services Register, the Standards and Interoperability Register, and the Best Practices Wiki have their own user interface for the entry and searching of the register contents, but can still be accessed via the GEO Portal.

As shown in the figure below, the Components and Services Registers interoperate via UDDI, ebRS, CSW and a Web user interface, while the Standards and Special Arrangements Registers interoperate via SRU (Z39.50) and a Web user interface. There is also a special interoperability arrangement between the Special Arrangements Registry and the Services Registry. This interoperability arrangement facilitates the registration of special interoperability arrangements with the Special Arrangements Registry seamlessly while registering the services they support at the Services Registry.

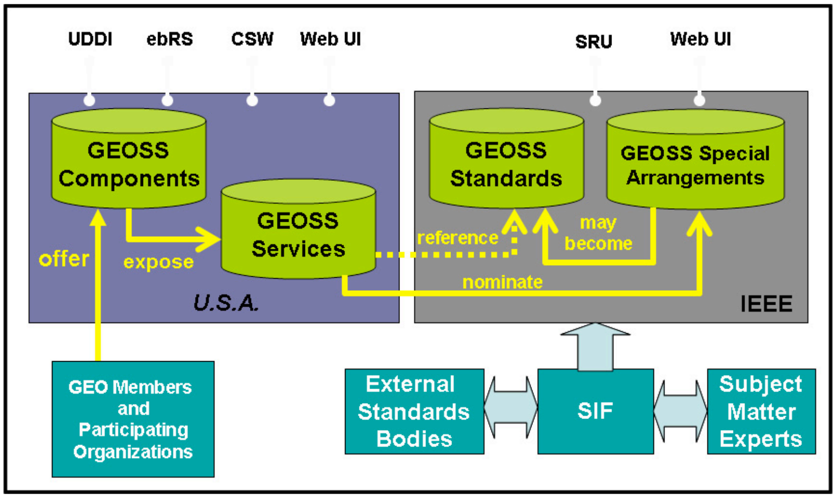

Figure 28 – GEOSS Components and Service Registries

5.4.2 GEOSS Clearinghouse

The GEOSS Clearinghouse provides access to a distributed network of catalogue services that support the interoperability arrangements of GEO. Member and participating organizations may nominate catalogues containing structured, standards-based metadata and other web services for access by the GEOSS Clearinghouse. The Clearinghouse provides search capability across the catalogues and their registered resources. The GEO Web Portal will search the GEOSS Clearinghouse in addition to other nominated GEOSS resources (e.g. other websites and documents). Through the use of interoperability standards, additional portals may be established for national or professional communities to access the GEOSS Clearinghouse. The Global Spatial Data Infrastructure (GSDI), for example, offers a similar clearinghouse capacity.

The GEOSS Clearinghouse will provide access to cached catalogue records from catalogue service instances registered with GEOSS in the Service Registry. This provides one-stop access to metadata on data, services, documents, ontologies, coordinate reference systems, and other resource types nominated within GEOSS. The GEOSS Clearinghouse context is defined in Figure 29

The GEOSS Clearinghouse accesses a federation of catalogues. Each catalog maintains its own metadata registry. The Clearinghouse is not a central metadata registry, although it may cache a significant amount of metadata from external, registered catalogues. The Clearinghouse enables discovering communities.

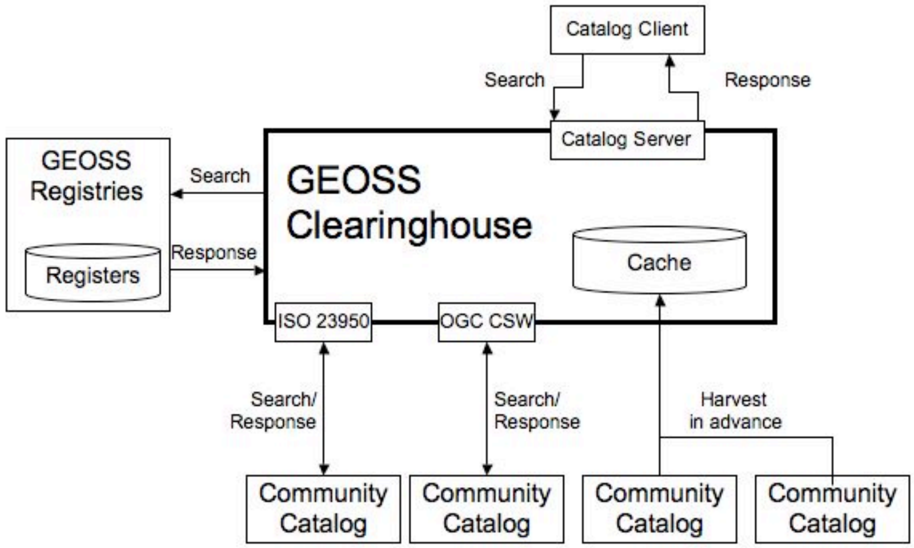

Figure 29 – GEOSS Clearinghouse

An important clearinghouse function is that of supporting distributed search. This is a critical function for the GEOSS Clearinghouse to be able to extend searches to Community Catalogues. A combination of distributed search and metadata harvest functions appears to be optimal based on Clearinghouse experiences in the AIP. A trade study conducted in AIP-1 concluded that of distributed the most important criteria regarding distributed search are: 1) User Response Time and 2) Results Ranking. Therefore, the harvest option should be selected for as many Community Catalogues as possible.

Given the nature of GEOSS, i.e., a system of systems, there will be catalogues that cannot or will not be harvested. Where a Community Catalogue distinguishes between collection and granule metadata, only the collection metadata should be harvested. Some catalogues will object to being harvested, i.e., criteria 4) Metadata ownership. Therefore, the Clearinghouse should provide a distributed Search functionality but its use should be minimized.

The GEOSS Clearinghouse itself is searchable via API from external clients such as the GEO Web Portal and embedded application clients. The separation of the Web Portal and Clearinghouse functionality is desirable to allow for optimization and specialization of the search and harvesting capability on a separate machine, to permit plug-and-play substitution of Web Portal and Clearinghouse implementations, and to allow fail-over of one Clearinghouse instance to another. This separation is achieved through the adoption of common interoperability arrangements for search – the Web Portal acting as the client, and the Clearinghouse acting as the federated catalogue service façade. The primary standard for the search capability is achieved through the CS-W version 2.0.2 “baseline.”

5.4.3 Community catalogues

Each distributed community catalogue will hold metadata records that describe geospatial information and the means to access them. The metadata records shall be structured in accordance to standards agreed to by GEO. For maximum interoperability, catalogues should support metadata standards and structures adopted widely in the community, such as ISO 19115 (with 19139 to define a common XML encoding). A given metadata record may represent a collection of imagery, an individual image, a vector data set or collection of features, a scanned map or other georeferenced information. Additional resource types that may be described in metadata include documents (e.g. spreadsheets, text files, HTML files), schemas, ontologies, lists of coordinate reference systems, feature catalogues or data dictionaries, or other resource types of interest. Each metadata record should include a web-accessible link to the resource being described, though it may simply include instructions for other means of access. Where standards-based web access methods are available to visualize or access a data set, these should be expressed and included in the metadata record.

5.4.4 Mediation Components

These components participate in Semantic Mediation activities and will be defined further in AIP-3.

Mediation servers federate several catalogue services with differing vocabulary and offers results through a catalogue service.

5.4.5 Alerts Servers

These components provide RSS feeds and CAP Alerts. It is also anticipated that the work on events in this phase of AIP will result in further development of this component.

5.4.6 Workflow management

A workflow, in general sense, is a sequence of operations composed of work of a person, work of a simple or complex mechanism, work of a group of persons, work of an organization. In the context of GEOSS, we focus on workflows combining algorithms, models, and systems in the Web environment. A workflow management engine should be capable of managing workflows, services, activities, and workflow execution instances. Figure 30 shows the overall architecture. It has two groups of functions. One is the portal that supports human interactions, such as administrative function, manual deployment/undeployment, interactive execution, and debugging. Another set is the suite of services that are consumed by programs or Web services, such as management services for deploying, undeploying, and executing workflows. Each deployed workflow should be accessible as standard Web services by other software programs.

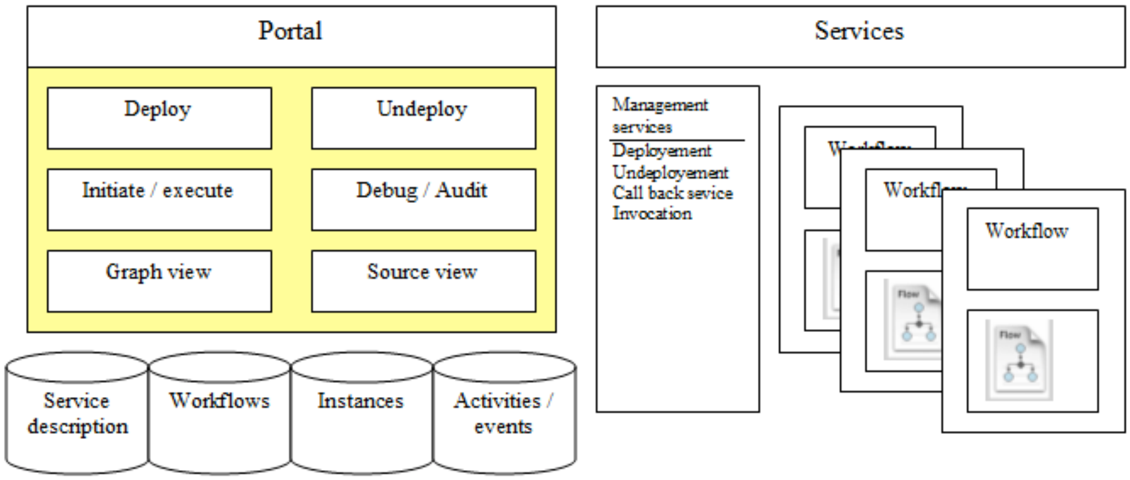

Figure 30 – Architecture for a workflow management engine

To support workflow development, workflow designers aid in the development of workflow scripts. Such designers aid the automatic checking of data types and support the user in evaluation of the semantic correctness of the products derived by a workflow. Workflow designers are available either desktop version or Web version.

5.4.7 Processing servers

Processing Server components are both clients and servers. They provide a service interface such as OGC WPS that accepts requests to process data. The process achieved by algorithms and data handlers provided by the Processing Server. The data is accessed from a remote service, i.e., the client role of a Processing Server. Processing Servers may be used individually or as part of a workflow.

5.4.8 Portrayal servers

Portrayal is for the "presentation of information to humans" (ISO 19117 (2004)) for human visualization. For example, map portrayal is concerned with the shape and color of symbols representing features or is concerned with rules for displaying text labels or for showing or not showing symbols.

A Portrayal Service produces visual pictures from geographic data. Portrayal Services are components that, given one or more inputs, produce rendered outputs such as cartographically portrayed maps or perspective views of terrain.

Example Portrayal Service implementations include: Web Map Service (WMS), Coverage Portrayal Services (CPS) and Feature Portrayal Services (FPS). An FPS is a specialised component-WMS able to portray GML data from WFS services. A CPS is a specialised component-WMS able to portray coverage data from WCS services.

These services usually generate maps in pictorial formats like JPEG, PNG or GIF. Besides these 2D maps as a direct visualization of geospatial data, OGC Web Map Context Documents and OGC KML, as an in-direct visualization of geospatial data, is also valuable in terms of promoting global sharing of geospatial data visualization among different GEOSS practitioners.

5.4.9 Test Facility

The Testing Services Facility was created in the frame of the GEOSS AIP-2 activities to provide a persistent testbed able to support the service contribution process to GEOSS. This facility is mainly based on contributed tools from ESA and FGDC.

The Service Test Facility is intended to ensure proper and interoperable use of GEOSS components and services in applications and interfaces. The Test Facility is intended to promote predictable and reliable access to services registered with the GEOSS Service Registry. The facility will support service providers, service operators, technology providers, integrators, and other users. It will provide a means for service operators and technology providers to get feedback on the efficacy of their interfaces and applications in implementing and using GEOSS Interoperability Arrangements. The Test Facility should enable web services developers to test their data and model prototypes for GEOSS SBA scenarios and demonstrations. In this way, the facility can foster improved collaboration for interoperability It will allow service operators to test their service interfaces at the operation level to determine nominal conformance/compliance with published interface specifications, where they exist. This will promote interoperability between compatible client and service instances of the same version and allow integration of diverse resources across GEOSS. The facility will also enable periodic checking as to the availability and reliability of registered components and services, encourage cross-community implementations, and shorten prototyping cycles. To these ends, the Test Facility needs to be a permanent, sustainable resource.

5.5 Access components

5.5.1 GEONETCast

GEONETCast is a near real time, global network of satellite-based data dissemination systems designed to distribute space-based, air-borne and in situ data, metadata and products to diverse communities.

The concept of GEONETCast is to use bandwidth on commercial satellites for the data broadcast using standard DVB-S broadcast. Each regional system GEONETCast-Americas, EUMETCast and FENGJUNCast make use of this concept by having procured bandwidth on commercial satellites to which the data is uplinked and then broadcast within the footprint of this satellite. The result of the cooperation of the partners is a nearly global coverage.

GEONETCast Global Design Document[xxvi] describes the conceptual idea of a global GEONETCast implementation is that several regional centres take on the responsibilities for establishing a satellite based regional dissemination system and provide the same services to the common user community. The concept of interconnected regional GEONETCast Network Centres (GNC) would allow such an implementation.

A fundamental premise in the design of a GEONETCast capability for interoperability is that the regional systems are as loosely coupled as possible to maximize each region’s flexibility to implement optimal solutions based on its own unique regional challenges. However they must possess common interfaces standards and processes and service level based business-to- business relationships that facilitate exchange of data in both directions in a way that minimizes (but not necessarily eliminates) burden on participants, including providers, data providers, and end users.

Each User accesses in the first instance a central GEONETCast portal on http://www.geonetcast.org (one stop shop). Based on the input of geographical information, the user is then re-directed to the responsible regional GNC, which hosts the regional implementation of the portal. There the user can access services for:

- Data discovery (searchable) on global and regional products and services;
- Links to the regional service performance indicator and news messages;
- Links to the help-desk services;
- Links to the GEONETCast subscription service;
- Web links to the regional archives of the various data providers

Implementations of such distributed portals are widely available. It is pre-mature to discuss now the actual portal technology to be used for GEONETCast; the only important aspect for now is the requirement that the portal technology and implementation of its services should follow recognized international standards.

5.5.2 GEONET

GEONET is to be developed as a global communication network of interconnected networks by which GEOSS related information, data and products can be circulated and distributed in response to users and providers needs. GEONET is based on the sharing of national, regional and global telecommunications networks and will serve all GEOSS Societal Benefit Areas. GEONET will be based on communication network typologies, satellite and terrestrial, considered most suitable to meet the service requirements, providing access points for users and data providers at identified locations.

5.5.3 Data Broker

During AIP-2 there was development of “data broker” components to provide access to data that is behind firewalls, is not to be made fully available, or for other reasons where the primary data holder does not offer the access service to GEOSS but rather relies on a data broker to provide the function. As shown in Figure 31, the broker provides access to a select portion of an institutional data provider in a machine outside of the institution. The Data broker handles the registration of the datasets into GEOSS. The client, e.g., a GEOSS Web Portal, then discovers and access the data that is associated with the institution. A data broker was used to make data available in the AIP-2 Disaster Response Scenario.

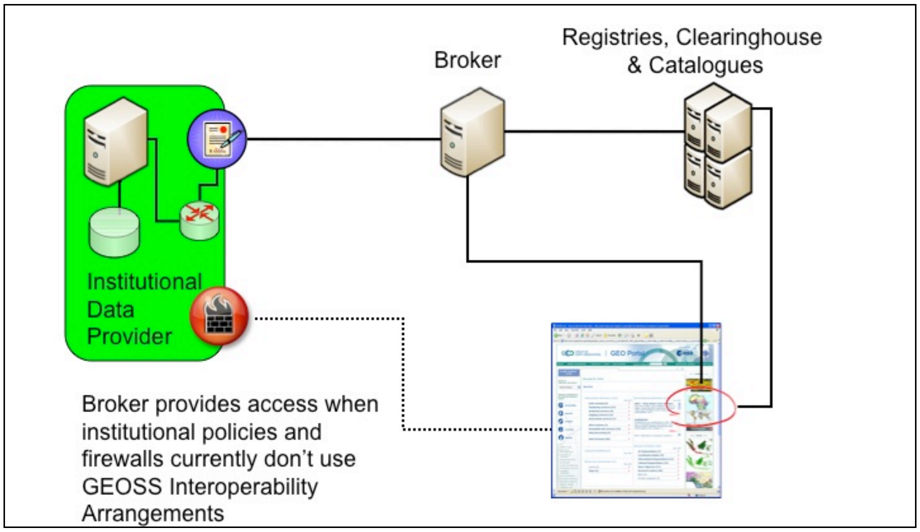

Figure 31 – Data Broker

5.5.4 Product Access Component

These components provide services to access Earth Observation data. The components are typically hosted by an archive data center or other facility that provides redundant resources for both high availability and high performance. Product access components provide access to information of value to the GEOSS community: features, coverages, and observations and maps. The services may be of several types, e.g., WMS, WFS, WCS, SOS, other. It is typical to see a catalogue associated with one or several product access server nodes that provides metadata for the products hosted by the facility.

Product Access Servers are similar to the Imagery Archive Nodes as identified in ISO/TS 19101-2, Geographic information – Reference model – Part 2: Imagery (Figure 32).

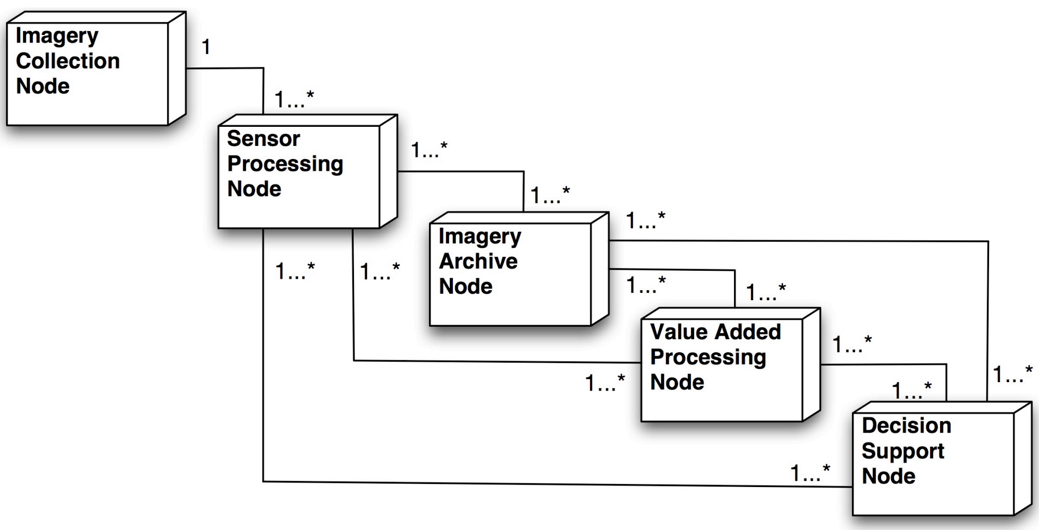

Figure 32 – Imagery reference model nodes

5.5.5 Model Access Component

These components provide services to access outputs of environmental models of geospatial information. The components are typically hosted by a simulation and modeling center or other facility that provides redundant resources for both high availability and high performance. Model Access Components provide access to information of value to the GEOSS community: features, coverages, and observations and maps. The information may be through several types of services, e.g., WMS, WFS, WCS, SOS, other. It is typical to see a catalogue associated with one or several product access server nodes that provides metadata for the products hosted by the facility.

5.5.6 Sensor web components

These components provide services to sensors networks. Examples include: 1) a ground station and associated satellites and 2) in-situ networks of sensors available through sensor web.

The components are typically hosted by a facility that provides redundant resources for both high availability and high performance. Sensor components provide access to information of value to the GEOSS community: features, coverages, and observations and maps. The information may be through several types of services, e.g., WMS, WFS, WCS, SOS, other. It is typical to see a catalogue associated with one or several product access server nodes that provides metadata for the products hosted by the facility.

The Sensor Web represents a meta-platform that integrates arbitrary sensors and sensor networks; each maintained and operated by individual institutions. This reflects the existing legal, organizational and technical situation. Sensors and sensor systems are operated by various organizations with varying access constraints, security, and data quality and performance requirements. The architectural design of the Sensor Web allows the integration of individual sensors as much as the integration of complete sensor systems without the need of fundamental changes to the constituent systems.

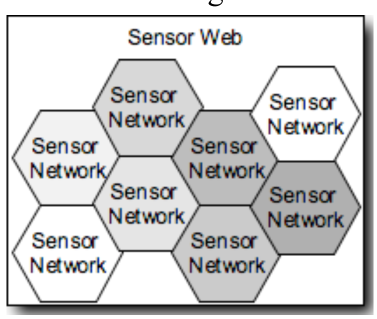

Figure 33 – Sensor Web: Aggregation of Sensor Networks

5.6 Engineering use cases

This section describes the Engineering Use Cases to be developed, refined and applied during AIP-3. The Engineering Use Cases define reusable activities within a service-oriented architecture, tailored for the GEOSS environment.

As expected, the AIP-3 Engineering Use Cases will follow and evolve, as needed, the Engineering Use Cases developed and applied within AIP-2. Furthermore, AIP-3 also introduces four new Engineering Use Cases to better meet the end-to-end needs of the community scenarios in the areas of semantic mediation, user registration, data restrictions handling and integration of sensors.

Responses to the CFP are encouraged to describe their current (or planned) approaches (as well as suggested interoperability arrangements) that address the new use cases within their operational environments. Guidance and best practices in the user registration and data restrictions handling areas are particularly encouraged with an eye on reusable functionality of the GEOSS service –oriented architecture implemented through Interoperability Arrangements.

5.6.1 Use Cases developed in AIP-2

AIP-2 defined and piloted a process for using and augmenting the GCI to meet SBA community needs that is based on implementing community-defined scenarios using generalized transverse technology use cases. The use cases describe reusable functionality of the GEOSS service oriented architecture implemented through Interoperability Arrangements. Within AIP-2, several use cases were further refined and/or specialized as needed to meet the specific SBA scenario requirements.

As shown in Figure 34, the use cases were grouped in five categories based on supporting the end-to-end GEOSS process from resource deployment (02), registration (01) and harvesting (03) to discovery (04), access (05, 06) and exploitation (07) of resources enabled by infrastructure-support functionality such as workflow construction/processing (08), service testing (09) and interoperability arrangements management (10).

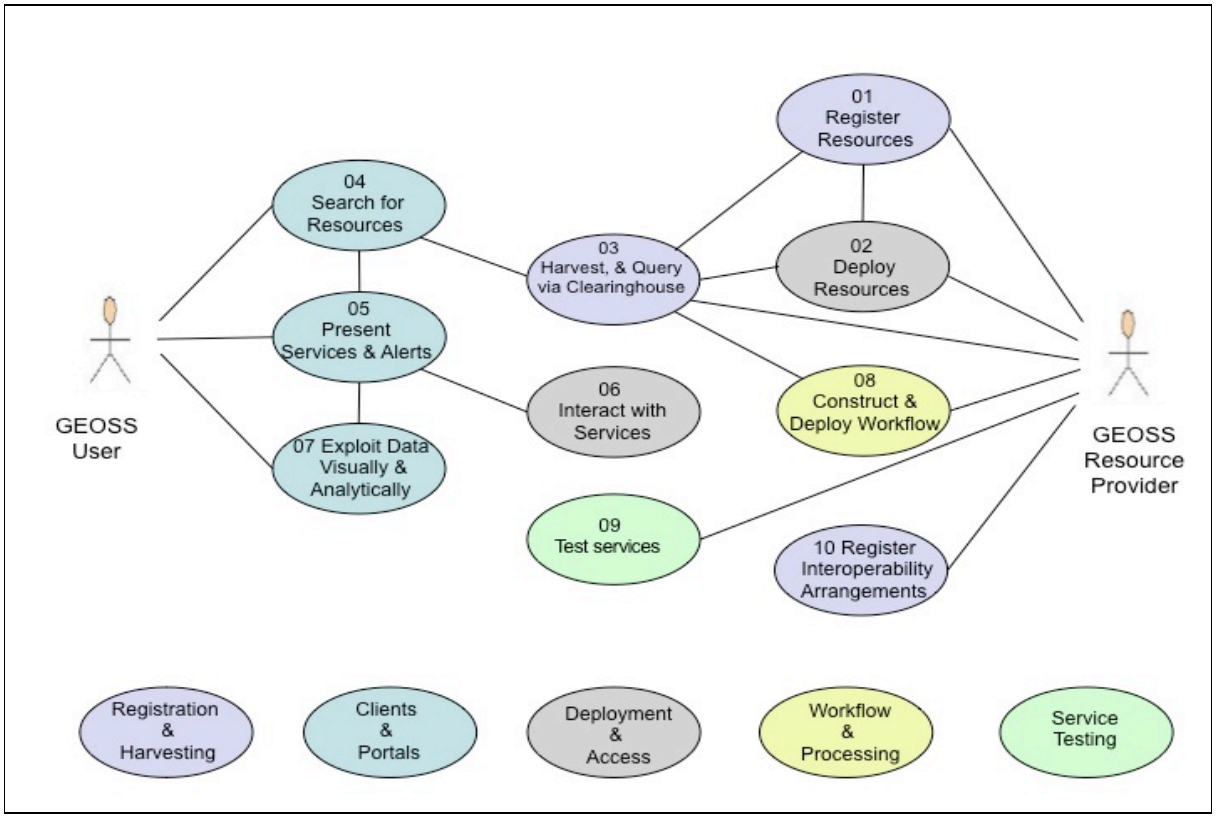

Figure 34 – AIP-2 Engineering Use Cases

Each use case was described in detail including the actors involved as well as the series of steps (or alternate steps). The table provides a quick summary of those use cases. For further detail, refer to the GEOSS AIP-2 Use Cases ER at http://www.ogcnetwork.net/AIP2ERs#UseCases.

Table 7 – Summary of AIP-2 Use Cases

Use Case	Title	Actors and Interfaces
Registration and Harvesting Use Cases		
1. Register Resources	Register resources in GEOSS Components and Services Registry (CSR) or Community Catalog	# Service Provider # Components and Services Registry # Community Catalog Provider
10. Register New Interoperability Arrangements	Register, in the GEOSS Standards and Interoperability Registry (SIR), new and recommended interoperability arrangements) as well as utilized standards.	# Service Provider # Components and Services Registry # Standards & Interoperability Registry # SIF Moderator
3. Harvest & Query via 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	# Service Provider # GCI Registry # GEOSS Clearinghouse # Client Application
Clients and Portals Use Cases		
4. Search for Resources	Steps for portals and application clients to support the GEOSS user in searching for resources of interest via the GEOSS Clearinghouse or Community Catalogs	# GEOSS User # Portals and Client Applications # GEOSS Clearinghouse # Community Catalog
5. Present Services and Alerts	Present GEOSS User with services and alerts as returned per the user's search criteria	# GEOSS User # Portals and Client Applications # GEOSS Service Providers
7. Exploit Data Visually and Analytically	Steps for exploitation in Client Applications of datasets served through Web Services and online protocols as used within GEOSS.	# GEOSS User # Components and Services Registry # GEOSS Service Providers # Portals and Client Applications
Deployment and Access Use Cases		
2. Deploy Resources	Deploy Resources for use in GEOSS	# Service Provider # Components and Services Registry
6. Interact with Services	Interact with Services	# Service Provider # Portals and Client Applications
Service Testing Use Cases		
9. Test Services	Service Provider tests its service using a proper Test tool discovered in the GEOSS CSR.	# Service Provider # Components and Services Registry # Test Facility/Tool # Relevant Standards Authority
Workflow Use Cases		
8. Construct and Deploy Workflow	Design, deploy and execute a workflow. described in Business Execution Language (BPEL) or any other script language.	# GEOSS Integrator # Client Application # Service Provider

5.6.2 Semantic mediation use case

Semantic mediation is a function provided by service brokers (See Section 4.1) and clients to overcome mismatches in community concept vocabularies between service providers and consumers. The "meaning mediation" function has traditionally been carried out by individuals who are familiar with multiple communities. Distributed computing infrastructure can now at least assist in this function provided that formal representations of the vocabularies in question are available for processing.

The minimum infrastructure required to implement semantic mediation functions will be a registry for vocabularies, each of which may be a simple list, have a more complete taxonomic hierarchy, or at best include ontologic elements such as polymorphism and axioms (Figure 35). Five types of activities are required to leverage the vocabulary registry effectively:

1) Registration of community vocabularies themselves.
2) Descriptions and annotations of contributed components and services that make use of the vocabularies - as simple as keyword usage or more involved such as attributed domains and layered annotations.
3) Mappings from community vocabularies to and between a "lattice" of central ontologies, probably beginning with SWEET concepts and SKOS relationships.
4) Service broker components that perform expansion of clearinghouse searches utilizing the vocabulary mappings, concept subsumption relationships, and other forms of semantic processing.
5) Translation of search responses into target vocabularies, for example by way of linked terms.

Contributions of any of these facilities will be welcomed from AIP participants; registration of relevant vocabularies will be encouraged from all participant communities.

Development of this use case will be coordinated with GEO Task AR-09-01d "Ontology and Taxonomy Development".

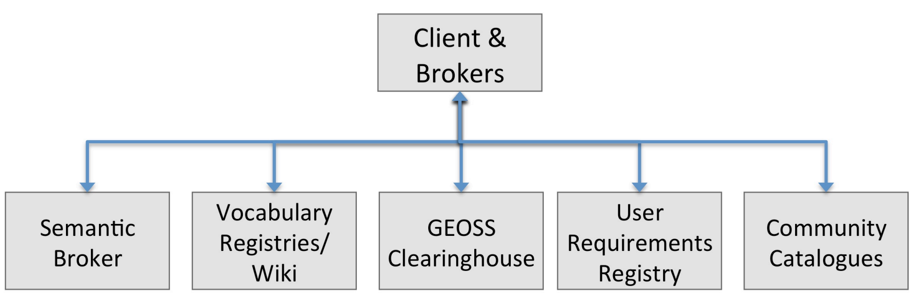

Figure 35 – Components involved in Semantic Mediation

5.6.3 User Identification use case

5.6.3.1 Overview

User identification includes user registration and subsequent user authentication. It is used to allow data providers to collect information as to who is using data, why they are using the data, and how it is being used. In AIP-3, user identification will be handled separate from data access conditions and licensing.

One of the objectives of AIP-3 is to establish a process for user registration and authentication, through which contributors of GEOSS services can register and authenticate users across the various domains of the GEO community. It is desirable to have this process be as consistent as possible across data providers, to be as minimally disruptive as possible to data consumers, to address the issue of repeated logins for various data set accesses, and to have as little impact as possible on the requirements of the GCI. As regards the GCI, the architecture is already in place to support data provider implementation of user registration and authentication via services. Appropriate use cases will be described and data providers are encouraged to implement and experiment with solutions.

AIP-3 will support alternatives for decentralized user registration and authentication by encouraging the implementation of a federated Single-Sign-On (SSO) solution between GEOSS data providers. GEOSS data consumers must also adhere to the same SSO solution, whether interacting with GEOSS manually or programmatically. Possible SSO solutions are OpenID[11], OAuth[12], and Shibboleth[13].

Within the GEOSS, SSO is an authentication model that allows a user to supply an identity token only once to successfully login to one or more services. To realize this authentication model, the GEO Portal or user application must be able to pass along an identity token for authentication by a GEOSS data provider, and GEOSS data providers must recognize when an identity token is received from another GEOSS data provider and honor it. This requires that data consumers must acquire an identity token and that data providers implement the means to perform authentication and pass the identity token to other GEOSS services, if necessary, to fulfill a GEOSS data request.

GEOSS data providers will need to provide metadata upon registering with the Components and Services Registry (CSR) that informs the GCI whether user registration and authentication is required.[14]

5.6.3.2 User Registration Use Cases

This use case refers to an identification service that facilitates SSO. This can be a registration service external to the GCI or one provided by the GCI. AIP-3 has an initial focus on registration services external to the GCI. Possible external registration services include OpenID, OAuth, and Shibboleth.

[11] OpenID can be found at http://openid.net

[12] OAuth can be found at http://oauth.net

[13] Shibboleth can be found at http://shibboleth.internet2.edu

[14] The CSR will need to be modified to support this metadata and make it available to the Clearinghouse.

Overview	
Title	User Registration
Description	This use case covers a GEOSS data consumer using an identification service to create an identity token for use within GEOSS.
Actors and Interfaces	# User Identification Service # GEOSS Data Consumer
Initial Status and Preconditions	# The GEOSS data consumer has not yet acquired an identity token to be used for accessing data from GEOSS.
Basic Flow	
Step 1: Data consumer uses browser to navigate to appropriate site for registration. **Step 2:** Data consumer provides information to the identification service: **Step 3:** Data consumer receives identification token from the identification service **Step 4:** Data consumer saves identification token for later use interactively or programmatically.	
Post Condition	
The data consumer is in possession of the identification key, and has saved it for future use with GEOSS data providers.	

5.6.3.3 User Authentication Use Cases

These use cases handle authentication of GEOSS users in two different manners. The first use case considers the situation where the GCI does not provide an identification service, while the second use case considers the situation where the GCI does provide an identification service. In both cases, SSO is assumed.

Overview	
Title	User Authentication via External Identification Service
Description	This use case covers a GEOSS data consumer authenticating for access to GEOSS data services via an identification service external to the GCI. Both programmatic and manual authentications are handled.
Actors and Interfaces	# User Identification Service # GEOSS Data Consumer # GEOSS Data Service # GEO Portal

Initial Status and Preconditions	# The GEOSS data consumer has acquired an identity token to be used for accessing data from GEOSS. # The GEOSS user has searched for data and is ready to access it.
Basic Flow	
Step 1: Data consumer accesses the data service by clicking on it in the GEO Portal or by accessing it programmatically. **Step 2:** The data service responds by asking for authentication information. There are two alternatives: 1. If the data consumer access was programmatic, then the user's identification token is retrieved and provided programmatically. 2. If the data consumer access was manual, via the GEO Portal, then the user types in the identification token, which is then forwarded to the data service. **Step 3:** Data consumer is granted access to the data service. **Step 4:** Data service supplies received identification token to other data services requiring authenticated access in order to fulfill the data consumer request for data. **Step 5:** Data consumer data request is fulfilled.	
Post Condition	
The data consumer is in possession of the data that was requested.	

Overview	
Title	User Authentication via GCI Identification Service
Description	This use case covers a GEOSS data consumer authenticating for access to GEOSS data services via a GCI identification service. Both programmatic and manual authentications are handled.
Actors and Interfaces	# GCI Identification Service # GEOSS Data Consumer # GEOSS Data Service # GEO Portal
Initial Status and Preconditions	# The GEOSS data consumer has acquired an identity token to be used for accessing data from GEOSS. # The GEOSS user has searched for data and is ready to access it.
Basic Flow	
Step 1: Data consumer accesses the data service by clicking on it in the GEO Portal or by accessing it programmatically. **Step 2:** The data service responds by asking for authentication information. There are two alternatives: 1. If the data consumer access was programmatic, then the user's identification token is	

retrieved from the GCI identification service by the data service (this assumes that there exists some way to identify the user to the GCI identification service). 2. If the data consumer access was manual, via the GEO Portal, then the GEO Portal queries the user for identification to the GCI identification service, and then the retrieved identification token is forwarded to the data service. **Step 3:** Data consumer is granted access to the data service. **Step 4:** Data service supplies received identification token to other data services requiring authenticated access in order to fulfill the data consumer request for data. **Step 5:** Data consumer data request is fulfilled.
Post Condition
The data consumer is in possession of the data that was requested.

5.6.3.4 GEOSS Data Provider Service Registration Use Case

This use case is taken from the AIP-2 Use Cases Engineering Report. It describes the conditions and steps to register resources in the GEOSS Components and Services Registry (CSR) or in (registered) Community Catalogs. This use case is a pre-condition to the discovery and harvesting of resources through GEOSS Clearinghouses.

A new capability that is being explored within AIP-3 is that of user registration and authentication. The pilot will examine the possibility of realizing a federated SSO for GEOSS data users. This will require that data providers include with their service registration whether user authentication is required. AIP-3 covers this with an additional step (i.e. Step 6) added to the Registration use case of AIP-2.

Overview	
Title	Register resources in GEOSS Components and Services Registry (CSR) or Community Catalog
Description	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.
Actors and Interfaces	# Service Provider # GEOSS Components and Services Registry (CSR) # Community Catalog Provider
Initial Status and Preconditions	# Service Provider has deployed an online resource of interest to GEOSS. For example: a data access service, a catalog, a model, an observation service or process (grid transformation or workflow). # Service Provider has registered their organization in the GEOSS CSR. # (Recommended) Community Catalog (incl. Web Accessible Folder) Provider has made their service available for resource

	description registration.
Basic Flow	
Step 1: Service Provider chooses between three alternatives: 1. Determine the appropriate component and service types to describe the resource and register those directly in the CSR. 2. Determine the appropriate component and service type for a metadata service / resource they have deployed and register that service in the CSR in lieu of registering individual resources directly. 3. Register their resource in a community catalog that has already been registered (possibly by another organization) in the CSR. For Alternatives 1&2: **Step 2:** Service Provider chooses a component type and registers the component corresponding to their resource in the CSR. **Step 3:** Service provider determines that metadata about their resource appropriate to the service type(s) it represents is available through one or more Web links. **Step 4:** Service provider chooses one or more service types to represent their resource and registers them with appropriate metadata links and update logistics. **Step 5:** Service Provider, when registering a resource with the CSR, can associate the standards and interoperability arrangements used with the resource. See Register Interoperability Arrangement Use Case. **Step 6:** Service Provider, when registering a resource with the CSR, associates the resource with whether user authentication is required or not.	
Post Condition	
The provided resource description or metadata holdings can be queried by a Clearinghouse and found by GEOSS users searching for useful resources.	

5.6.4 Data Access Conditions Use Cases

5.6.4.1 Overview

Data access conditions can play a key role in a data provider's management and oversight of its data. The Reference document of the GEOSS 10-Year Implementation Plan states, "*Services providing access to Earth Observation data and products often include significant requirements for assuring various aspects of security and authentication. These range from authentication of user identity for data with restricted access, to notification of copyright restrictions for data not in the public domain, and to mechanisms for assurance that data is uncorrupted. In addition to security, accommodations will be made for necessary data and information charges and fees, when appropriate*" (Page 134). This serves as a starting point for the handling of data access conditions in GEOSS. In AIP-3, only open access licenses will be considered.

In this section, it will be assumed that any necessary user registration and authentication has taken place. Therefore, use cases will be provided that explore the process of how data access conditions are imposed by data providers and adhered to by data consumers. These use cases will cover how data consumers are made aware of data access conditions, how data consumers acknowledge data access conditions, and how automated use of data access conditions, via mining of license information, controls merged data sets and derivative data sets and data products.

One of the objectives of AIP-3 is to establish a process for the realization of data access conditions that lessens the licensing alternatives in order to remain as close as possible to full and open access to data sharing, as well as to minimize the impact on the majority of data providers. It is desirable to have this process be as consistent as possible across data providers, to be as minimally disruptive as possible to data consumers, and to have as little impact as possible on the requirements of the GCI. As regards the GCI, the architecture is already in place to support data provider implementation of data access conditions. The purpose of this section is to highlight possible use cases that data providers and data consumers can implement.

Data access conditions are realized through licenses, and these licenses need to be implemented by data providers so that data consumers can use, aggregate, and reuse data in a number of ways with minimal license impact. Whenever possible, it is recommended that standardized open access licenses be used. It is important to understand that any licenses used are attached to the data, and remain attached to the data. The types of licenses being recommended for use within GEOSS for AIP-3 are not associated with people, organizations, or services, and are given in the following table:

Table 8 – Recommended License Options for AIP-3

Type of License	**License Symbol**
I. Dedication to the Public Option (CC0, i.e. Creative Commons Zero)	
II. Creative Commons Attribution Required License	
a. Attribution Required	
b. Non-Commercial Use Only	
III. Specialized GEOSS Open Access Licenses	
a. GEOSS Societal Benefit Areas Only	**SB**
IV. Non-Standard Open Access License	**Other**

These licensing options for AIP-3 have been extracted from the paper, "*Towards Voluntary Interoperable Open Access Licenses for the Global Earth Observation System of Systems (GEOSS)" by* Harlan Onsrud, James Campbell, Bastiaan van Loenen, where they are also described and explained. The Creative Commons[15] licenses are already

[15] http://creativecommons.org/

written and used widely. The Specialized GEOSS Open Access Licenses need to be written and made available to GEOSS users. In particular, the intent of the GEOSS Societal Benefit Areas Only open access license is to allow the associated data to only be used for GEOSS SBA benefit. Non-Standard Open Access Licenses are any open access licenses that are not Creative Commons licenses or Specialized GEOSS licenses. For non-standard licenses, it is completely the responsibility of the data provider to implement how that license should be used and possibly acknowledged by data consumers, and to negotiate with data consumers when necessary.

Associated with these licenses are symbols (found in the paper) so that data consumers, via a graphical user interface, can easily recognize what type of license is being used. In the interests of automating data access conditions, these symbols should be represented as text characters, or some other digital format inside the metadata associated with the data.

The GCI will be impacted by these licensing options in two ways. First, when data providers register their services in the CSR, they will need to provide metadata[16] that informs the GCI which licenses are being used. This will allow the Clearinghouse to capture the licensing metadata, as well, when the CSR is harvested. Second, the GEO Portal[17], via the Clearinghouse, will be able to programmatically, and through user interaction, deal with licensing criteria associated with data being requested by data consumers. The license symbols shown in the table will be used in the GEO Portal to notify users what licenses are associated with the data they have discovered through searching. The license conditions can also be used to help the data consumer use the GEO Portal to search for only data satisfying chosen licenses.

It is quite common for multiple data sources to be used in order to result in a merged or derivative data set, or data product, by data consumers. In these instances, for open access licenses, the most restrictive[18] license prevails as to the new license that is carried forward with the merged or derivative data set, or data product. However, if even one of the licenses of the multiple original data sets is not a standardized open access license, then every published non-standard license associated with the requested data must be investigated by the data consumer. If necessary, the data consumer will enter into negotiations with these data providers to come to an agreement on the licensing conditions.

Metadata pertaining to licensing will be carried with the data. This is necessary to satisfy the persistent nature of the licenses, to facilitate mining of license information by the GCI, to provide programmatic action based on licenses, and to provide data consumers the ability to discover data associated with specific licenses. One of the goals of AIP-3 is to investigate how best to use metadata to record license information. At a minimum, metadata for licensing needs to include:

- Encoding to identify the license associated with the data
- A link to where the license text can be found

[16] The CSR will need to be modified to support this metadata and make it available to the Clearinghouse.

[17] The GEO Portal will need to be modified to support the visualization of licenses associated with data.

[18] For the Creative Commons Attribution licenses, a hierarchy of restriction can be found at http://creativecommons.org/about/licenses/.

- Attribution information

ISO 19115 and the Dublin Core Metadata Initiative (DCMI) both have some support for licensing and attribution, but there may need to be extensions or profiles to these standards in order to properly capture the needs of GEOSS.

For AIP-3, open access licensing will not require active acknowledgement by the data consumer during data consumer authentication or during data access. Licenses will be assumed to be understood, acknowledged, and adhered to by the data consumer, including non-standard open access licenses once any needed negotiations have taken place. When a data provider takes no position on licensing, and provides no metadata describing any conditions on the use of the data, the presumption will be that there is no full and open access to the data, and that the data is not available for use until appropriate permissions are obtained directly from the source.

5.6.4.2 GEOSS Data Provider Service Registration Use Case

This use case is taken from the AIP-2 Use Cases Engineering Report[19]. It describes the conditions and steps to register resources in the GEOSS Components and Services Registry (CSR) or in (registered) Community Catalogs. This use case is a pre-condition to the discovery and harvesting of resources through GEOSS Clearinghouses.

A new capability that is being explored within AIP-3 is that of data access conditions, realized through open access data licenses. The pilot will examine the possibility of carrying license information along with the data being accessed, and using the license information to have data consumers properly use, process, and disseminate the data. This will require that data providers include with their service registration what license is attached to the data being served. AIP-3 covers this with an additional step (i.e. Step 6) added to the Registration use case of AIP-2.

Overview	
Title	Register resources in GEOSS Components and Services Registry (CSR) or Community Catalog
Description	This use case 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.
Actors and Interfaces	# Service Provider # GEOSS Components and Services Registry (CSR) # Community Catalog Provider
Initial Status and	# Service Provider has deployed an online resource of interest to GEOSS. For example: a data access service, a catalog, a model, an

[19] http://www.ogcnetwork.net/system/files/Final_20090708_AIP_Use_Cases_ER.pdf

Preconditions	observation service or process (grid transformation or workflow). # Service Provider has registered their organization in the GEOSS CSR**.** # (Recommended) Community Catalog (incl. Web Accessible Folder) Provider has made their service available for resource description registration.
Basic Flow	
Step 1: Service Provider chooses between three alternatives: 1. Determine the appropriate component and service types to describe the resource and register those directly in the CSR. 2. Determine the appropriate component and service type for a metadata service / resource they have deployed and register that service in the CSR in lieu of registering individual resources directly. 3. Register their resource in a community catalog that has already been registered (possibly by another organization) in the CSR. For Alternatives 1&2: **Step 2:** Service Provider chooses a component type and registers the component corresponding to their resource in the CSR. **Step 3:** Service provider determines that metadata about their resource appropriate to the service type(s) it represents is available through one or more Web links. **Step 4:** Service provider chooses one or more service types to represent their resource and registers them with appropriate metadata links and update logistics. **Step 5:** Service Provider, when registering a resource with the CSR, can associate the standards and interoperability arrangements used with the resource. See Register Interoperability Arrangement Use Case. **Step 6:** Service Provider, when registering a resource with the CSR, associates the resource with what type of data license is required by the data provider.	
Post Condition	
The provided resource description or metadata holdings can be queried by a Clearinghouse and found by GEOSS users searching for useful resources.	

5.6.4.3 GEO Portal Use Cases Involving Data Licenses

These use cases describe the situations when a data consumer uses the GEO Portal to discover data sets based upon the license information associated with the data. The GEO Portal will have implemented the use of license symbols to allow a data consumer to easily specify or recognize data license conditions in preparation for searching or accessing data via GEOSS. The symbols to be used are those shown in Table 8 – Recommended License Options for AIP-3.

Overview	
Title	GEOSS Data Consumer Performs Data Search Using Data License Conditions
Description	This use case covers the use of the GEO Portal to search for data sets satisfying specific license conditions chosen by the data consumer.
Actors and Interfaces	# GEO Portal # GEOSS Data Consumer
Initial Status and Preconditions	# Service Providers have registered services in the CSR, including, when applicable, license information for the data associated with the service. # The Clearinghouse has harvested the CSR and has metadata containing available license information for Service Providers' data. # The GEO Portal supports data searches via license type.
Basic Flow	
Step 1: Data consumer chooses data license types, along with other search criteria. **Step 2:** Data consumer begins the search. **Step 3:** The GEO Portal finds all records satisfying the search criteria, including the license types specified by the data consumer, and displays them for the user. The display also makes visible the icons used for the data licenses associated with each displayed data set.	
Post Condition	
The data consumer has a search result to view all data sets found satisfy the licensing criteria specified.	

Overview	
Title	GEOSS Data Consumer Makes Data Access Decision Using Data License Conditions
Description	This use case covers the use of the GEO Portal to assist the data consumer in deciding which data sets to access by including license information in the results of the search conducted by the data consumer.
Actors and Interfaces	# GEO Portal # GEOSS Data Consumer
Initial Status and Preconditions	# Service Providers have registered services in the CSR, including, when applicable, license information for the data associated with the service. # The Clearinghouse has harvested the CSR and has metadata containing available license information for Service Providers' data. # The GEO Portal supports data searches via license type and access to license description.

Basic Flow
Step 1: Data consumer performs a data search without specifying license types.
Step 2: Data consumer begins the search.
Step 3: The GEO Portal finds all records satisfying the search criteria and displays them for the user. The display also makes visible the icons used for the data licenses associated with each displayed data set.
Step 4: The data consumer clicks on license icons to navigate to the text of the license. This allows the user to read what the license conditions are.
Step 5: Data consumer chooses which data set to access.
Step 6: If the chosen data set has no associated data license, then the GEO Portal asks the user to confirm if appropriate access permission was obtained from the data provider. 1. If data access is permitted, then the data consumer's data request proceeds. 2. If data access permission has not been requested, then the data consumer must obtain the permission from the data provider. 3. If data access permission has been requested, but not obtained, then no data retrieval is not possible. The data consumer must adjust the data request, and start over at Step 1.
Post Condition
The data consumer can view the license conditions associated with each data set in the search results, and can read the text of the license, if necessary. The data consumer is in a position to make an informed access to data.

5.6.4.4 Use Case for Programmatic Access to Data Carrying a License

This use case describes the situation where an application or system will access a data set that carries a license. The decision as to which data set will be accessed has already been made. It will be known, at the time of access, whether the data set has a license attached to it, and which type.

Overview	
Title	Programmatic Access to License Carrying Data
Description	This use case covers an application or system programmatically accessing data via a GEOSS-registered data service where licensing conditions exist. The licensing conditions will be found in the metadata.
Actors and Interfaces	# Data Consumer Application or System # Data Service # Data Consumer
Initial Status	# Data Provider has appropriate metadata that contains license

and Preconditions	information, if applicable. # The data consumer is aware of any licensing conditions attached to the data set to be accessed, and has completed any negotiations necessary. # The data consumer application or system is aware of the licensing conditions attached to the data set to be accessed.
Basic Flow	
Step 1: Data consumer's application or system interoperates with the appropriate data service to retrieve data. **Step 2:** If not part of the data in Step 1, the data consumer's application or system interoperates with the data service to access and retrieve the metadata associated with the data from Step 1. **Step 3:** Data consumer's application or system verifies that the licensing conditions in the metadata match the licensing conditions expected. This includes attribution information, if applicable to the license used. **Step 4:** If licensing conditions are validated, including a check for a non-existent license, then the application or system continues execution as expected; otherwise, execution related to the accessed data halts and the data consumer is notified of a licensing issue to be rectified.	
Post Condition	
The data consumer's application or system has successfully retrieved the data and metadata, and has tested the validity of the license conditions attached to the data. The state of execution of the data consumer's application or system reflects the license check. The data consumer has been notified if there is a licensing problem.	

5.6.4.5 Use Cases for GEO Portal Access to Multiple Data Sets

These use cases describe the situations where the data consumer chooses to access multiple data sets through the GEO Portal for the purpose of creating a merged data set or a derived data product. The decision as to which data sets will be accessed will have already been made. It will be known, at the time of access, whether the data sets have licenses attached to them, and which types.

Overview	
Title	GEOSS Data Consumer Accesses Multiple Data Sets Through GEO Portal Using Standardized Open Access Data Licenses
Description	This use case covers the use of the GEO Portal, by a data consumer, to retrieve multiple data sets for the purpose of creating a merged data set or a derived data product. All data sets accessed will have standardized open access licenses associated with them.
Actors and	# GEO Portal

Interfaces	# GEOSS Data Consumer
Initial Status and Preconditions	# Data Consumer has conducted a search to determine which data sets to retrieve. # Data Consumer is knowledgeable of the various licenses associated with the data sets to be retrieved. # The GEO Portal supports the generation of metadata for retrieved data sets where merged records or derived data products will result.
Basic Flow	
Step 1: Data consumer commences the access of data from multiple data sets simultaneously. **Step 2:** GEO Portal retrieves the various data sets. **Step 3:** GEO Portal accesses the metadata for all data sets retrieved, and isolates licensing conditions for analysis. **Step 4:** GEO Portal takes all license conditions and determines the collective license to be associated with the merged data or data product. **Step 5:** GEO Portal takes all attributions and generates new attribution metadata to reflect the merged data or data product. **Step 6:** GEO Portal generates metadata for merged data or data product that reflects the new licensing conditions and attribution, **Step 7:** GEO Portal makes merged data set or derived data product available to the data consumer.	
Post Condition	
The data consumer has access to a merged data set or derived data product with appropriate metadata to accurately reflect licensing and attribution.	

Overview	
Title	GEOSS Data Consumer Accesses Multiple Data Sets Through GEO Portal Using a Non-Standardized Open Access Data License or No License
Description	This use case covers the use of the GEO Portal, by a data consumer, to retrieve multiple data sets for the purpose of creating a merged data set or a derived data product. At least one of the data sets accessed will have a non-standardized open access license associated with it or no data license associated with it.
Actors and Interfaces	# GEO Portal # GEOSS Data Consumer
Initial Status and Preconditions	# Data Consumer has conducted a search to determine which data sets to retrieve. # Data Consumer is knowledgeable of the various licenses associated with the data sets to be retrieved, and has completed

	negotiations as necessary. # The GEO Portal supports the generation of metadata for retrieved data sets where merged records or derived data products will result.
Basic Flow	
Step 1: Data consumer commences the access of data from multiple data sets simultaneously. **Step 2:** Data consumer is notified by the GEO Portal if any data set to be accessed carries no data license, and is asked to confirm if appropriate access permission was obtained from the data provider. 1. If data access is permitted, then the data consumer's data request proceeds. 2. If data access permission has not been requested, then the data consumer must obtain the permission from the data provider. 3. If data access permission has been requested, but not obtained, then no data retrieval is not possible. The data consumer must adjust the data request, and start over at Step 1. **Step 3:** GEO Portal retrieves the various data sets. **Step 4:** GEO Portal accesses the metadata for all data sets retrieved, and isolates licensing conditions for analysis. **Step 5:** GEO Portal takes all license conditions and determines the collective license to be associated with the merged data or data product. **Step 6:** GEO Portal takes all attributions and generates new attribution metadata to reflect the merged data or data product. **Step 7:** GEO Portal generates metadata for merged data or data product that reflects the new licensing conditions and attribution, **Step 8:** GEO Portal makes merged data set or derived data product available to the data consumer.	
Post Condition	
The data consumer has access to a merged data set or derived data product with appropriate metadata to accurately reflect licensing and attribution.	

5.6.4.6 Use Case for Programmatic Access to Multiple Data Sets

This use case describes the situation where an application or system will access multiple data sets programmatically for the purpose of creating a merged data set or a derived data product. The decision as to which data sets will be accessed will have already been made. It will be known, at the time of access, whether the data sets have licenses attached to them, and which types.

Overview

Title	Programmatic Access to Multiple Data Sets Using Open Access Data Licenses or No License
Description	This use case covers an application or system programmatically retrieving multiple data sets for the purpose of creating a merged data set or a derived product via GEOSS-registered data services. All licensing conditions and attributions will be found in the metadata for each data set accessed.
Actors and Interfaces	# Data Consumer Application or System # Data Service # Data Consumer
Initial Status and Preconditions	# Data Provider has appropriate metadata that contains license information, if applicable. # The data consumer is aware of any licensing conditions attached to the data sets to be accessed, and has completed any negotiations necessary. # The data consumer application or system is aware of the licensing conditions attached to the data sets to be accessed.
Basic Flow	
Step 1: Data consumer's application or system interoperates with the appropriate data services to retrieve all requested data. **Step 2:** If not part of the data in Step 1, the data consumer's application or system interoperates with the data services to access and retrieve the metadata associated with all data from Step 1. **Step 3:** Data consumer's application or system verifies that the licensing conditions in the metadata match the licensing conditions expected. This includes attribution information, if applicable to the license used. **Step 4:** If licensing conditions are validated, including a check for a non-existent license, then the application or system continues execution as expected; otherwise, execution related to the accessed data halts and the data consumer is notified of a licensing issue to be rectified. **Step 5:** Data consumer's application or system isolates all licensing conditions for analysis. **Step 6:** Data consumer's application or system takes all license conditions and determines the collective license to be associated with the merged data or data product. **Step 7:** Data consumer's application or system takes all attributions and generates new attribution metadata to reflect the merged data or data product. **Step 8:** Data consumer's application or system generates metadata for merged data or data product that reflects the new licensing conditions and attribution. **Step 9:** Data consumer's application or system makes merged data set or derived data product available to the data consumer, or continues with processing.	
Post Condition	

The state of the data consumer's application or system reflects the license check. If successful, the data consumer's application or system has successfully generated a merged data set or derived data product with appropriate metadata to accurately reflect licensing and attribution.

5.6.5 Sensor Web Use Case

The following use case illustrates the integration of taskable sensors into GEOSS. Based on the assumption that a catalogue search for observation data was didn't produce any results, the client searches for sensors that could be used to produce the required data.

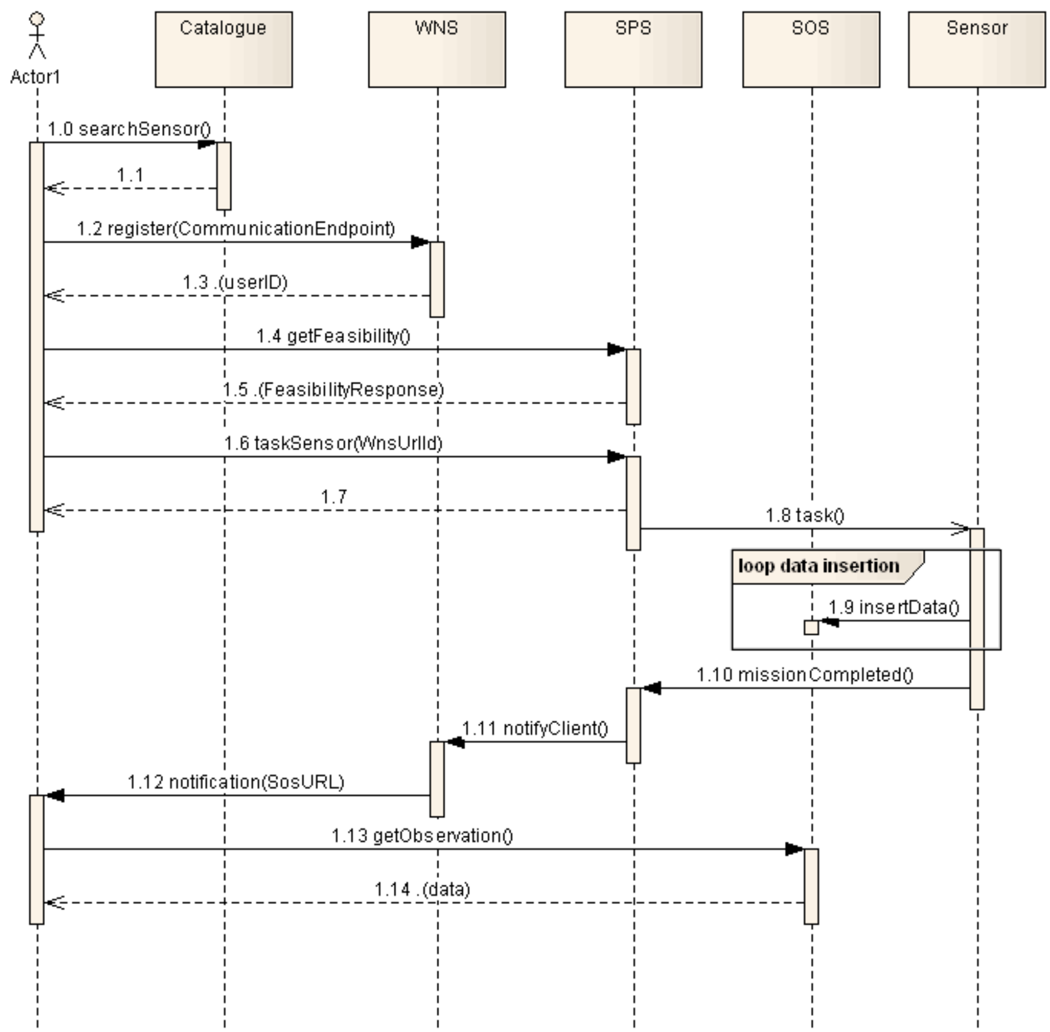

Figure 36 – Sensor Tasking Sequence

Table 9 – Sensor Tasking Steps

Step Label	Description
Initial Conditions	• Sensor and observable types have been registered in GEOSS registries • All services types have been registered in GEOSS component registry • All service instances have been catalogued
1.0 SearchSensor	Client searches for taskable sensors that can produce the required data sets
1.1 Response	Catalogue provides list of services interfaces facading appropriate sensors
1.2 Register (CommunicationEndpoint)	The client registers at a Web Notification Service to allow asynchronous communication
1.3 message (UserID)	WNS provides UserID that can be used to identify the user at this WNS
1.4 getFeasibility	Client tests feasibility of intended tasking request
1.5 FeasibilityResponse	SPS provides feasibility response that allows the client to formulate the tasking request.
1.6 taskSensors (WnsUrlId)	Client submits the tasking request and provides its WNS ID to allow asynchronous communication (SPS has to inform the client once the sensor has been tasked and data is available)
1.7 Response	SPS acknowledges
1.8 task	SPS tasks the sensor
1.9 insertData	Sensor performs observation and pushes data to transactional SOS until mission is completed (loop)
1.10 missionCompleted	Sensor informs SPS about completion of mission
1.11 notifyClient	SPS sends notification request to WNS. Access information to data is piggybacked.
1.12 notification (SosURL)	WNS forwards the message to the client. Message contains all information to retrieve the data from SOS
1.13 getObservation	Client requests data from Sensor Observation Service
1.14	Data is delivered to the client.

6 Technology Viewpoint – Component Instances

6.1 GEOSS Common Infrastrucutre

The GEOSS Common Infrastructure has been deployed and is operational. A main point of entry for the GCI is the main GEO web site:

http://www.earthobservations.org/gci_gci.shtml

6.2 Registered Components and Services

The Technology Viewpoint identified the component and service instances that comprise the "as-built" system. The GEOSS Registries are the definitive source for this information

http://geossregistries.info

A purpose of the Pilot Development process is to augment the component and service instances.

6.3 Operational persistence

An objective of AIP-2 was to increase the operational capability of GEOSS by focusing on components and services that provide a high availability and performance. These components are termed "persistent exemplars." Persistent exemplars are the subset of CSR registered components that meet these criteria:

1. Registered in CSR: Component is registered in the GEOSS CSR with the Resource Availability field set to be "Continuously Operational".
2. Standards-accessible services: The services associated with the "continuously operational components" are accessible through a GEOSS Interoperability Arrangements that is an international standard.
3. Level of service: Services are expected to be available at least 99% of the time, except when otherwise required by the nature of the service. This allows for approximately 7 hours of down time a month. Adequate network service must be provided in order to provide this level of availability.

It is planned that this definition will be entered into the GEOSS Best Practices Wiki for discussion.

As of 13 July 2009, the CSR lists 269 services associated with 231 components that meet criteria 1; and 192 services that meet criteria 1 and 2. AIP-2 has contributed to the establishment of this set of servers but not all of the persistent services were the result of AIP-2.

Table 10 – Services meeting Persistent Exemplar Criteria 1 and 2

Service Type	Number of Services meeting criteria 1 and 2
Catalog/Registry Service	21 services
Data Access	36 services
Portrayal and Display Service	131 (102 are WMS)
(Processing Services)	2 (both are WPS)
(Alerting)	2 (one CAP, one RSS)
Total	192

Criteria 1 and 2 are rather easy to assess. Criterion 3 is more difficult to assess and has not been attempted for this report. The emphasis in the future should be on assessing the operational status of the services that meet criteria 1 and 2 using the Service Test Facility created in AIP-2. By monitoring the operational status of the registered services, the overall availability and performance of GEOSS can be increased.

6.4 Operational test facilities

Two test facilities have been established: FGDC and ESA.

FGDC provides a Service Status Checker (SSC) web service to validate, test and score spatial web services. It returns a set of summary and test diagnostic information about the tests performed on each service. The web service can and will perform health tests on spatial services that provide access to geospatial metadata and data.

http://registry.fgdc.gov/statuschecker/index.php

The ESA contributed tools are mainly based on the SSE environment.

http://services.eoportal.org/

ESA SSE Infocenter (http://services.eoportal.org/infocenter/index.jsp) provides exhaustive information on SSE and the testing services.

7 GEO ADC Definitions

The following Candidate GEOSS Architecture-related Definitions were compiled during GEO ADC meeting, December 2006.

GEO (Group on Earth Observations): GEO is an intergovernmental partnership among GEO Member countries and Participating Organizations: see http://earthobservations.org/

GEO Member: Any member State of the United Nations may become a GEO Member on request and after having endorsed the GEOSS 10-Year Implementation Plan.

GEO Participating Organization: Subject to approval by GEO Members, any intergovernmental, international, or regional organization with a mandate in Earth observation or related activities may become a GEO Participating Organization on request and after having endorsed the GEOSS 10-Year Implementation Plan.

GEOSS (Global Earth Observation System of Systems): The collection of collaborating earth observation systems that are registered with the GEO to provide access to diverse, multi-disciplinary data and services associated with earth observation. GEOSS reflects a global scientific and political consensus that information vital for societies requires comprehensive, coordinated, and sustained Earth observations.

GEOSS 10 Year Implementation Plan: The GEOSS 10 Year Implementation Plan is directed by GEO (Group on Earth Observations) to achieve the vision of comprehensive, coordinated, and sustained Earth observations for the benefit of societies worldwide.

component: a part of GEOSS contributed by a GEO Member or Participating organization. Example types of components include observing systems, data processing systems, dissemination systems, educational programmes, or other initiatives. Components may expose *service* interfaces to provide access to earth observation-related functions and/or data. Components are described in the *GEOSS Component Registry*.

service: Functionality provided by a component through component system interfaces. Services communicate primarily using structured messages, based on the Services Oriented Architecture view of complex systems. Services are described, along with information about their operating organizations, in the *GEOSS Service Registry*.

Services Oriented Architecture [get official website] OASIS, W3C

interoperability: the ability to link two or more components/services to execute a particular task that spans those components without knowledge of underlying implementation. Interoperability may be addressed at the component level and/or defined at the service interface level through the adoption of common standards.

interoperability arrangement: a registered declaration by one or more GEO Members or Participating Organizations to provide access to *services* and data through identified non-proprietary standards. Formal international standards are documented and referenced in the Standards Registry. Interoperability arrangements that document informal standards are referenced in the Special Arrangements Registry. Special arrangements are not required when referencing formal international standards starting from those in the Standards Registry.

standard: documented approach for conducting an activity or task. Standards may be de jure (formally recognized) or de facto (informally adopted) within a community of application. De jure standards are typically managed by a standards development organization. Formal international standards are documented and referenced in the *Standards Registry*. Interoperability arrangements that document informal standards are referenced in the *Special Arrangements Registry*.

GEOSS Clearinghouse: a component that provides access to a network of catalogues and registries that conform to identified catalogue service and metadata standards. The Clearinghouse supports access to data, documents, services, and other resources through the search of descriptive properties (metadata) offered by GEO Members and Participating Organizations.

GEO Web Portal: a website that provides access through *standard* interfaces to the *GEOSS Clearinghouse*, GEOSS registries, and related information.

register: set of files containing identifiers assigned to items with descriptions of the associated items (ISO 19135)

registry: information system on which a register is maintained [and accessed] (ISO 19135)

8 Acronyms

ADC	Architecture and Data Committee (GEOSS)
AIP-2	Architecture Implementation Pilot, Phase 2
BPEL	Business Process Execution Language (OASIS)
CAP	Common Alerting Protocol
CEOS	Committee on Earth Observation Satellites
CFP	Call for Participation
CODATA	Committee on Data for Science and Technology
CSR	Component and Service Registry (GEOSS)
CSW	Catalogue Service for the Web (OGC)
ER	Engineering Report
ESA	European Space Agency
ftp	file transfer protocol
GCI	GEOSS Common Infrastructure
GEO	Group on Earth Observations
GeoDRM	Geospatial Digital Rights Management
GeoRSS	Geospatial RSS
GEOSS	Global Earth Observation System of Systems
GIGAS	The GEOSS, INSPIRE and GMES an Action in Support
http	hyper-text transfer protocol
ICSU	International Council for Science
IOC	Initial Operating Capability
IP Team	Interoperability Program Team
IRI	International Research Institute on Climate and Society
KML	formerly “Keyhole Markup Language” (OGC)
OGC	Open Geospatial Consortium
OPeNDAP	Open Data Access Protocol
OWS	OGC Web Services
RM-ODP	Reference Model of the Open Distributed Processing
RSS	Really Simple Syndication
SBA	Societal Benefit Areas
SEDAC	Socioeconomic Data and Applications Center

SIR	Standards and Interoperability Registry (GEOSS)
SoA	Service Oriented Architecture
SOS	Sensor Observation Service (SOS)
SPS	Sensor Planning Service (SOS)
UIC	User Interface Committee (GEOSS)
UML	Unified Modeling Language (OMG)
USGS	U.S. Geological Survey
WCS	Web Coverage Service (OGC)
WFS	Web Feature Service (OGC)
WMS	Web Map Service (OGC)
WPS	Web Processing Service (OGC)

Endnotes

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