GEO UNSPU Specifications

GEOSS User Needs and System Performance Utility: Functional Specifications and Database Structure

GEOSS-UNSPU

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By:
Hans-Peter Plag,
Nevada Bureau of Mines and Geology &
Seismological Laboratory
University of Nevada, Reno
USA
with input from UIC members and others

For:
The GEO User Interface Committee

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About this document

Purpose

This document is provided in response to an action agreed upon during the GEO User Interface Committee meeting on November 30, 2006 in Bonn. Basically, the action requested is described by the following: "*Hans-Peter Plag agreed to establish a small writing group with the task to draft a specification of the functionality of a user needs and requirements utility. This utility would constitute a component of the 'appropriate mechanism to coordinate user requirements across societal benefit areas' requested in the 10-Year Implementation Plan (10YIP). It would provide GEO with a tool to link users groups, specific applications, and requirements; to analyze system performance with respect to these requirements; and to identify gaps in the observation systems. Plag requested that at least WMO, CEOS, and IGOS-P are represented in the writing team. The team should provide a draft for the next UIC meeting and a final document that could serve as a Statement of Work for the implementation of the utility through a contractor within three months.*".

The present document is a draft which covers in detail the database structure and sketches the main ideas concerning the function to be supported by a *User Needs and System Performance Utility* (UNSPU) for GEO. The draft is meant to serve as a basis for the further discussion how to proceed with the implementation of a GEO user needs and system performance utility.

Scope

This document specifies the functionality of the UNSPU. The rationale for this utility is derived from a review of the "*Ten-Year Implementation Plan for GEOSS*" and the associated Reference Document. In order to make as much as possible use of the existing user requirement databases and expertise, a review of the relevant current status is included. The functional specifications are motivated by the fact that GEOSS is intended as a user-driven system responding to specific user needs, and the notion that such a system can only be achieved if there is an utility that allows the comparison of user needs to the products delivered by the system to the users. The document also addresses on a high level the actual structure of the database underlying the utility, proposes a methodology to populate the utility, and reviews the current knowledge of GEOSS user needs and system performance.

Anticipated audience

The document is prepared for internal use in GEO. A key goal of the activity is to provide a tool in support of all GEO Work Plan Tasks related to user needs, requirements, identification of observation priorities (e.g., Task US-06-01), and system performance. Therefore, the relevant Task Teams are part of the audience.

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Summary

For the planning, implementation, and future development of GEOSS as a system that is driven by and responding to well-defined user needs, a utility that allows the comparison of the products provided by GEOSS to the requirements in terms of Earth observations and higher level information of applications supported by GEOSS is a powerful if not mandatory tool to identify gaps in the observation system and to define priorities for the development of GEOSS. A necessary basis for this UNSPU is a comprehensive database describing the users in the nine Societal Benefit Areas (SBAs), their needs and applications, the qualitative and quantitative requirements in terms of Earth observations and derived information, and the services and products provide by GEOSS. Utilizing this database, algorithms for system performance assessment and gap analysis can be developed. The output of these algorithms provides a basis for informed decisions on priorities for the system development.

The functional specifications for the UNSPU address the editing and analysis functions to be supported by the UNSPU. They define the output that the utility will be able to provide.

An initial structure of the UNSPU database is proposed. The key innovative element is the ability to link users to applications, applications to requirements, requirements to products, products to observations, and these to system components. This database will be a component of the GEOSS architecture. Therefore, the detailed development of the database structure is a task that needs to be supervised jointly by the GEO Architecture and Data Committee (ADC) and the User Interface Committee (UIC). The GEO Tasks related to GEOSS architecture are considered to be the main source for populating the system-related part of the UNSPU database. It is anticipated that the information concerning the services and products provided by many of the systems contributing to GEOSS is already available, although not necessarily in easily accessible databases.

A major challenge is the collection of information for the UNSPU database. The GEO UIC is supervising the progress in populating the database with respect to the users, applications, and requirements. The Communities of Practice established under the UIC are considered pivotal in providing the necessary information. With respect to user needs, a strategy for surveys is discussed.

Tools for the system performance assessment and the identification of the system gaps appear not to be available directly and will have to be developed. These tools should also be ale to support the identification of priorities through an analysis of the user needs and application requirements that certain Earth observations would serve.

1 Introduction

GEOSS is intended as a user-driven system that responds to the needs of users in a wide range of societal application areas in terms of Earth observations and derived information. Therefore, the five functional components of GEOSS specified in the "*10-Year Implementation Plan*" (GEO, 2005a, denoted in the following as the 10YIP) include two user-related components namely

- "*To address identified common user requirements;*"
- "*To monitor performance against defined requirements and intended benefits.*"

Implicitly, the inclusion of these functional components in GEOSS requests that the implementation of GEOSS should be guided by a comprehensive set of explicitly known User Needs (UNs) and Observation Requirements (ORs). The "*10-Year Implementation Plan Reference Document*" (denoted in the following as the Reference Document) emphasizes the importance of user involvement in identifying and monitoring the requirements:

"*To maintain the effectiveness of GEOSS, it is essential to regularly review and assess the needs and requirements for Earth Observation data, products and services. GEOSS should focus not only on global users, but also on local and national users contributing to global observations.*" (GEO, 2005b, page 119).

"*GEOSS will regularly involve users in reviewing and assessing requirements for Earth Observation data, products and services. The benefits of GEOSS will be realized globally by a broad range of user communities, including managers and policy makers in the targeted societal benefit areas, scientific researchers and engineers, civil society, governmental and non-governmental organizations, and international bodies, such as those tasked with implementing multilateral environmental agreements. Engagement of users in developing countries will maximize their opportunities to derive benefits from GEOSS.*

Geo will perform a coordination role to address the adequacy, efficiency, and integrative way user requirements are being met and transmit recommendations for improvements to the relevant contributing systems.

The need of users, and the technical solutions to those needs, change with time. GEO will organize regular GEOSS User Fora among and within societal benefit areas or subareas, making use of user communities where they exist and catalyzing the formation of new ones where they do not. It will also create an appropriate mechanism for coordinating user requirements across societal benefit areas. The function of the User Fora will be to document and review user requirements, assess the extent to which they are being met, and make recommendations to GEO with the objective of improving the delivery of information appropriate to user needs." (GEO, 2005b, pages 140-141).

With respect to System Performance (SP), the Reference Document identifies a first step for *in situ* networks "*to track the performance of observational networks and identify and fix problems*" (GEO, 2005b, page 118).

The task of involving users in GEOSS and understanding their needs and requirements is delegated to the UIC. While GEO through this UIC has made significant progress towards identifying and networking users, in particular through the Communities of Practices (CoPs) and in the frame of the Task US-06-01, little progress has been made so far with respect to collecting an explicit set of qualitative and quantitative ORs and making these ORs accessible for other GEO Committees. One reason, although not the only one, for this lack of progress may be the absence of an agreement on how to describe the ORs in a language common to all SBAs and a tool for storing the ORs and making them available for analysis.

The importance of a tool for involving users in defining new requirements is underlined in the Reference Document. The Reference Document requests that "*a distinct and common user requirements database should be established and maintained by GEOSS, building on and linking to existing user requirements databases, such as the Committee on Earth Observation Satellites (CEOS)/World Meteorological Organisation (WMO) database of user requirements and observation system capabilities. The database should provide a link between the observation capabilities, data products requirements and societal benefit areas. Furthermore, the database should provide a gap analysis mechanism on the basis of comparison of available observations and data products with the required ones*" (GEO, 2005b, page 163).

Figure 1 illustrates the two parallel branches required to achieve a basis for an informed gap analysis. On the one side, the GEOSS infrastructure needs to provide the necessary database elements to store the information on UNs and SP, and on the other side, the information needs to be collected and described in a well defined language common to all SBAs. Only if this can be achieved can a rigorous gap analysis be performed, which would be valuable as a guide for the development of GEOSS.

The goal of the present document is to make progress towards a language for the description of UNs and ORs, and a tool for linking of GEOSS products to UNs, for the identification of observational priorities, for the assessment of the GEOSS performance, and for the utilization and documentation of GEOSS benefits. In the Reference Document, GEO requires that the UN utility should allow for the determination of gaps in the observing system (see above). Therefore, a GEO UNSPU needs to integrate information on UNs with information on SPs.

Thus, the document aims to specify a core element of the GEOSS architecture. It does not address in detail the methodology for populating the database that is a core element of the utility. However, we include here a few comments on this important step.

The 10YIP Reference Document indicates the potential mechanism to be used for reviewing and updating user require-

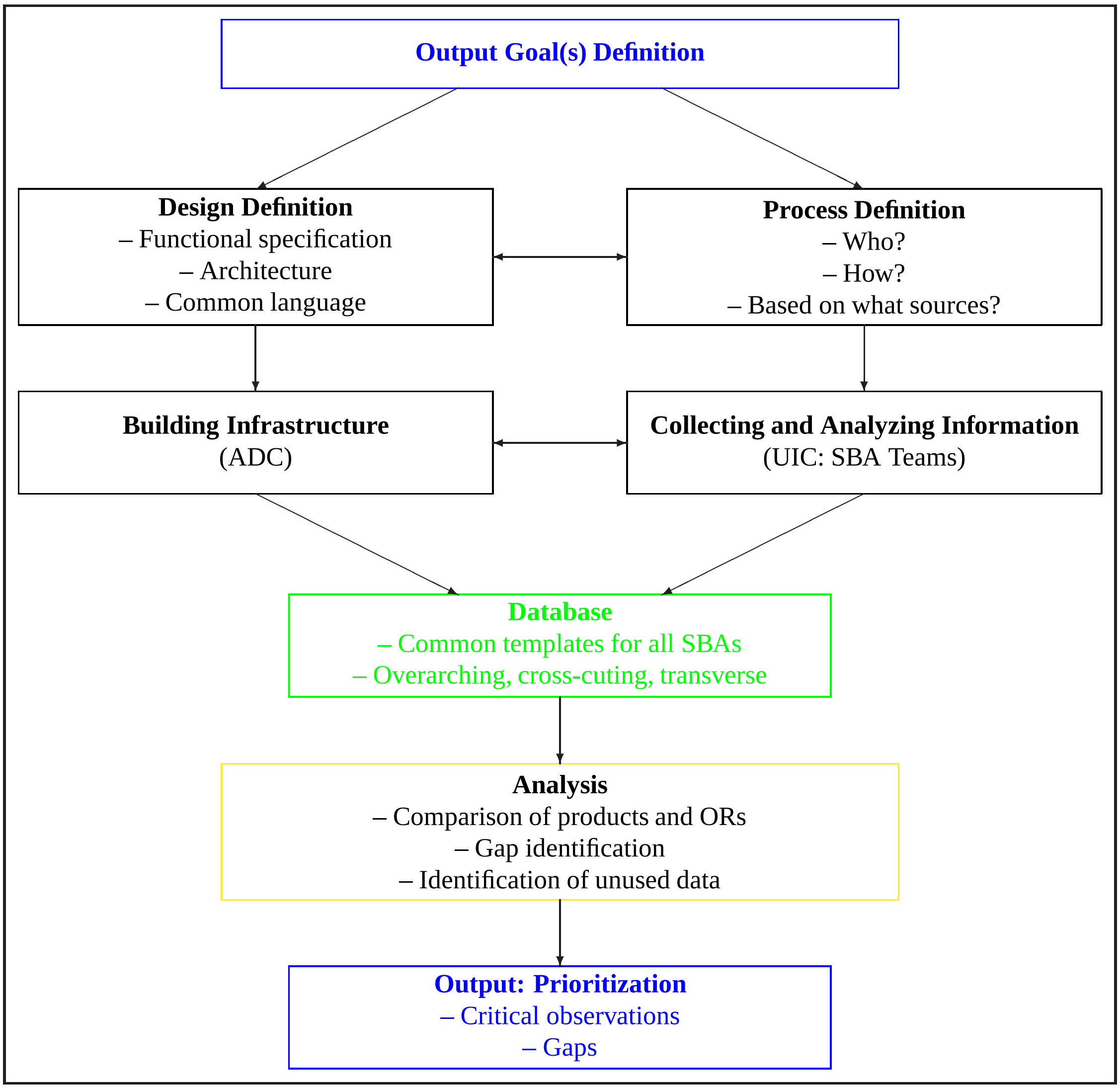

Figure 1. Process of establishing and populating a UNSPU. After the definition of the output goals, the process splits into two parallel activities, one focusing on building the infrastructure and the other on collection the information on UNs and ORs. The latter process has been defined by the GEO UIC. The design definition for the UNSPU is the purpose of the present document.

ments: ”*For updating user requirements, the WMO experience in setting, reviewing, and updating observational data following their process called the Rolling Review of Requirements (RRR) could be used as a model*” (GEO, 2005b, page 165). An important goal of this document is to assess the extent to which the RRR process is applicable to all SBAs and which potential modifications and extensions are required to develop it into the GEOSS process for updating UNs.

In many cases, scientific observing systems are not defined on the basis of a rigorous set of UNs or ORs but rather a set of scientific goals. Often, the main requirement is to be “as good as possible.” For less science-driven and more user-focused systems, the ORs are mostly derived from specific applications and problems. In these cases, the definition of threshold and target values is of key importance, also for the assessment of the system performance.

In the following, we first review existing OR databases and summarize the considerations of GEO with respect to UNs and ORs (Section 2). Subsequently, we provide specifications of the functionality for the UNSPU for GEOSS (Section 3). Then we specify the layout for the database integrated in the UNSPU, which implicitly defines the language for describing UNs and ORs (Section 4). The obstacles in identifying users and quantifying their needs and requirements associated with applications are addressed in Section 6 and a strategy for GEO is proposed. Subsequently, we summarize the current status of the quantitative knowledge of ORs for GEOSS (Section 7), and give an overview concerning the information available with respect to the GEOSS performance (Section 8).

2 Review of present approaches to user requirements and system performance analysis

2.1 Overview

A number of key players in Earth observation have addressed UNs and derived ORs in an attempt to achieving user-driven system development. Main players to be mentioned here include but are not limited to Integrated Global Observing Strategy Partnership (IGOS-P), CEOS, WMO, governmental agencies including European Environment Agency (EEA), National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA), and, not last, GEO. The methodologies used derive ORs and to analyse these vary from player to player considerably, but in most cases, a provider-based view on the UNs is dominant while user involvement is limited.

Examples of mechanisms are WMO's RRR, IGOS-P Themes, and GEO's CoPs. The RRR of WMO is to a large extent a provider-based approach, where mainly users close to the observation system (e.g., national meteorological agencies, scientists, etc.) provide their ORs. The IGOS-P theme approach was mainly based on expert views on UNs and ORs. With the CoPs, GEO makes a novel attempt to base the information on UNs and derived ORs on input from actual users. However, up to now, in most CoPs (although not all), end user involvement is still limited.

In order to get a general or area specific overview, a number of organizations, countries and projects have carried out surveys of UNs and ORs. An example of a national surveys is the one carried out by Canada in the the *ad hoc* GEO phase. This survey examined qualitative requirements for Earth observation data asking large number of potential users (> 400) for input. An example for a project related survey is the one conducted in the frame of the EU-funded project Assessing and forward planning of the Geodetic and Geohazards Observing Systems for GMES applications (GAGOS), which aimed to identify needs and requirements for geodetic and geohazards related observations. An example for a community-based assessment is the report The Global Geodetic Observing System: Meeting the Requirements of a Global Society on a Changing Planet in 2020 (GGOS2020), which is a deliverable of the GEO Task AR-07-03 of the Work Plan 2007-2009.

Existing databases normally are build more around ORs and less linked to UNs. Examples of OR databases include, but are not limited to:

- CEOS WMO Online Database for observational requirements and system characteristics at http://alto-stratus.wmo.ch/sat/stations/SatSystem.html;
- the Reporting Obligations Database (ROD) of the EEA at http://rod.eionet.europa.eu/index.html.
- NOAA/NASA have several linked components, including the Consolidated Observation Requirements List (CORL);

The subsequent subsections will consider a few relevant examples in more detail.

2.2 The WMO/CEOS database and the Rolling Requirement Review

The WMO database and the RRR process for updating the database are mentioned in the 10YIP Reference Document as the preferred template for GEO. Therefore, we need to introduce the database and process in more detail.

The CEOS and WMO maintain an Online Database for observational requirements and system characteristics at http://alto-stratus.wmo.ch/sat/stations/SatSystem.html. Besides table for the observational requirements, the database also provides information on Space Agencies and Missions, Missions and Instruments, Instruments, parameters measured by space-based and in-situ instruments, as well as instruments that measure a specific parameter.

In terms of observational requirements, this database gives access to separate tables of requirements established for WMO, World Climate Research Programme (WCRP), Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), Global Terrestrial Observing System (GTOS), International Geosphere-Biosphere Programme (IGBP), International Council for Science (ICSU), and United Nations Environmental Programme (UNEP). For each parameter, the tables list the requirements in terms of horizontal and vertical resolution, observation cycle, accuracy, delay, confidence, and use. For each quantitative characteristics, both the optimal value and a threshold value are given.

The level of detail differs for the various systems and organisations. For example, the WMO table lists in a comprehensive way quantitative requirements for a large number of mainly geophysical parameters. For GTOS, as another example, the list of parameters is much shorter and appears to be incomplete. For United Nations Office for Outer Space Affairs (UNOOSA), the list includes only one entry, while for ICSU, the list is empty (status as of December 2007).

2.3 NOAA/NASA

NOAA and NASA maintain a system made up of several components. A key component, CORL is based on a need to accomplish the missions and not so much on what system(s) can provide, and includes:

- association to the NASA GCMD Environmental Parameter Topic, Term, Variable structure;
- association to the GCMD Variable Definition;
- association to a Priority level (three levels of Mission Critical, Optimal and Enhancing);

- for 10 parameters attributes which include the major ones of geographical coverage, all vertical, horizontal, temporal, latency, long-term stability, etc,;
- importance "weights" for the major attributes (which is a kind-of sub-prioritization scheme, for example, does a user deem "horizontal resolution" more important within the parameter set than "geographical coverage" and/or "temporal coverage".

CORL is based on threshold and objective levels, and it is structured by NOAA "Goals", which are very similar to GEO's and US-GEO's SBA levels. It is also sub-structured by NOAA's Goal Programs, which is very similar to GEO's and US-GEO SBA "Missions".

With a GEO/US-GEO CORL, an attempt has been made to map NOAA Goals/Programs to best associated GEO and US-GEO SBAs/Missions. This activity has just started by entering, from the available documents, the observation requirement "names" in a SBA/Mission structure. It is planned to link this utility to NASA GCMD levels. However, up to date it has not been possible to find associated "attribute values" other than those that could be pull from a variety of sources, including GCOS, IOOS, etc. A goal is to show associations, similarities, discrepancies of the NOAA CORL ORs and the GEO/US-GEO ORs.

The NASA-NOAA Observation Systems Architecture captures current, planned and potential (concept) systems for space-, surface- and subsurface- (land and ocean), and air-based observations, both for in-site and remote sensing techniques. It provides the associated time-line, status, location, costing, and programmatics of each system. It has have already identified/noted which of these systems are/will be contributing from NOAA's perspective to GEOSS.

It also includes observing system Environmental Parameter (EP) capabilities, which capture numerous associated specifications, including all those listed above for CORL plus additional ones to capture system level data. Each EP capability is linked to its observation system and specific instrument on the observation system.

The Information Management System (IMS) and the associated EP database captures specifications of further IMS systems (product processing, distribution, archiving systems, etc.) and their associated EPs as done for the above observation systems and EPs

Finally, there is the OR and Capabilities Analysis System (CAS) which, using the common NASA GCMD "Variable" (or if needed, more specific, 4-th level NOAA "Detailed Variable") matches each OR (from CORL) to the comprehensive current, planned and potential Observation and IM System capabilities. Once matched, it uses an OR Gap Assessment algorithm, including the attribute "weights", to assess the current, planned potential requirements satisfaction level for a given OR. This process can also be reversed to assess the utility score of one given Observation or IM System to the comprehensive list of ORs for a particular EP.

Table 1. The nine societal benefit areas identified by EOS-II (see Appendix 2 in GEO, 2005b).

Disaster:	reducing loss of life and property from natural and human-made disasters
Health:	understanding environmental factors affecting human health and well being
Energy:	improving management of energy resources
Climate:	understanding, assessing, predicting, mitigating, and adopting to climate variability and change
Water:	improving water resource management through better understanding of the water cycle
Weather:	improving weather information, forecasting, and warning
Ecosystems:	improving the management and protection of terrestrial, coastal, and marine ecosystems
Agriculture:	supporting sustainable agriculture and combating desertification
Biodiversity:	understanding, monitoring and conserving biodiversity

2.4 The GEO approach

The anticipated GEO approach to a user-driven system development and understanding user needs is summarized in Section 1 based on the information provided in the 10YIP Reference Document. Progress made since EOS-III is more difficult to assess. A critical assessment requires a preliminary assessment of the concept of CoPs and their success in making UNs available. The GEO UIC has the oversight of the tasks in the GEO Work Plan that have some involvement of user or are related to user needs. The UIC needs to facilitate progress towards a better understanding of user needs and the application requirements, and, therefor, assessing the GEO approach implies an assessment of the UIC work as well. Finally, we need to consider the status with respect to the capability to populate the UNSPU database.

As pointed out above, GEOSS is strongly focused on users in the nine SBAs identified by EOS-II (see Annex 2 in GEO, 2005b, for a list of the benefit areas, see Table 1). For these benefit areas, the Reference Document addresses the ORs in terms of observations or derived products versus a set of applications, and for each of these pairs, it states the current status of availability. Scanning through these observational requirements, a set of high-level requirements can be aggregated that is common to all or some of the SBAs (for examples, see Table 2).

3 Functional specifications for the UNSPU

The functions of the UNSPU in terms of database contents, editing functions, analysis functions, and update capabilities are described in an informal way. Formal functional specifications easily can be derived from these specifications.

The UNSPU shall have the following database components:

- Properties: registry of properties, that is variables and

Table 2. Examples of observational requirements as specified in GEO (2005b) for the nine SBAs. The examples are for geodetic observations or products derived from these observations. The variables and products and their observational status are extracted and aggregated from the respective tables in GEO (2005b). The status is indicated with the follow classes: 0: ok; 1: marginally acceptable accuracy and resolution; 2: could be ok within two years; 3: could be available in six years; 4: still in research.

Variable or products	Status
Deformation monitoring, 3-D, over broad areas	3
Subsidence maps	3
Strain and creep monitoring, specific features or structures	2
Gravity, magnetic, electric fields - all scales	3
Gravity and magnetic field anomaly data	2/3
Groundwater level and pore pressure	4-1
Tides, coastal water levels	1
Sea level	2-1
Glacier and ice caps	2
Snow cover	2
Moisture content of atmosphere/water vapor	2
Extreme weather and climate event forecasts	3
Precipitation and soil moisture	3-1

products that are related to the Earth system's state and trends;

- Users: registry of GEOSS user types, groups and classes;
- Applications: registry of applications using GEOSS observations and products;
- Requirements: list of quantitative requirements for GEOSS observations and products;
- Specifications: Specifications of system performance in terms of products and their characteristics;
- Techniques: registry of observation techniques, including the observed variables, accuracy, resolution, latency, reliability, availability, and status (research, operational);
- Observation: registry of observations available to GEOSS;
- Products: list of products (may include observations) made available through GEOSS services, including a quantitative characterization;

The UNSPU shall provide for the following link functions:

- the linkage of users to applications and applications to users;
- the linkage of applications to requirements and requirements to applications;
- the linkage of observations to products and products to observations;

The UNSPU shall provide the following edit functions for GEO members:

- registration of users;
- registration of applications;

The UNSPU shall provide for authorized administrators edit functions for the following components:

- Properties;
- Techniques;
- Requirements
- Observations.
- Systems;
- Products

The UNSPU shall provide the following analysis functions:

- identification of deviations of system performance from specifications;
- identification of requirements not met by products and applications not receiving the required products (gaps analysis);
- identification of users not able to utilize the full benefit of Earth observations.

4 GEOSS User Needs and System Performance database structure

4.1 Overview

A core element of the UNSPU is a database providing information on UNs, ORs, and SP. The structure of this database is illustrated in Figure 2. The database separates into two parts, with the user-related part describing the user types, applications, and requirements, and the system-related part describing the observations and products made available by the observation system. The system performance specifications, which are derived from the requirements, allow for a matching of these two parts against each other and thus facilitate a gap analysis and the identification of priorities.

The table that links the two parts together is the PROPERTIES table with the columns as defined in Table 3. In a sense, this table parametrizes the Earth system and specifies properties that are related to the Earth's state and variability or are necessary to describe the Earth system's state. The properties include both variables that can be observed directly and products that have to be derived, some times in a complex way, from observations. These properties can be so different as health indicators, local or regional land cover parameters, local, regional

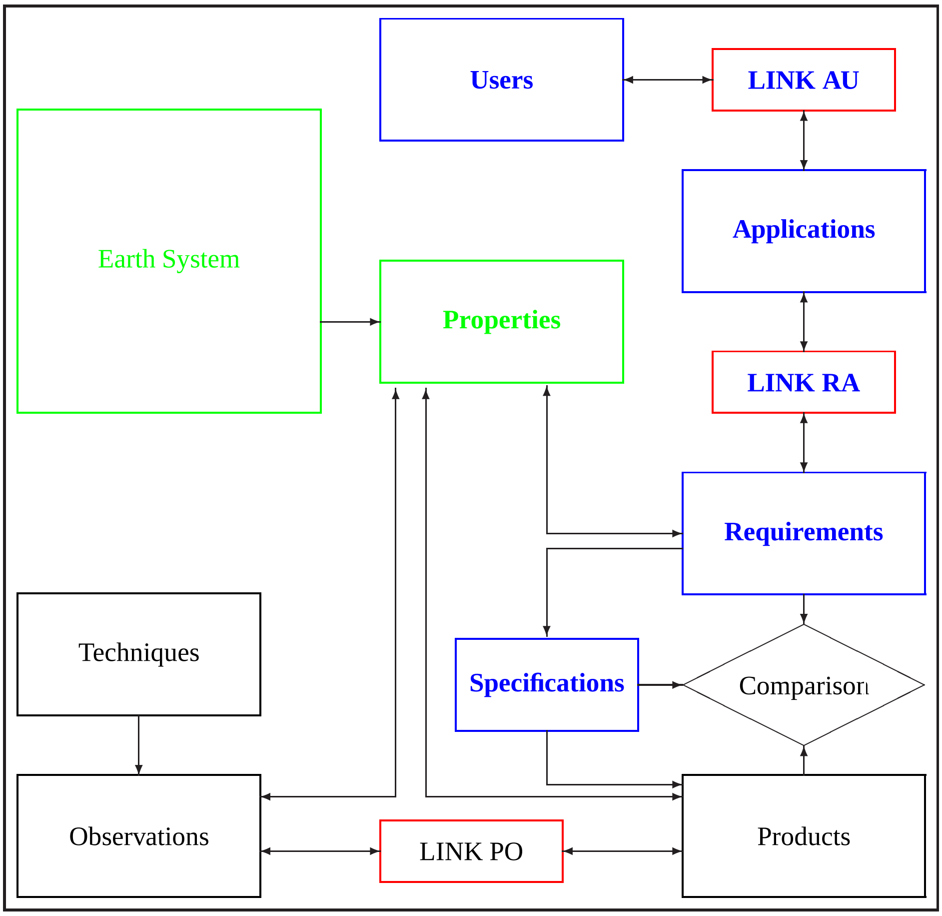

Figure 2. Overview of the UNSPU structure. The blue boxes indicate tables referring to users, applications and requirements. Black boxes stand for tables containing information on the techniques, observations and products that characterize the observing systems and its performance. The two green boxes symbolize the Earth system and the table containing the definitions of properties describing the Earth system. The red boxes are link tables providing the option to introduce multiple cross links between tables. The link table OP is introduced to allow for the same observations being linked to different products. The link table AU provides the flexibility to link an application to multiple users and vise versa. Similarly, the link table RA enables links of a requirement to multiple applications.

and global air temperatures, point coordinates, local and global sea levels, reference frames, coefficients in the Earth's gravity field representation, strain field, earthquake parameters, etc.

The ontology chosen to describe the properties will, to a large extent, determine the interoperability of the UNSPU with other databases. For the time being, it is recommended to adopt the Semantic Web for Earth and Environmental Terminology (SWEET) Ontology (see http://sweet.jpl.nasa.gov/) for entries in the PROPERTIES table.

In the user-related part, users are generically described in table USERS. Entries in this table refer to user types and classes, rather than individual specific users. Independent of users, applications are specified in table APPLICATIONS without specific reference to users. The links between users and applications are defined in a separate table LINKAU, which allows for a linking of an application to several users. Requirements are specified in terms of properties defined in the PROPERTIES table. In order to allow for a requirement to be linked to several applications, we introduced the link table LINKRA. It is important to note that requirements for properties do not necessarily translate directly into observational requirements.

At any given point in time, only a subset of the requirements will be possible to meet. Therefore, system specification for the observing system in terms of the parameters to be delivered, including their quantitative characteristics, will have to be agreed upon. It is these specifications that will provide the metric for assessing the system performance. The agreed upon specifications are compiled in table SPECIFICATIONS.

In the part related to system performance, the available observation techniques are specified in table TECHNIQUES. The techniques are linked to observations, which are compiled in the OBSERVATIONS table. The final products are listed in the PRODUCTS table and specified in terms of the properties defined in the PROPERTIES table. Since a given observation may be used for several products, and a product may require several observations, we introduce the link table LINKPO, which collects all the cross-links between observations and products.

The comparison of products, specifications and requirements can be done for individual properties or groups of properties. The link tables allow to construct the link between a given observation on the one hand and the applications and users that this observation serves on the other hand. Algorithms for the comparison can be rather complex, with the goals to assess the value of specific techniques and observations in terms of relevance for applications and users, and to identify specifications that are not met and requirements that are not served with the current observing system.

In the following, we first describe the tables in the user-related part and then those in the system-related part.

Table 3. Contents of table PROPERTIES. This table defines all properties consider in connection with the Earth system, which include directly observable variable as well as quantities derived from Earth observations. This table may have to be modified to be better adopted to the hierarchical nature of the SWEET Ontology, which should be the basis for any entry in this table. The columns for 'PROPERTY', 'REALM', and 'UNITS' should only allow entries already defined in SWEET.

No	Name	Description	Type	Key	Len
1	PROPERTY	Acronym identifing the property. This should be taken from the SWEET ontology.	Char	I	F
2	REALM	Earth realm to which this property pertains.	Char	F	F
3	DESCRIPTION	Brief description of property.	Char		V
4	REFERENCE	Reference to a comprehensive description.	Char		V
5	TYPE	Type of property (observable, derived, modeled)	Char/R		F
6	UNITS	Physical units of property, if applicable	Char/R		F

Table 4. Contents of table USERS. This table summarizes the main generic user types and user groups of Earth observations and derived products.

No	Name	Description	Type	Key	Len
1	USER	Acronym identifing the user type.	Char	I	F
2	DESCRIPTION	Description of user type.	Char		V
3	CLASS	User classes (e.g. scientific, governmental, education, commercial)	Char/R		F

4.2 The user-related tables

In order to allow for maximum flexibility, separate tables describe the user types, applications, and individual requirements in terms of Earth system related properties (observations and products). Relations that combine these tables are then defined in specific link tables.

The user types are described in the USERS table, with the columns of this table defined in Table 4. However, the entries in the USERS table give a description that is as far as possible generic, without identifying specific users. Users are linked to applications and through these applications to properties and requirements. The extent and type of users can be very variable. Some examples of users are *coastal zone managers*, *geophysicists*, *teachers*, *climatologists*, *scientists*, *offshore industry*, and *public health officers*.

The applications are described in the APPLICATIONS table with the columns of that table being defined in Table 5. Again, applications are as far as possible described in a generic way. Applications can be rather different in extent and nature. Examples of applications are *hydrology*, *numerical weather forecast*, *ocean circulation studies*, *surveying*, *outdoor activities*, *disaster prevention*, *early warning*, *fire fighting*, and *earthquake damage assessment*. Similar applications that have different requirements in terms of accuracy (e.g., point positioning for surveying and out-door activities) have to be specified as different applications. The definition and description of applications should, as far as possible, use a terminology consistent with the SWEET ontology.

The quantitative requirements in terms of properties are specified in the REQUIREMENTS table, for which the columns are given in Table 6. Each requirement is given for a property specified in the PROPERTIES table (see Table 3).

A simple LINKAU table (see Table 7) is then used to cross-link users and applications. Users can be linked to several applications, and applications to several users.

The link table LINKRA (see Table 8) associates applications given in the APPLICATIONS table (see Table 5) with requirements. An application can be linked to several requirements, and a requirement may be serving several applications.

4.3 System specifications

The system performance specifications are collected in one table, the SPECIFICATION table (Table 9). Specifications are conventional and detail what GEOSS is expected to provide concerning specific properties. In principle, the specifications are a subset of the requirements collected in the REQUIREMENTS table and summarize the consensus of the GEO community in terms of prioritization and expected system performance. Normally, specifications will be for a product and will be meeting a specific requirement.

4.4 The tables related to the observing system and its output

Products corresponding to the properties defined in the PROPERTIES table can be obtained in various ways, and their characteristics depend very much on how they actually were obtained. Some of the products will be closely related to observations (or even identical) while others will be the results of considerable modeling and analysing. Observations are obtained with certain techniques. Thus, the tables related to the observing system are TECHNIQUES, OBSERVATIONS, and PRODUCTS.

The observing techniques are compiled in the TECHNIQUES table (Table 11. There, techniques are described in

Table 5. Contents of table APPLICATIONS. This table summarizes the main generic application of GEOSS products.

No	Name	Description	Type	Key	Len
1	APPLICATION	Acronym identifing the application.	Char	I	F
2	FIELD	General field of application.	Char/R		F
3	DESCRIPTION	Description of Application.	Char		V
4	BENEFIT	Main Benefit area (SBA).	Char/R		V
5	ADD-BENEFIT	Other Benefit areas (SBAs).	Char/R		V
6	WEIGHT	Estimated weight in terms of relevance for the SBAs (in the range from 0 to 9)	Int/R		F
7	BC-RATIO	Benefit/Cost ratio	Real		F

Table 6. Contents of table REQUIREMENTS. This table provides an overview of the quantitative observation and product requirements.

No	Name	Description	Type	Key	Len
1	NUMBER	Identification of the requirement.	Char	I	F
2	DESCRIPTION	Description of requirements.	Char		V
3	TYPE	Type of requirements (general, target, threshold, ...).	CHAR/R		F
4	QUALITY	Quality of the requirement, e.g. firmly established, estimated, only qualitatively known	CHAR		F
5	PROPERTY	Property identification.	Char/R	F	F
6	SPAT_RES	Spatial resolution.	Real		F
7	TEMP_RES	Temporal resolution.	Real		F
8	REL_ACC	Relative accuracy.	Real		F
9	ABS_ACC	Absolute accuracy.	Real		F
10	TIME_ACC	Time accuracy, where applicable.	Real		F
11	LATENCY	Maximum latency.	Real		F
12	LENGTH	Length of record (time series) required for application.	Real		F
13	REF_FRAME	Reference frame (local, national, regional, global).	Char/R		F
14	REPRO	Reproducibility, i.e., time window over which the stated property is reproducible with the stated accuracy.	Char		F

a more generic way providing information on the main characteristics of the output of the technique. Technical details are kept at a minimum.

Physical quantities such as 3-d displacement, sea level, etc. can be measured with various techniques resulting in quite different properties. Even if we aim for a mainly generic description, the accuracy of the quantity depends very much on the observation technique used. For example, in local sea level measurements, a radar gauge has different properties from a bottom pressure gauge. Thus the observation SEA-LEVEL/R will have different characteristics than for example SEA-LEVEL/BP obtained with a bottom pressure sensor. And GPS has different accuracies and properties than SLR. Thus 3-D-DISP/SLR will have rather different characteristics from what 3-D-DSIP/GPS or 3-D-DISP/GLONASS would have.

For the example 3-D displacements, a product that could be directly linked to application could be '3-D-displacement time series' and depending on the way the time series are created, the product would have rather different characteristics that may or may not meet the requirements for a particular application.

In order to account for this situation, we propose initially two tables. The OBSERVATIONS table with the structure as defined in Table 10 compiles all observations that are available in the system in a generic way. In this table, the column OBSERVATION identifies a given observations, e.g. *SEA LEVEL/BP*, for which the TECHNIQUE could be *Pressure Gauge* (which has to be defined in the separate TECHNIQUES table, see Table 11), while PROPERTY would give the actual goal of the observations, e.g. the variable *Local Sea Level*. All properties referred to need to be first defined in the PROPERTIES Table (Table 3. All other columns would refer to this variable, not to the measured quantity (which in our example is bottom pressure).

In the PRODUCTS table, the available products are listed, and this table has the columns as given in Table 13. An example related to the above example would be the product 'Monthly Mean Sea Level Time Series', or 'Hourly Sea Level Time Series' or 'Real time 3-D displacements'.

Products can be based on several observations while observations can be used to produce several products. Therefore, the link table LINKPO (Table 12) compiles all the links between products and observations and visa versa.

Table 7. Contents of table LINKAU. This table links applications to users.

No	Name	Description	Type	Key	Len
1	APPLICATION	Application identification	Char	F	F
2	USER	User identification	Char	F	F
3	DESCRIPTION	Description of link	Char		V
4	TYPE	Type of link (primary, inverse, ...)	Char/R		F

Table 8. Contents of table LINKRA. This table links requirements to applications.

No	Name	Description	Type	Key	Len
1	REQUIREMENT	Requirement identification	Char	F	F
2	APPLICATION	Application identification	Char	F	F
3	DESCRIPTION	Description of link	Char		V
4	TYPE	Type of link (primary, inverse, ...)	Char/R		F

Table 9. Contents of table SPECIFICATIONS. This table provides the specification of the agreed upon expected performance of GEOSS.

No	Name	Description	Type	Key	Len
1	SPECIFICATION	Acronym identifying the specification	Char	I	F
2	PRODUCT	Identification of a product	Char	F	F
3	REQUIREMENT	Requirement identification	Char	F	F
4	DESCRIPTION	Description of specification	Char		V
5	LEVEL	Level of requirements (mandatory, desirable, optional, ...)	Char/R		F

Table 10. Contents of table OBSERVATIONS. This table gives an overview of the observations currently carried out by the observational infrastructure in GEOSS.

No	Name	Description	Type	Key	Len
1	OBSERVATION	Acronym identifing the observation.	Char	I	F
2	TECHNIQUE	Specifying the observation technique.	Char	I	F
3	PROPERTY	Key of property determined.	Char	F	F
4	DESCRIPTION	Description of the observation.	Char		V
5	UNITS	Physical units of observation	Char/R		F
6	SPAT_RES	Spatial resolution.	Real		F
7	TEMP_RES	Temporal resolution.	Real		F
8	REL_ACC	Relative accuracy.	Real		F
9	ABS_ACC	Absolute accuracy.	Real		F
10	TIME_ACC	Time accuracy, where applicable.	Real		F
11	LATENCY	Latency of the observation.	Real		F
12	LENGTH	Length of record (time series) available.	Real		F
13	REF_FRAME	Reference frame (local, national, regional, global).	Char/R		F
14	REPRO	Reproducibility, i.e. time window over which the stated quantity is reproducible with the stated accuracy.	Char		F

Table 11. Contents of table TECHNIQUES. This table gives an overview of the techniques currently available to GEOSS through the individual observing systems.

No	Name	Description	Type	Key	Len
1	TECHNIQUE	Acronym identifying the specification	Char	I	F
2	OUTPUT	Description of output parameter(s)	Char		V
3	REFERENCE	Reference to a description of the technique	Char		V
4	STATUS	Status of technique (operational, research, proposed)	Char/R		F

Table 12. Contents of table LINKPO. This table links products and observations.

No	Name	Description	Type	Key	Len
1	PRODUCT	Product identification	Char	F	F
2	OBSERVATION	Observation identification	Char	F	F
3	DESCRIPTION	Description of link	Char		V
4	TYPE	Type of link (primary, inverse, ...)	Char/R		F

Table 13. Contents of table PRODUCTS. This table provides an overview of the products currently available quantitative user requirements for quantities and derived products.

No	Name	Description	Type	Key	Len
1	PRODUCT	Acronym identifing the products.	Char	I	F
2	DESCRIPTION	Description of products.	Char		V
3	PROPERTY	Identification of the property.	Char	F	F
4	TYPE	Type of products (observable, derived, modeled)	Char/R		F
5	UNITS	Physical units of product	Char/R		F
6	SPAT_RES	Spatical resolution.	Real		F
7	TEMP_RES	Temporal resolution.	Real		F
8	REL_ACC	Relative accuracy.	Real		F
9	ABS_ACC	Absolute accuracy.	Real		F
10	TIME_ACC	Time accuracy, where applicable.	Real		F
11	LATENCY	Latency of the product.	Real		F
12	LENGTH	Length of record (time series) available.	Real		F
13	REF_FRAME	Reference frame (local, national, regional, global).	Char/R		F
14	REPRO	Reproducibility, i.e., time window over which the stated quantity is reproducible with the stated accuracy.	Char		F

5 Data model based on the Value-Chain concept

To be added

6 Methodology for the identification of user needs and observation requirements

To be added

7 GEOSS User needs

To be added

8 GEOSS System Performance

To be added

9 Conclusions

A comprehensive database providing information on user needs, applications and theior requirements, as well as system performance in terms of the products provided is of considerable value for the planning, implementation and further development of GEOSS. The establishment of such a database will not only provide a better knowledge of the users of GEOSS products and their needs but also provide guidance for the development of GEOSS towards meeting these needs.

Combinig this database with the ability to analyse to which degree the products provided by GEOSS meet the users need and the application-specific requirements would provide a powerful tool for GEO to identify observation gaps and set priorities for the development of new GEOSS components and the improvements of existing ones.

References

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Table 14. Structure of database sheets.

Name of Column	Explanation of content
No.	Number of attribute within structure
Name	Short name of the attribute
Description	Explanatory description of the attribute
Type	Data type and domain of the attribute
Key	Key type of attribute
Len	Length of input field in characters

Table 15. Different data types.

Abbrev.	Explanation
Char	Data type is 'ASCII-String'
Int	Data type is 'Integer number'
Real	Data type is 'Real number'
Sw	Data type is 'Logical', i.e. either T of F
Date	Date type is 'Calender data', i.e. yyyy-mm-dd-hh-mm-ss with the time being optional.
Vect/n	Vector of dimension n, given as n-tuple '(x1,x2,...,xn)'
Geo	Data type is 'Geographical Coordinate', i.e. a real number between -90. and 90. for latitude (negative numbers being S) and -180. to 180. for longitude (negative numbers being W)
Phone	Data type is 'Phone number', i.e. a string containing a leading + for international number, '(', and ')' to indicate the part to be omitted for international calls, '-' to separate parts of the number, 'x' to indicate that the following part is an extension, and the numbers from 0 to 9.
File	File name, given as a string
URL	Data type is 'URL'. Currently, the URL syntax is not checked, is for future use.
EMA	Data type is 'E-mail address'. Currently syntax is not checked. For future use.
IP-Ad.	Data type is an IP address. For future use.

A Syntax of table sheets

The structure of a table is displayed in a fixed tabular form. It consists of the columns described in Tab. 14.

The attribute numbers are just used within this text for reference purposes. The short names are provided for use in a database program for screen masks, while the descriptions may be used in help functions and documentations.

Each attribute has a certain scalar data type, which to a large extent determines the input allowed for this attribute. The data type is indicated by an abbreviation. These have the meanings given in Tab. 15

The domain of an attribute may be the complete set of a

Table 16. Data domain restrictions.

Value	Explanation of domain restrictions
R	Domain of attribute is restricted to certain discrete values of the corresponding data type. For each such attribute, a list of the allowed values must be given.
I	Domain of attribute is restricted to an interval contained in the complete domain of the corresponding data type.
D	Domain is dynamic, i.e. this attribute is a foreign key.

Table 17. The different key types.

Value	Explanation
I	Attribute is an identification key, i.e. it must be unique within the whole database
S	Attribute is a secondary identification key, i.e. it must be unique in combination with an identification key
F	Attribute is a foreign key, linking the present table to a higher level table. The domain of such a key is always dynamic.

data type or it may be a subset. The subset is specified by a one letter abbreviation separated from the data type by a slash. The abbreviations currently used are given in Tab. 16, and the key type of an attribute are listed in Tab. 17.

If the entry for Length is a 'V', the item has variable length and the input/output fields are increased to the size actually needed. If the entry is 'F', then the length is fix, though the maximum size is not yet specified.

B definitions

Properties: Properties are variables associated in any form with the Earth system. These variable may be observable or only accessible/determinable through a complex analyses of combinations of observations and models. Examples of Properties are ...

Users: Users are persons or organizations that make use in any form of Earth observations, derived products or higher level information derived on the basis of Earth observations. Examples of users are ...

Applications: Applications are activities that require, in any form, input of Earth observations, products based on Earth observations, or information fully or partly derived from Earth observations. Examples of applications are ...

Requirements: Requirements are statements that define the quantitative and, in some case, qualitative characteristics of properties. The quantitative characteristics that may be defined include accuracy, precision, spatial and temporal resolution and coverage, latency, and availability. The qualitative characteristics include ..

Products: Products are observations or the output of the analysis of observations, often in combination with models. Products are linked to properties.

Specifications: Specifications define the desired characteristics of products using the same syntax as for requirements. Specifications give agreed-upon expectations for the system performance with respect to the output.

Observations: Observations are the output of observation techniques. Examples of observations are ...

Techniques: Techniques are tools that provide observations of properties related to the Earth system. Examples of techniques are ...

C Acronyms

10YIP 10-Year Implementation Plan

ADC Architecture and Data Committee

CAS Capabilities Analysis System

CEOS Committee on Earth Observation Satellites

CoP Communities of Practice

CORL Consolidated Observation Requirements List

EEA European Environment Agency

EOS Earth Observation Summit

EP Environmental Parameter

GAGOS Assessing and forward planning of the Geodetic and Geohazards Observing Systems for GMES applications

GCOS Global Climate Observing System

GGOS2020 The Global Geodetic Observing System: Meeting the Requirements of a Global Society on a Changing Planet in 2020

GOOS Global Ocean Observing System

GTOS Global Terrestrial Observing System

ICSU International Council for Science

IGBP International Geosphere-Biosphere Programme

IGOS-P Integrated Global Observing Strategy Partnership

IMS Information Management System

NASA National Aeronautics and Space Administration

NOAA National Oceanic and Atmospheric Administration

OR Observation Requirement

ROD Reporting Obligations Database

RRR Rolling Review of Requirements

SBA Societal Benefit Area

SP System Performance

SWEET Semantic Web for Earth and Environmental Terminology

UIC User Interface Committee

UN User Need

UNEP United Nations Environmental Programme

UNSPU User Needs and System Performance Utility

UNOOSA United Nations Office for Outer Space Affairs

WCRP World Climate Research Programme

WMO World Meteorological Organisation