Arctic Food Chain

Climate Change and Biodiversity WG Use Scenario Engineering Report
GEOSS Architecture Implementation Pilot, Phase 2

Version 1.0
Revision History

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Climate Change and Biodiversity Use Scenario

1. Introduction

1.1 Scope of this document

This AIP-2 ER will briefly describe the use scenario entitled "Arctic Food Chain" of the Climate Change and Biodiversity WG. The ER describes how the GEOSS-based system was tested to assess the impact of climate change on the species of a simple food chain in the Arctic region. The architecture of the developed system is described, focusing on the GEOSS standard components and services utilized by the demonstration. Persistent Exemplars services identified are listed.

1.2 GEOSS AIP

The GEOSS Architecture Implementation Pilot (AIP) leads the incorporation of contributed components consistent with the GEOSS Architecture using a GEO Web Portal and a Clearinghouse search facility to access services through GEOSS Interoperability Arrangements in support of the GEOSS Societal Benefit Areas. AIP is a GEO task for elaborating the GEOSS Architecture under the purview of the GEO Architecture and Data Committee.

This ER is a key result of the second phase of AIP, namely AIP-2. This was conducted from July 2008 to June 2009. A separate AIP-2 ER describes the overall process and results of AIP-2 and thereby provides a context for this Community SBA ER.¹

2. Community SBA Objectives

Predicting how biodiversity will change with climate is critical to understand the implications of climate change, and one of the key biodiversity changes will be how the distribution of individual species changes. 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 distribution of a species, such as physiological limitations relative to weather and climate. This work, along with occurrence information, can be used to predict how future changes in climate will effect that distribution. Moving further towards the applied end of the continuum then includes developing approaches that allow the implications of changing climate to be assessed.

This prototype aims to address the needs for achieving best sustainability options raised by the global public, scientists, and more specifically, by the local decision-maker.

The Arctic lacks spatial models. The developed system will allow to model four species in a simple Arctic food chain to assess the impact of potential future climates on each species’ distribution and abundance. Once the impact of climate is assessed on the individual species the dependencies between the species will be incorporated and the impact on species further along the chain assessed. While this robust approach has some limitations, it is a good way to begin to understand the implications of climate change on ecosystems that have many interdependent species.

The scenario models will allow to assess the amount and quality of Ecological Services provided by the Arctic, habitat areas changed, using relevant biodiversity components and conservation scenarios. All outputs will carry statistical confidence, e.g. ROC and confidence intervals, and should allow to feed directly into policy making.

It is intended that this model banks on existing modeling frameworks and tools to deliver standardized results. In fact, the model outputs are mostly based on the IP3 modeling infrastructure, but could also be done in different modeling frameworks (e.g. RandomForest and Marxan). The outputs are as maps of Arctic biodiversity, habitat and ecological service changes, as well as a summarized scenario run with all relevant spatial metrics provided in a simply to comprehend table.

¹ A listing of all AIP-2 Engineering Reports: http://www.ogcnetwork.net/AIP2ERs
The present prototype demonstrates part of the entire food chain model: the polar bear specie distribution model and its assessment. The prototype discover and collects valuable historical datasets in order to run an Ecological Niche Model (ENM) and generate the present polar bear distribution for the model, in the arctic area. Then, the model is assessed by comparing the predicted polar bear presences and the actual observed ones, nowadays. That valuation is extremely important in order to measure the goodness of the generated model and, hence, decide whether and how to apply it in the food chain context for predicting the future distributions (e.g. 2030, 2050).

3. Scenario

3.1 Actors

The main involved actors in this Scenario are:

- **Scientist**: end user of the developed system;
- **Environmental, Climate Change and Biodiversity Data/Service Providers**:
  - Government Agencies;
  - Academic and Other Research Institutes;
  - International Organizations;
- **Model Providers** (Ecological Niche Model).

3.2 Context and pre-conditions

The following demonstration aims to evaluate the relationships between different environmental parameters and the Polar Bears distribution. To estimate such relationships, statistical algorithms provided by OpenModeller will be used.

This will demonstrate the reliability of this tool for predicting future species distribution for all species belonging to the Arctic Food Chain. The Area Of Interest (AOI) is thus the North Pole region (defined as the 60 degree latitude circle). In general, this Scenario might occur in any geographic AOI. As well as for AOI, the species of interest might be other than Polar Bears (which is the species of interest of the specific demonstration).

One type of critical data is the observation data for the species of interest. These can be provided through a WFS Server (which will be used in this Scenario) or other sources. In this example, presence data were provided by the demo scientific patron: Dr. Falk Huettmann of the Institute of Arctic Biology, Biology and Wildlife Department at the University of Alaska Fairbanks. The availability of good data over a range of dates may be of particular value because they can support model validation.

When it is not possible to use data over a range of dates, like in the present case, an alternative way to evaluate the reliability of the calculated species distribution is to split data (both presence and environmental) into two sets according to their spatial extent: the first one to create the Ecological Niche Model and the second one to assess the result.

In the following description we will use the term *creation region* to refer the region on which the ENM will be created and with the term *projection region* we will refer the region on which the ENM will be projected.

Another type of critical data involves environmental parameters important for species survival. Even though species distribution may be controlled by just a few environmental parameters, it is common to predict distribution based on a variety of parameters because it is often not known a priori which parameters are most significant to the species. Again, this particular use scenario example benefits from previous modeling of environmental factors (climate metrics) that can explain Arctic Food Chain animal species distribution. In the following example Bathymetry and Distance to Coast datasets will be used (these datasets will be published on ESSI Lab WCS Server).

An important processing function is that which correlates species occurrence to environment, often called an Ecological Niche Model (ENM), or species distribution model. This software, of which there are a variety of different types that each use different techniques, identifies a quantitative relationship between observations and environment that can be used to predict distribution. When provided with environmental data covering a different space or time extent, it can produce predicted distributions. In this example a niche modeling system,
based on the OpenModeller technology, provides the niche modeling engine. OpenModeller is an open-source project used within the context of the GEO GBIF IP3 demonstration system developed earlier. IP3 extended the OpenModeller system coupling it with the IP3 Community Distributed catalog/broker system.

The following datasets and services are assumed to be available before the scenario begins:

- **GEO Portal**, through this portal the end user will be able to search, find and access the services which are needed for the Scenario execution (ESA GEOPortal will be used);
- **IP3 Client Application** is registered on the Components and Services Registry (CSR) and accessible through the GEO Portal;
- **IP3 Brokering & Mediation Service**. This is a distributed catalogue which federates several services (exposing them through the CSW-ISO interface). Federated services publish the following datasets:
  - Environmental datasets concerning the two AOI (WCS);
  - Species presence datasets concerning the given species and the AOI (WFS);
- **Ecological Niche Model Server** (WPS);
- **WCS-T**

### 3.3 Scenario Events

At summary level, the Scenario proceeds as it follows:

1. The user access GEO Portal, finds IP3 Client Application and accesses to it;
2. Through the IP3 Client Application the user searches, discovers and accesses presence datasets concerning both creation and projection region;
3. Through the IP3 Client Application the user searches, discovers and accesses environmental datasets concerning the creation region;
4. Through the IP3 Client Application the user searches, discovers and accesses environmental datasets concerning the projection region;
5. Through the IP3 Client Application the user generates an Ecological Niche Model (ENM) using the discovered datasets (presence and environmental);
6. Through the IP3 Client Application the user projects the generated ENM using the discovered environmental datasets of the projection region;
7. Projections are published on a WCS-T;
8. Through the IP3 Client Application the user searches, discovers and accesses the generated projection;
9. The user validates the result using the presence datasets concerning projection region

The steps which have to be performed in order to compose the Scenario are detailed in Table 1 where the different colors are to be interpreted as it follows:

- **AIP-2 Components and Services in blue**
- **AIP-2 Products in red**
- **AIP-2 Actors in orange**
### Table 1 – Steps in the Use Scenario

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Trans. Tech Use Case</th>
<th>Specialized Use Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Scientist accesses GEO Portal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01.1</td>
<td><strong>Scientist</strong> accesses the GEO Portal and searches for “Biodiversity Analyzing Systems”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>01.2</td>
<td><strong>Scientist</strong> selects IP3 Client Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>01.3</td>
<td><strong>Scientist</strong> accesses IP3 Client Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td><strong>Scientist</strong> selects species of interest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02.1</td>
<td><strong>Scientist</strong> uses IP3 Client Application to submit a query to the IP3 Brokering&amp;Mediation Service and discover the presence datasets for a given species concerning both creation and projection region</td>
<td>UC #4 – Client Search of Metadata</td>
<td>Species Presence Query</td>
</tr>
<tr>
<td>02.2</td>
<td>IP3 Brokering&amp;Mediation Service mediates the query request distributing it to the WFS server</td>
<td>UC #5 – Presentation of Reachable Services &amp; Alerts</td>
<td></td>
</tr>
<tr>
<td>02.3</td>
<td><strong>Scientist</strong> selects one or more presence datasets returned by the query</td>
<td>UC #5 – Presentation of Reachable Services &amp; Alerts</td>
<td></td>
</tr>
<tr>
<td>02.4</td>
<td><strong>Scientist</strong> gets the selected dataset(s) using the IP3 Brokering&amp;Mediation Service, which mediates the access request distributing it to the WFS server</td>
<td>UC #6 – Interact with Services</td>
<td>Species Presence Access</td>
</tr>
<tr>
<td>03</td>
<td><strong>Scientist</strong> selects environmental data (creation region)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>03.1</td>
<td><strong>Scientist</strong> uses IP3 Client Application to submit a query to the IP3 Brokering&amp;Mediation Service and discover environmental data</td>
<td>UC #4 – Client Search of Metadata</td>
<td>Environmental Query</td>
</tr>
<tr>
<td>03.2</td>
<td>IP3 Brokering&amp;Mediation Service mediates the query request distributing it to the WCS where the datasets are published</td>
<td>UC #5 – Presentation of Reachable Services &amp; Alerts</td>
<td></td>
</tr>
<tr>
<td>03.3</td>
<td><strong>Scientist</strong> selects one or more datasets returned by the query</td>
<td>UC #5 – Presentation of Reachable Services &amp; Alerts</td>
<td></td>
</tr>
<tr>
<td>03.4</td>
<td><strong>Scientist</strong> gets the selected dataset(s) using the IP3 Brokering&amp;Mediation Service, which mediates the access request distributing it to the WCS</td>
<td>UC #6 – Interact with Services</td>
<td>Environmental Access</td>
</tr>
<tr>
<td>04</td>
<td><strong>Scientist</strong> selects environmental data (projection region)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04.1</td>
<td><strong>Scientist</strong> uses IP3 Client Application to submit a query to the IP3 Brokering&amp;Mediation Service and discover available datasets</td>
<td>UC #4 – Client Search of Metadata</td>
<td>Environmental Query</td>
</tr>
<tr>
<td>04.2</td>
<td>IP3 Brokering&amp;Mediation Service mediates the query request distributing it to the WCS where the datasets are published</td>
<td>UC #5 – Presentation of Reachable Services &amp; Alerts</td>
<td></td>
</tr>
<tr>
<td>04.3</td>
<td><strong>Scientist</strong> selects one or more datasets returned by the query</td>
<td>UC #5 – Presentation of Reachable Services &amp; Alerts</td>
<td></td>
</tr>
<tr>
<td>04.4</td>
<td><strong>Scientist</strong> gets the selected dataset(s) using the IP3 Brokering&amp;Mediation Service, which mediates the access request distributing it to the WCS</td>
<td>UC #6 – Interact with Services</td>
<td>Environmental Access</td>
</tr>
<tr>
<td>05</td>
<td><strong>Scientist</strong> generates the Ecological Niche Model (ENM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05.1</td>
<td><strong>Scientist</strong> uses <strong>IP3 Client Application</strong> to ingest the selected <strong>species presence and environmental datasets</strong> (concerning the creation region) into the <strong>ENM Server</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05.2</td>
<td><strong>Scientist</strong> uses <strong>IP3 Client Application</strong> to select the appropriate algorithm for the prediction and to set the algorithm parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05.3</td>
<td><strong>IP3 Client Application</strong> sends a request to <strong>WPS Server</strong> for generating the ENM</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>06</strong></td>
<td><strong>Scientist</strong> generates projection of the Ecological Niche Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>06.1</td>
<td><strong>Scientist</strong> uses <strong>IP3 Client Application</strong> to ingest the <strong>projection region environmental datasets</strong> into the <strong>ENM Server</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06.2</td>
<td><strong>Scientist</strong> uses <strong>IP3 Client Application</strong> to select the <strong>ENM</strong> to be projected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>06.3</td>
<td><strong>IP3 Client Application</strong> sends a request <strong>WPS Server</strong> for projecting the ENM</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>07</strong></td>
<td><strong>Result Publication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07.1</td>
<td><strong>IP3 Client Application</strong> sends a transaction request to the <strong>WCS-T</strong> for publishing the <strong>generated projection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>08</strong></td>
<td><strong>Projection retrieval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08.1</td>
<td><strong>Scientist</strong> uses <strong>IP3 Client Application</strong> to retrieve the <strong>generated projection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08.2</td>
<td><strong>IP3 Brokering&amp;Mediation Service</strong> mediates the query request distributing it to the <strong>WCS-T</strong> where the <strong>projections</strong> are published</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08.3</td>
<td><strong>Scientist</strong> selects the <strong>generated projection</strong> among the ones returned by the query</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08.4</td>
<td><strong>Scientist</strong> gets the selected <strong>projection</strong> using the <strong>IP3 Brokering&amp;Mediation Service</strong>, which mediates the access request distributing it to the <strong>WCS-T</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>09</strong></td>
<td><strong>Validation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08.5</td>
<td><strong>Scientist</strong> validates the result comparing it with the <strong>presence datasets</strong> concerning projection region</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.4 Post-Conditions

After the execution of all the steps of the Scenario, a prediction of future species distribution in the AOI has been generated. Such prediction is also immediately available through an OGC Web Service—i.e. it is published by a WCS component.

### 4. System Model of the Scenario

#### 4.1 Use Case Diagram

A use case diagram describes the behaviors and dynamics of the system being modeled, and is composed of a component boundary, use case name, external actors and their relationships. Within the use case diagram, actors are represented as person stick figures, and use cases are shown as bubbles.
The following diagram presents the overview use case diagram for Arctic Food Chain. It identifies the use cases that comprise Arctic Food Chain and decision support using GEOSS-2 and the high level relationships between them.

![Use Case Diagram for Arctic Food Chain](image_url)

**Figure 1 – Enterprise Viewpoint Use Case Diagram for Arctic Food Chain**

Actors formalize the roles of systems, individuals, or external components which interact with this system. The following Table describes the actors in the use case diagram.

<table>
<thead>
<tr>
<th>Actor Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic Food Chain Scientist</td>
<td>Arctic Food Scientist selects species of interest, uses IP3 Mediation Service to develop correlation model between species and environment. Climate data (published and accessed through a Web Coverage Service), validates model using additional observations. Uses known physiological limits of the species to direct the development of models relating predicted climate change to predicted change in species distribution. uses GBIF IP3 system to predict how range distributions will contract in the future</td>
</tr>
</tbody>
</table>

### 4.1.1 Use Case: Select Presence Dataset

**Purpose:** CB-AF-01. Scientist selects species of interest.

**Pre-Conditions:** Connectivity with IP3 Mediation Service.

**Post-Conditions:** Scientist uses known physiological limits of the species to direct the development of models relating predicted climate change to predicted change in species distribution.

### 4.1.2 Use Case: Scientist validates model using additional observation

**Purpose:** CB-AF-03. Scientist validates model using additional observations.
Pre-Conditions: Scientist has received correlation models between species and environment.
Post-Conditions: Scientist uses known physiological limits of the species to direct the development of models relating predicted climate change to predicted change in species distribution.

4.1.3 Use Case: Predict changes in species distribution

Purpose: Scientist uses GBIF IP3 system to predict how range distributions will contract in the future.
Pre-Conditions: Scientist has required known physiological limits of the species to direct the development of models relating predicted climate change to predicted change in species distribution.
Post-Conditions: Scientist has used GBIF IP3 system provided data to predict range distributions.
4.2 Processes
This section has the processes of the scenario presented in form of SysML Activity Diagrams.
This process encompasses all four use cases depicted on activity diagram.

Figure 2 – Activity Diagram for the “Arctic Food Chain Request for Data” process

4.3 Computational view
The computational view is described in accordance with ISO/IEC 19793 for the use of UML for Open Distributed Processing system specification.

The computational specification functionally decomposes Arctic Food Chain and decision support using the GEOSS-2, with “units of function as computational objects, and interactions among those computational objects, without considering their distribution over networks and nodes.”
4.3.1 Basic Structure of the computational viewpoint for Arctic Food Chain

The following diagram describes the elements or packages of the computational viewpoint for Arctic Food Chain. Interface templates are described as ports, where interface signatures define operations that can handle data and return values. Data types are defined for this data handled and return values. Computational objects are components and are also described by their templates.

Figure 3 - Basic structure of the computational viewpoint for Arctic Food Chain

4.3.2 Object and Interface Template

4.3.2.1 High-Level Architecture

In the following component diagram, system functionality is decomposed into computational objects (or components) that interact at the interfaces (or port instances). The system consists of four main components – the Arctic Food Chain Main Functionality for Wildfire, and the user interfaces that interact with it which includes the Modeler, the Arctic Food Chain Analyst/Manager, and the GEOSS Registry. This defines the high-level architecture.

Figure 4 - Computational object templates
4.3.2.2 Detailed Architecture

The following component diagram decomposes the high-level architecture further to define the internal components, and interactions between those components.

Figure 5 - Internal structure of the Arctic Food Chain System Functionality Computational Object
4.3.3 Interaction Signatures

The following diagram defines the interaction signatures that are instantiated by the ports defined in the prior two component diagrams.

**Figure 6 - Interaction signatures**

![Diagram of interaction signatures](image)

4.3.4 Data Types

Interface templates are described as ports, where interface signatures define operations that can handle data and return values. The following (incomplete) diagram describes the data types that are defined for the data handled and return values for interfaces.

**Figure 7 - Data types handled by the computational objects**

![Diagram of data types](image)
5. Specialized Use Cases

The following sections describe the Specialized Use Cases that were reported in Table 1.

5.1 Species Presence Query

IP3 Client Application communicates with the IP3 Brokering&Mediation Service through the CSW-ISO AP 2.0.2 interface. The submitted query contains both geographic (i.e. the envelope characterizing the specific AOI) and Full Text (i.e. the scientific name of the targeted species) constraints.

5.2 Species Presence Access

IP3 Client Application sends the access request to the IP3 Brokering&Mediation Service which mediates the request and passes it to the WFS Server (GetFeature request). The WFS Server receives the request and sends the response to the IP3 Brokering&Mediation Service.

5.3 Environmental Query

IP3 Client Application communicates with the IP3 Brokering&Mediation Service through the CSW-ISO AP 2.0.2 interface. The submitted query contains geographic (i.e. the envelope characterizing the specific AOI) and Keywords/Full Text (i.e. the name of the targeted parameters/fields) constraints.

5.4 Environmental Access

IP3 Client Application sends the access request to the IP3 Brokering&Mediation Service which mediates the request and passes it to the WCS Server (GetCoverage request, subsetting the coverage). The WCS Server gets the requested datasets and sends them to the IP3 Brokering&Mediation Service.

5.5 WPS Request

IP3 Client Application sends an Execute request to the WPS Server.

5.6 WCS-T Transaction Request

IP3 Client Application generates a “CoverageDescription” document describing the prediction that was generated by the model run. Then, it sends a transaction request (of type “Add”) to the WCS-T component.

5.7 Projection Retrieval

IP3 Client Application sends the access request to the IP3 Brokering&Mediation Service which mediates the request and passes it to the WCS Server (GetCoverage request). The WCS Server gets the requested datasets and sends them to the IP3 Brokering&Mediation Service.

6. AIP-2 Implementation of SBA Scenario

6.1 Demonstration

The demonstration that was prepared deals with the Polar Bear species. The AOI is the North Pole Area. The used datasets were the ones published on WFS (concerning observed Polar Bears presence) along with those provided by the demo scientific patron, Dr. Falk Huettmann of the Institute of Arctic Biology, Biology and Wildlife Department at the University of Alaska Fairbanks. Concerning the environmental data, we used the datasets provided again by Dr. Huettmann; we published them on a WCS 1.1 server. Projections are published through a WCS-T server.

A demo video was prepared showing the Use Scenario execution, it is available on both the GEOSS AIP-2 demo web page and ESSI Lab server.

6.2 Next Steps

To make this Scenario fully operational the only need is a further testing of services which compose it. After this testing phase such services should be identified as persistent exemplars.

The first and immediate steps which can be performed to further develop the Scenario are the following:

- characterize more biodiversity data providers, this would allow to use these new data both for creating new Niche Models and for validating the existing models;
• test with other animal species distribution;
• test with different models for the downscaling of environmental and Climate Change data;
• test with different algorithms for Ecological Niche Model computations.

A more complex development of the Scenario concerns the IP3 Brokering&Mediation component. We are extending it in order to federate not only heterogeneous data provider services, but also model provider services – i.e. WPS.

7. References


Appendix – AIP-2 Transverse Technology Use Cases

In previous sections we described some steps of the present Use Scenario in terms of Transverse Technology Use Cases (and their specialization). These use cases describe GEOSS service oriented architecture functionalities and are detailed in a separate ER\(^2\). Figure 8 and in Table 2 below show and briefly describe such use cases.

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**Figure 8 - GEOSS Transverse Technology Use Cases**

![GEOSS Transverse Technology Use Cases](http://www.ogcnetwork.net/AIP2ERs#UseCases)

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\(^2\) [http://www.ogcnetwork.net/AIP2ERs#UseCases](http://www.ogcnetwork.net/AIP2ERs#UseCases)
## Table 2 - AIP-2 Use Cases Summaries

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