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IMPACT MONITORING
OF MINERAL RESOURCES
EXPLOITATION

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WP4/5 – SATELLITE/LIGHTWEIGHT AERIAL REMOTE SENSING

DELIVERABLES D4.2 & D5.2 REPORT ON THE COMPLIANCE WITH THE RELEVANT GEO TASKS

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SEVENTH FRAMEWORK PROGRAMME

Table of contents

List of figures

List of tables

Abbreviations

CEN	Comité Européen de Normalisation
CEOS	Committee on Earth Observation Satellites
CSW	Catalogue Services for the Web
EC	European Commission
EO	Earth Observation
ESRI	Environment System Research Institution
ETPSMR	European Technology Platform on Sustainable Mineral Resources
GEO	Group on Earth Observations
GEPW	GEO European Projects Workshop
GIGAS	GEOSS, INSPIRE and GMES an Action in Support
GMES	Global Monitoring of Environmental Security
GML	Geographic Markup Language
GEOSS	Global Earth Observation System of Systems
ISO	International Organization for Standardization
KML	Keyhole Markup Language
OGC	Open Geospatial Consortium
QA4EO	Quality Assurance for Earth Observation
QC/QA	Quality Control/Quality Assurance
SBA	Societal Benefit Area
SDI	Spatial Data Infrastructure
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service
WSSD	World Summit on Sustainable Development

1 INTRODUCTION

The objective of the ImpactMin project is to develop new methods and a corresponding toolset for the environmental impact monitoring of mining operations using Earth Observation (EO). In Work Package 4 and 5 the basis for this development is laid by generating a scientific knowledge pool of methods derived from mineral resources exploration methods, satellite and airborne EO environmental monitoring techniques and by ‘translating’ research results from other field of science with a possible applicability in ImpactMin.

This report gives an overview of existing standards, directives and guidelines for data formats, procedures, data sharing etc. and formulates recommendations for the ImpactMin project.

The structure of this report is as follows: Chapter 2 describes GEO and GEOSS and how ImpactMin can contribute to and benefit from these international initiatives. Chapter 3 gives an overview of existing standards, directives and guidelines. Examples of the implementation of standards are described in Chapter 4. In Chapter 5, recommendations for the ImpactMin project, based on GEO(SS) and standards for data formats, data processing and data sharing are listed. Finally, Chapter 6 contains the compliance assessment with existing standards and practices.

The main contributor to this report is Geonardo Ltd. Input to this report was given by Geosense and VITO.

2 GEO(SS) AND IMPACTMIN

2.1 GEO and GEOSS

The Group on Earth Observations (GEO) is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS[1]. GEO was launched in response to calls for action by the 2002 Johannesburg World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.

GEO is a voluntary partnership of governments and international organizations. It provides a framework within which these partners can develop new projects and coordinate their strategies and investments. As of October 2010, GEO's Members include 85 Governments and the European Commission. In addition, 61 intergovernmental, international, and regional organizations with a mandate in Earth observation or related issues have been recognized as Participating Organizations.

GEO is constructing GEOSS on the basis of a 10-Year Implementation Plan for the period 2005 to 2015. The Plan defines a vision statement for GEOSS, its purpose and scope, expected benefits, and the nine "Societal Benefit Areas" (SBAs) of disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity.

GEOSS will yield a broad range of societal benefits, notably:

- Reducing loss of life and property from natural and human-induced disasters;
- Understanding environmental factors affecting human health and well-being,
- Improving the management of energy resources,
- Understanding, assessing, predicting, mitigating, and adapting to climate variability and change,
- Improving water resource management through better understanding of the water cycle,
- Improving weather information, forecasting and warning,
- Improving the management and protection of terrestrial, coastal and marine ecosystems,
- Supporting sustainable agriculture and combating desertification, and
- Understanding, monitoring and conserving biodiversity.

GEOSS coordinates a multitude of complex and interrelated issues simultaneously. This cross-cutting approach avoids unnecessary duplication, encourages synergies between systems and ensures substantial economic, societal and environmental benefits.

The transverse areas of GEOSS are:

- Capacity building: strengthening human skills, institutional capacities and infrastructure
- Architecture and data: information exchange and integrated data and information products
- Science and technology: generation of comprehensive, near-real-time and integrated Earth observation data and information
- User Interface: engage a large variety of mutually interdependent users

[1] www.earthobservations.org

Figure 2-1 The Global Earth Observation System of Systems

A concrete example of a proactive approach to engage the science community in GEOSS through international research programmes is that introduced by the European Commission under the environment theme of the European Commission 7th Framework Programme (EC FP7).

The Global Earth Observation System of Systems will provide decision-support tools to a wide variety of users. As with the Internet, GEOSS will be a global and flexible network of content providers allowing decision makers to access an extraordinary range of information at their desk.

This 'system of systems' will proactively link together existing and planned observing systems around the world and support the development of new systems where gaps currently exist. It will promote common technical standards so that data from the thousands of different instruments can be combined into coherent data sets. The 'GEOPortal' offers a single Internet access point for users seeking data, imagery and analytical software packages relevant to all parts of the globe. It connects users to existing data bases and portals and provides reliable, up-to-date and user friendly information – vital for the work of decision makers, planners and emergency managers. For users with limited or no access to the Internet, similar information is available via the 'GEONETCast' network of telecommunication satellites.

The GEOSS Common Infrastructure allows the user of Earth observations to access, search and use the data, information, tools and services available through the Global Earth Observation System of Systems. The infrastructure consists of four main elements:

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

vital to the ability of GEOSS to function as a true system of systems and to provide integrated and cross-cutting information and services. Contributors can also share ideas and proposals informally via the associated *Standards and Interoperability Forum*.

- The *Best Practices Wiki* provides the GEOSS community with a means to propose, discuss and converge upon best practices in all fields of earth observation.

Each element of the GEOSS Common Infrastructure has been contributed by GEO Members and Participating Organizations. Their commitment and generosity in assuring its operation and continuity will remain vital to the success of GEOSS.

2.2 GEO(SS) and ImpactMin

The objective of the ImpactMin project is to develop new methods and a corresponding toolset for the environmental impact monitoring of mining operations using Earth Observation (EO). One particular aim of ImpactMin is to assess the possibilities of existing earth observation tools and instruments for environmental impact monitoring of mineral mining. The tools and instruments will be tested at different demo-sites. While developing, attention will be paid to existing standards and protocols, in order to identify a framework for data acquisition, processing, interpretation and sharing. Moreover, ImpactMin intends to apply quality control and quality assurance (QC/QA) procedures for in-situ, airborne and spaceborne data acquisition and integrated data processing. One of the key objectives of GEO is the optimization of observations and information for understanding and predicting environmental phenomena, including the integration of various sources of data. This integration of in-situ, airborne and spaceborne data is one of the key components of ImpactMin. The outcomes of the project can contribute to GEO(SS) in different societal benefit areas. Vice versa, the knowledge gained by and made available through GEOSS can guide ImpactMin developments and the ImpactMin consortium can therefore benefit from the information provided by the GEO Portal.

2.2.1 GEOSS Societal Benefit Areas and ImpactMin

GEO targets 9 Societal Benefit Areas. GEOSS points towards a future wherein decision making is based on coordinated, comprehensive and sustained Earth Observation and information. Moreover, in the implementation of GEOSS, increased sharing of methods for modeling and analysis needed to transform data into useful products will be advocated. The toolset of EO can aid decisions and thus it can have positive impacts on lives of people in the society.

Mineral mining activities can have negative impacts on the environment. In deliverables D4.1 and D5.1, the environmental variables associated with mining activities, and to some extent detectable with satellite and airborne earth observations, were identified. Direct impacts include: weathering of minerals, acid mine drainage and ferruginous materials, atmospheric pollution, temperature increments. Indirect variables include land use and land cover change, vegetation stress, changes in soil moisture and groundwater environment, and subsidence.

The relation between mining and society is getting more focus lately. Society needs minerals for every day live and the mining sector needs to respect the environment and the needs of the affected society by the operation of mines and processing plants. Negative mining related impacts get attention by the media and this is reflected in people's perception towards the extraction industry. Nevertheless, mining used to operate with less control for decades. Nowadays there are several “codex” to follow regarding Corporate Social Responsibility (ImpactMin deliverable D3.1).

In order to contribute to GEOSS, it is important to identify the societal benefit areas addressed by the ImpactMin project. There is no clear Mineral Resources GEO Task. However, a number of SBAs would benefit from the development of observation and analysis tools for exploration and exploitation of Mineral Resources. It is evident that mining is associated with geohazards (disasters), health conditions and ecosystem alteration. Thus during ImpactMin the Consortium will focus on the following Societal Benefit Areas: “Disasters”, “Health” and “Ecosystems”.

a. Disasters

"Reducing loss of life and property from natural and human-induced disasters"

Disaster-induced losses can be reduced through observations relating to hazards such as: wild land fires, volcanic eruptions, earthquakes, tsunamis, subsidence, landslides, avalanches, ice, floods, extreme weather, and pollution events. GEOSS implementation will bring a more timely dissemination of information through better coordinated systems for *monitoring*, *predicting*, *risk assessment*, *early warning*, *mitigating*, *responding* to hazards and *recovery* at local, national, regional, and global levels.

Recognizing and identifying the risks of mining operations can be crucial in order to reduce the severity of hazards (number of accidents, mitigate the losses). Also a proper, reliable monitoring system can aid better mine site management and enable authorities to control more efficiently and to support decision making processes. Timely information on the status of the mining environment can have an impact on the prevention or response in case of a "catastrophe".

In the ImpactMin project, tools for environmental monitoring of impacts and recovery will be developed and tested at different demo-sites. The objective is to generate reliable, repeatable and systematic observation and monitoring systems. The project therefore contributes to better coordinated monitoring system at local level.

The project will address "Disaster" related research at each of the demonstration sites. In deliverables D4.3 and D5.3, specific products of demo-site implementation were identified. For example, for all demo-sites, the extent of polluted areas (surface perturbation and minerals) will be determined. In the specific case of the Mostar demo-site, the success of clean-up and stabilization efforts after mine closure will be monitored. Acid mine drainage will be monitored in Mostar, Rosia Montana, Karabash and Mednogorsk. Surface perturbation impacts of mining are limited in space, however, other impacts can have a larger extent. Depending on the magnitude and spatial extent of environmental alteration, the best suitable satellite image data source will be chosen. It will also be a challenge to integrated different sources of data (in-situ, airborne and spaceborne). By making it possible to integrate different types of disaster-related data and information from diverse sources, GEOSS aims to strengthen analysis and decision making for disaster response and risk reduction.

ImpactMin can contribute to the following Disaster Work Plan Tasks:

Systematic Monitoring to Support Geohazards Risk Assessment (DI-09-01)

Implementation of a Multi-Risk Management Approach (DI-09-02a)

Use of Satellites for Risk Management (DI-06-09)

b. Health

"Understanding environmental factors affecting human health and well-being"

The Group on Earth Observations is working with the Health community to improve the flow of user-friendly environmental data. Comprehensive data sets support prevention, early warning, research, health-care planning and delivery, and timely public alerts. Gathered and distributed through the Global Earth Observation System of Systems, these Earth observation data contribute to improving our understanding of how the environment affects human health and well-being. Key variables include airborne, marine, and water pollutants; stratospheric ozone depletion; land-use change; persistent organic pollutants; food security and nutrition; noise levels; weather-related stresses and disease vectors; and many others.

In general, (human induced) airborne and water pollution (e.g. resulting from mining activity) can have a consequence directly or indirectly on human health and/or well-being. The magnitude of the impact is usually correlated with the distance between the polluting source and the community which is affected, but the effects are also dependent on the significance of the pollution.

Pollution of the atmosphere in mining areas can be complex, as it is often not just a phenomenon restricted to the mining itself, but also extends to activities around the mine, such as refining, smelting, other related industries, and human settlement. The spatial extent this type of pollution by far exceeds the scale of other types of mining-related pollution. Fine dust particles can be transported over tens of kilometers, whereas transport of aerosols can take place over many hundreds of kilometers. Mineral mining can cause water pollution: surface waters are affected by acid mine drainage, and elevated sediment concentrations and its chemical composition can have toxic effects on vegetation, animals and humans.

As an example, air pollution affects the health status of the community near the Karabash mine and processing plant (Russia – ImpactMin report D3.1 and D4.1) directly, by breathing polluted air, and indirectly, by consumption of crops grown on contaminated soils.

Beside the statistical data available about a community health status, EO measures can be utilized to reveal the link between environment and health data. In-situ measurements and remotely sensed data sets can determine the possible extent of pollution which in turn can aid decision making on regional or local level. EO instruments can be important tools to quantify possible effects and determine the spatial scale of health risks.

ImpactMin can contribute to the following Disaster Work Plan Tasks:

Information Systems for Health (HE-09-01)

Monitoring and Prediction systems for Health – sub-task a 'Aerosol Impacts on Health and Environment: Research, Monitoring and Prediction' (HE-09-02)

c. Ecosystems

"Improving the management and protection of terrestrial, coastal and marine resources"

Terrestrial, coastal and marine ecosystems provide essential socio-economic and environmental benefits. Ecosystems the world over, however, are under tremendous stress from rapid land-use change, pollution and the overexploitation of natural resources. In particular, GEO is improving spatial information on ecosystem conditions and trends. Observations are needed on the area, condition, and natural-resource stock levels of ecosystems such as forests, rangelands, and oceans. GEOSS implementation will seek to ensure that methodologies and observations are available on a global basis to detect and predict changes in ecosystem condition and to define resource potentials and limits. Ecosystem observations will be better harmonized and shared, spatial and topical gaps will be filled, and in situ data will be better integrated with space-based observations. Continuity of observations for monitoring wild fisheries, the carbon and nitrogen cycles, canopy properties, ocean color, and temperature will be set in place.

Surface mining has serious consequences on vegetation (land use) and morphology by altering the natural settings of an area. Even underground operations can have impacts above ground (waste, subsidence, change in groundwater environment). Direct effects like land use changes are well identifiable with EO tools.

ImpactMin will address "Ecosystems" related research at each of the demonstration sites. In deliverable D4.3, specific products of demo-site implementation were identified. Both in Rosia Montana, Karabash and Mednogorsk, spatial gradients of vegetation stress caused by acid mine drainage along pathways (in Rosia Montana) or by atmospheric pollution (Karabash and Mednogorsk) will be investigated. Time series of satellite imagery will be used to monitor natural recovery of vegetation in the Mostar mining area. Also in Karabash and Mednogorsk, time series will be analyzed to monitor the evolution of vegetation and vegetation stress.

ImpactMin can contribute to the following Disaster Work Plan Tasks:

Human Dimension of Ecosystem Utilization and Conservation (EC-09-02)

2.2.2 GEOSS Transverse Areas and ImpactMin

There are four Transverse Areas: user engagement, architecture, data management and capacity building, which cut across, and are relevant to, each of the Societal Benefit Areas.

The User Interface Committee engages users in the nine societal benefit areas in the development, implementation, and use of a sustained GEOSS that provides the data and information required by user groups on national, regional and global scales. The specific goal is to address cross-cutting issues by coordinating user communities of practice, ensuring continuity and avoiding duplication.

The Architecture and Data Committee supports GEO in all architecture and data management aspects of the design, coordination, and implementation of the Global Earth Observation System of Systems (GEOSS) for comprehensive, coordinated, and sustained Earth observations.

The Science and Technology Committee engages the scientific and technological communities in the development, implementation and use of a sustained GEOSS in order to ensure that GEO has access to sound scientific and technological advice.

Finally, the Capacity Building Committee supports GEO in strengthening the capability of all countries, in particular developing countries, to use Earth observation data and products in a sustainable manner and to contribute observations and systems to GEOSS. The GEO capacity building strategy follows the World Summit on Sustainable Development (WSSD) concept of a global partnership between those whose capacity needs development and those who are able to assist in the process, recognizing that activities have intertwined social, environmental, and economic impacts.

ImpactMin can contribute to some of the transverse areas:

GEOSS Common Infrastructure (AR-09-01)

Data Management (DA-09-01)

Capacity Building Needs and Gap Assessment (CB-09-04)

2.2.3 GEOSS Common Infrastructure and ImpactMin

GEOSS will be a global and flexible network of content providers allowing decision makers to access an extraordinary range of information at their desk. This ‘system of systems’ will proactively link together existing and planned observing systems around the world and support the development of new systems where gaps currently exist. The GEOSS Common Infrastructure allows the user of Earth observations to access, search and use the data, information, tools and services available through the Global Earth Observation System of Systems.

For the ImpactMin project, it will be interesting to search the ‘GEOPortal’[2] for existing data, imagery and analytical software packages that might contribute to reach the project objectives. On the other hand, ImpactMin might actively contribute to the GEOSS Common Infrastructure by providing database access and by registering to the GEOSS Component and Services Registry. Also, practices can be sent in for review in the Best Practices Wiki[3].

GEOSS relies on what is available on the field of Earth Observation. However, until now different players were functioning on their own without addressing interoperability and transparency in general.

Many international standards are related to GEOSS. Some of these (ISO, OGC, etc.) are described in the next chapter. The Open Geospatial Consortium provides standards and solutions for location based information. GEOSS Common Infrastructure is highly based on the outcomes of ISO and OGC.

The cornerstones of GEOSS common infrastructure are:

- ISO standards for geographic information
- OGC standards for geospatial services
- GEOSS data sharing principles.

[2] www.geoportal.org
[3] http://wiki.ieee-earth.org

In the frame of Impactmin, the ISO 19100 series of standards and the Architecture Implementation Pilot (AIP) by the Open Geospatial Consortium (OGC) is studied and described in §3.1.3 p.16.

Each of the cornerstones were analyzed separately with the aim of synthesizing useful information for the application in the ImpactMin project. For each item the possibility of implementation will be evaluated, with the objective of making ImpactMin data and map products as far as possible compatible with GEOSS. To which extent archived or newly acquired data or generated products can be made available will be studied, but this depends on local policies of data providers and countries. A more technical aspect should be bearded in mind regarding the utilization of data and information provided by the Consortium. Web service specifications will determine significantly how accessible the data or generated information products are.

The following are the GEOSS data-sharing principles:

- There will be full and open exchange of data, metadata and products shared within GEOSS, 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 being free of charge or no more than cost of reproduction will be encouraged for research and education.

The possibility to contribute to the GEOSS Component and Service Registry and GEOSS Standards and Interoperability Registry will only be decided when the implementation of the ImpactMin project will be in mature stage, to allow the consortium to envisage what are the outcomes of the project with regard to tools and services and data or map products.

3 OVERVIEW OF EXISTING STANDARDS, DIRECTIVES AND GUIDELINES

3.1 Standards

In order to share data in a harmonized manner, the Open Geospatial Consortium (OGC), the European Committee for Standardization (CEN) and the International Standards Organization (ISO) established various standards. The following chapter contains an overview of the main standardization organizations and their work.

3.1.1 ISO/TC 211 Geographic Information/Geomatics

ISO is a nongovernmental organization that aims to develop standards bridging the public and private sector. The activity of ISO has an influence on almost every field, meeting the broader needs of society. ISO/TC 211 has developed a set of standards that relate to information technology and geographic information society (ISO 19000 series of standards).

Experts delegated from respected organizations jointly consider existing procedures, formats and IT infrastructure and contribute as such to the ISO standard developments.

The objective of the ISO/TC 211 is to integrate information technology and geographic information to stimulate *interoperability and transparency* of spatial information. ISO data models and operators are shaping how the globe and geographic features and their spatial characteristics should be treated.

Standards dealing with *data administration* give guidance about the quality principles of GI datasets, views on their descriptive information, including metadata and on how to spatial reference them generally.

Primary the following ISO standards were considered valuable for ImpactMin purposes:

ISO 19101-2:2008 Reference model – Part 2: Imagery

ISO 19111:2007 Geographic information – Spatial referencing by coordinates

ISO 19111-2:2009 Geographic information – Spatial referencing by coordinates -- *Part 2*

ISO 19113:2002Geographic information – Quality principles

ISO 19114:2003 Geographic information – Quality evaluation procedures

ISO 19115:2003 Geographic information – Metadata

ISO 19115-2:2009 Geographic information – Metadata -- *Part 2*

ISO 19131: 2007 Geographic information – Data product specifications

ISO 19138: 2006 Geographic information – Data quality measures

In the list above there are standards that aid operational work of ImpactMin (e.g. choosing the appropriate coordinate system for integrated data handling) and some determine, how the Project formulates its concept in order to make a link towards information technology and geographic information society. The ISO 19101-2:2008 – Part 2: Imagery standard helps to keep track with the overall objective of ImpactMin (e.g. develop tools and services) and other standards serve as “frame” to generate useful and applicable products. In the following table the standards had been put in a structure where will be employed in during the Project flow.

Table 3-1 ImpactMin data flow

Planning procedures and data acquisition	Processing and analysis	Delivery (ImpactMin data and map products) - Data sharing
19101 - Part 2: Imagery *19111- Spatial referencing by coordinates* *19115 – Metadata*	*19113 - Quality principles* *19114 – Quality evaluation procedures* 19138 – Data quality measures	*19115 – Metadata* 19131 – Data product specifications

a. Technical specification – Imagery (ISO 19101 - 2)

ImpactMin intends to analyze and create knowledge primary from remote sensed imagery. This can be described as a stepwise process (Figure 3-1). [describe figure and translate to ImpactMin]

Geographic information – imagery – are frequently acquired, processed and analyzed in open distributed manners (different companies, organization etc.). The main objective of ImpactMin is to help this widespread process become integrated by providing geolocated information (GI) from imagery (satellite/airborne) in a way to help digitally represent the Earth, and to support critical decisions for the benefit of the society. To be part of the integration process there are certain protocols that should be followed while ImpactMin partners investigate the topic of the project along the below table:

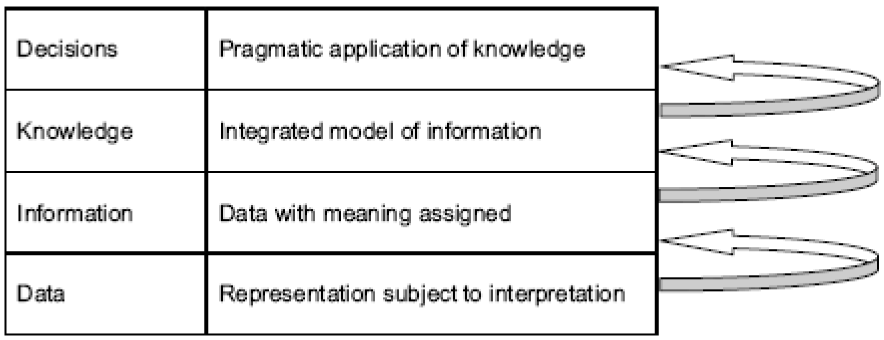

Figure 3-1 ISO 19101-2:2008 Reference model – Part 2: Imagery

In case of ImpactMin project it practically means (modify a little): 2 stepwise approaches

PREPARATION:

environment phenomena → IMPACTS → observables → detection methods

PROCESS:

satellite imagery (= DATA) → results/outcomes (= INFORMATION) → analysis (= KNOWLEDGE) → benefits (= DECISIONS)

b. Coordinate systems (ISO 19111)

It contains general guidelines to design a suitable referencing system by coordinates (Coordinate reference system, coordinate system, datum package) and define a minimum data required to define a 2 or 3D spatial coordinate reference system.

c. Quality principles and Quality evaluation procedures (ISO 19113, 19114)

The fundamental of quality evaluation procedures (and principles) are laid down in two ISO standards: 19113 and 19114.

The principles for describing the quality of the geographic data (imagery or map data products) should follow a very simple scheme to be compliant with ISO and generally conform to general procedure on the field of geospatial data management:

I. Identify quality information → II. Evaluate quality → III. Report quality information

Below there is a list of quality element subtracted from the standard :

Non-quantitative quality information (data quality overview elements):

- purpose
- usage
- lineage

Quantitative quality information (data quality elements and subelements):

- Completeness (commission, omission)
- Logical consistency (conceptual, domain, format, topological)
- Positional accuracy (absolute or external, relative or internal, gridded data position)
- Temporal accuracy (accuracy of time measurement, temporal consistency, temporal validity)
- Thematic accuracy (classification correctness, non-qualitative attribute correctness, quantitative attribute accuracy)

Description of data quality subelements:

- data quality scope;
- data quality measure;
- data quality evaluation procedure;
- data quality result;
- data quality value type;
- data quality value unit;
- data quality date.

The standard on quality evaluation procedures (19114) is a framework for determining and evaluating quality that is applicable to digital geographic datasets (create a figure):

I. Define a dataset for the scope → II. Identify a data quality element → III. Identify proper measure for that element → IV Apply a quality measure method → V. Determine data quality results → VI. Report results

There are direct and indirect evaluation procedures. Direct evaluation procedures evaluate the quality elements that were chosen to check the quality of the data. Indirect evaluation method use external knowledge to evaluate the data.

d. Metadata (ISO 191115, 191115-2)

ISO 19115:2003 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data[4].

ISO 19115:2003 is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

ISO 19115:2003 defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;

[4] http://webstore.ansi.org

- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements - to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialized needs.

Though ISO 19115:2003 is applicable to digital data, its principles can be extended to many other forms of geographic data such as maps, charts, and textual documents as well as non-geographic data.

e. Data product specification (ISO 19131)

It is a general description on how geographic data products should be specified whether it is feature-based data, coverage-based or imagery data. It defines how to describe the data product (reference system, data quality degree, data capture, portrayal, data product delivery, metadata). This standard is very general but contains mandatory items.

f. Data quality measures (ISO 19138)

It is important to provide the data user with quality information of geographic data in order to allow the user to choose the best suitable data quality for his/her purposes. This standard defines a set of quality measures.

3.1.2 CEN/TC 287 Geographic Information, European Committee for Standardization

CEN is basically blending ISO 19100 set of standards and filling in gaps. The adapted standards' names are: EN ISO 19101, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 123, 125, 126, 128, 132, 133, 134, 135, 136, 137, 139, 141.

CEN/TR 15449:2006 Geographic information – Standards, specifications, technical reports and guidelines, required to implement Spatial Data Infrastructure is unique for CEN compare to ISO.

3.1.3 OGC Standards

The Open Geospatial Consortium (OGC) is a "non-profit, international, voluntary consensus" working on to provide standard solutions to location based services[5]. Practically it means OGC members are working on protocols that are "geo-enabling" the web. OGC standards allow system developers to align their work to mainstream "Geo-IT" developments, securing the interoperability of Open Distributed Processing (organizations dealing with spatial information).

Some examples of standards for Information and data sharing are:

- KML
- GML
- WEB Map Service (WMS) Implementation Specification is now available as ISO 19128, a standard titled "ISO 19128:2005 Geographic information - Web map server interface."
- Web Feature Service (WFS) Implementation Specification
- Web Coverage Service (WCS) Implementation Specification

Some of the above listed standards are to exchange geographic information like GML or KML. GML encoded geographic feature (points, lines, polygons) can be applied to various objects on earth surface. A GML encoded line can mean highway or river, but a pathway of contaminant as well. GML encoded features can be handled by geoportals that support Web Feature Services or KML encoded feature can be visualize in Google Earth. These "tools" can aid the dissemination effort of the Consortium.

Web coverage services make geospatial "coverages" (grid coverages e.g satellite images, DEMs, "phenomena represented by values at each measurement point") digestible for geoportals eventually for the WEB.

[5] http://www.opengeospatial.org/

3.2 Directives

3.2.1 INSPIRE

The INSPIRE Directive lays down general rules to establish an infrastructure for spatial information in Europe for the purposes of Community environmental policies and policies or activities which may have an impact on the environment[6]. INSPIRE has to be adapted on a Member States level while it contains that data should be managed as close as possible for its creation. The Directive is compulsory for public entities.

History:

1. Entry into force 15 May 2007
2. Transposition phase (2007-2009) Continue with work of implementing rules and to transport to national legislation
3. 2009-2013 implementation
4. Operation from 2019

There are 34 Spatial Data Themes in three Annexes. These spatial data themes are drafted and will be defined (thematically and technically) in order to make them interoperable throughout the EC.

INSPIRE adopted several ISO/TC 211 and OGC standards. Some of them only to mention here (built in the Directive):

- INSPIRE Specification on Coordinate Reference Systems (ISO 19111)
- INSPIRE Metadata Regulation (ISO 19115)
- INSPIRE GeoPortal (WMS, WFS etc.)

Available guidelines (relevant to ImpactMin) for the **spatial data themes** that supplement the Implementing rule for interoperability and helping the preparation for implementation:

- INSPIRE Specification on Geographical Grid Systems
- INSPIRE Specification on Coordinate Reference Systems
- Etc.

The spatial data themes listed in Annex II and III are currently under development. A document “Definition of Annex Themes and scope” is already published on the INSPIRE web site that gives short definitions of single themes, scope and use examples, overlaps and links with other themes. However, the detailed description of these themes will come later as calls for data specification has just been ended early this year. It will be worth to monitor the progress of development throughout ImpactMin project course.

The forthcoming data specification “will provide a detailed definition of data content by means of application schema and feature catalogue. Furthermore the Data Specifications will specify requirements to data quality, data consistency, reference systems and metadata.”

INSPIRE Metadata is for:

- Interoperability of spatial data sets and services
- Network services (discovery, view, download, invoke) made available through the European geo-portal
- Data and Service sharing (policy)
- Coordination and measures for Monitoring & Reporting

Based on the Metadata Regulation (2008) ImpactMin developed and conveyed metadata questionnaire for data collection purposes (**Annex I**). It was distributed among the partners to provide information about the available geographic datasets.

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

3.3 Guidelines

3.3.1 QA4EO

The Committee on Earth Observation Satellite (CEOS) has established a quality assurance (QA) strategy to facilitate interoperability of Global Earth Observations systems[7]. This strategy is based upon a set of key operational guidelines derived from "best practices" for implementation by the community. The QA4EO has been completed and endorsed by CEOS and is recommended for implementation and use throughout the GEO community.

The QA4EO PRINCIPLES provides the background to QA4EO and introduces the key guidelines:

- QA4EO-QAEO-GEN-DQK-001
  A guide to establish a Quality Indicator on a satellite sensor derived data product
- QA4EO-QAEO-GEN-DQK-002
  A guide to content of a documentary procedure to meet the Quality Assurance requirements of CEOS
- QA4EO-QAEO-GEN-DQK-003
  A guide to "reference standards" in support of Quality Assurance requirements of QA4EO
- QA4EO-QAEO-GEN-DQK-004
  A guide to comparisons – organization, operation and analysis to establish measurement equivalence to underpin the Quality Assurance requirements of QA4EO
- QA4EO-QAEO-GEN-DQK-005
  A guide to establishing validated models, algorithms and software to underpin the Quality Assurance requirements of QA4EO
- QA4EO-QAEO-GEN-DQK-006
  A guide to expression of uncertainty of measurements
- QA4EO-QAEO-GEN-DQK-007
  A guide to establishing quantitative evidence of traceability to underpin the Quality Assurance requirements of QA4EO

When using satellite products, the user should check for what purpose they are "offered" by the operator of the satellite system. Satellite systems are intentionally developed to provide specific products (base for cartographic mapping e.g. Quickbird, soil moisture e.g. ESA SMOS). If the EO instrument/satellite imagery is planned to be used to derive other products (e.g. WorldView 2 image for mineral mapping), careful investigation and validation for the new purpose must be performed.

"It is noted that the relatively high cost and time associated with the development of these space assets means that often, following launch, there is a significant expansion in the range of applications for which delivered data is used. This, of course, should be encouraged. However, to maximize the benefit, one should seek to ensure that, where possible and without excessive cost, there is sufficient knowledge about the sensor to allow this to occur in a quality assured manner."[8]

This means all satellite-system-product descriptions should be checked, before use in the ImpactMin project (e.g. Worldview 2 documentation[9]), and also the ImpactMin purpose should be defined. If the two don't match, then careful validation process is needed. If possible the data provider should be asked or documentation should be overviewed for any calibration information.

Also employing satellite imagery, that is unique on the "market", brings uncertainty to data continuation. Thus satellite sensor/imagery with similar characteristics has to be identified next to primary identified satellite imagery. This would ease the problems in case of any error in the primary

[7] http://qa4eo.org/
[8] http://qa4eo.org/docs/QA4EO-QAEO-GEN-DQK-001_v4.0.pdf - 'A guide to establish quality indicator on a satellite sensor derived data product'
[9] http://worldview2.digitalglobe.com

identified satellite system (satellite imagery). This aspect is very important in longer term of monitoring. It is not really foreseen at the moment, how far ImpactMin investigation can stretch in the future, because of the nature of the project being a ‘small scale research project’.

QA4EO-QAEO-GEN-DQK-001 - A guide to establish a Quality Indicator on a satellite sensor derived data product

This is a top-level guide that explains the “requirements that should be carried out for each (space based) sensor during its development and operation”.

QA4EO-QAEO-GEN-DQK-002 - A guide to content of a documentary procedure to meet the Quality Assurance requirements of CEOS

This guideline covers all QA/QC aspects that can be applied on “EO data” on “data collection” on “data processing” on “data archiving” and on “dissemination”. The QA/QC has two main goal:

1. Data interoperability for the GEO community
2. Data transparency for end-users.

This generic approach is built on a broad-based, non EO specific QA best practice.

Acting along this guide allows the products’ users (analysts/experts or stakeholders/en-users) to assess the “fitness for purpose” of the product (raw and/or processed). It is a template so it can be extended for specific purposes and state “not relevant” in case some if its items. The following “headers” are the core content to describe a process:

1. Identifier
2. Title
3. Author
4. Authority
5. Issue/version number/date
6. Abstract
7. Overview/scope
8. Terminology/definition
9. Background/context/requirement
10. Outcomes
11. Inputs
12. Standards and traceability
13. Task description
14. Evaluation of performance
15. Evidence to support a performance indicator
16. Review of Process

Along these guides the Consortium can set “best practice” on the field of impact monitoring of mineral resources exploitation, thus the consortium should bear in mind to register the developed “flow of process(es)”, disseminate it to formal peer review within the GEO community.

QA4EO-QAEO-GEN-DQK-003 - A guide to “reference standards” in support of Quality Assurance requirements of QA4EO

The guideline provides:

- advice to those seeking to find a “reference standard” for a particular application as well as the establishment of new ones
- a template to aid those documenting the characteristics of a “reference standard” and serves as a checklist for those seeking to find one.

This guide helps; in the meanwhile one is establishing QA process (overviewed above). It helps in point No. 12 ‘Standards and traceability’.

QA4EO-QAEO-GEN-DQK-004 - A guide to comparisons – organization, operation and analysis to establish measurement equivalence to underpin the Quality Assurance requirements of QA4EO

This guide helps to use the "principle techniques of the scientific field" to comparisons. Also it describes a procedure in selecting, conducting and evaluating comparisons. Eventually, a sole researcher body (ImpactMin partner) can perform a control on the result of their analyses (HSI data analyses, Gamma-ray data analyses etc.).

QA4EO-QAEO-GEN-DQK-005 - A guide to establishing validated models, algorithms and software to underpin the Quality Assurance requirements of QA4EO

This guide aids to find the appropriate instrument (in terms of algorithm and models and derived software) that leads a researcher reach from product "Level 1" to 'Level n" within the processing chain of EO data products.

Model validation:

- Correctness
- Comprehensiveness
- Statistical model

"In many cases, a well-established model will be appropriate and the model validation will simply be by citing established references."

Algorithm validation: Good Practice Guide No 16 "Testing and Validation of Algorithms and Software".

"In many cases, a well-established and documented algorithm will be appropriate and the algorithm validation will simply be by citing established numerical analysis texts."

Software validation: Best Practice Guide No. 1 "Validation of Software in Measurement Systems

QA4EO-QAEO-GEN-DQK-006 - A guide to expression of uncertainty of measurements

This document provides the link to ISO guide on 'Expression of Uncertainty in Measurement'; the GUM, which is the recognized standard.

QA4EO-QAEO-GEN-DQK-007 - A guide to establishing quantitative evidence of traceability to underpin the Quality Assurance requirements of QA4EO

This key guideline summarizes the type of evidence needed, the means to achieve it and guidance to any "approving authority" on how to assess its adequacy

4 EXAMPLES OF IMPLEMENTATION OF STANDARDS

In this chapter three examples will be shortly introduced with different approach to implement international standards. These examples relates to ImpactMin project in a sense that they either have similar concept of operation (GMES as EO based services) or adapt rigorously the “guidelines” of international standards like ESRI, who is developed their software products along ISO/TC 211 and OGC standards. The GIGAS Forum project funded by the EC has revealed that even on high level adaptation of protocols and standards there can be different perception and exploitation of these guidelines.

4.1 GMES

Global Monitoring of Environmental Security (GMES) is the European Initiative for the establishment of a European capacity for Earth Observation[10]. GMES is the major European contribution to GEOSS.

GMES is expected to be compliant with GEOSS. GMES supports several SBAs and geoland2 project, as a pre-operational GMES Land Monitoring Core Service, is registered in the GEOSS Architecture Implementation Pilot – Phase 3 (AIP-3 was demonstrated at the Ministerial Summit in Beijing 2010). It means geoland2 is compliant with GEOSS in terms of quality assured procedures and products, and it provides web services that are based on the ISO and OGC specification. Geoland2 SDI (www.geoland2.eu), that is not only a database of spatial data but the whole infrastructure of web based geospatial services, is operational.

4.2 GIGAS

The GIGAS Forum project investigated the similarities and differences of three major EO related programs (GMES, GEOSS, INSPIRE) concerning adopted standards, protocols and open architectures[11]. The GIGAS project found minor discrepancies when the GIGAS project was checking GEOSS, INSPIRE and GMES against their established criteria (enterprise, information, computation and engineering viewpoint).

This technology watch [12] that was accomplished by the GIGAS Forum project revealed risks due to different timeline and technical development of the investigated initiatives.

4.3 ESRI

ESRI's approach to interoperability fully encompasses the International Organization for Standardization Technical Committee 211 (ISO/TC 211) and Open Geospatial Consortium, Inc.® (OGC®), specifications and standards.

Supported OGC Specifications as of 2008 are in **Annex II**.

Supported ISO/TC 211 International Standards are in **Annex III**.

ESRI follows two main metadata formats (ArcGIS 9.3.1. Desktop Help):

1. Federal Geographic Data Committee's – FGDC metadata (U.S.)
2. ISO 19115:2003 Geographic information -- Metadata

In ArcCatalog one can create *metadata* content. With the metadata editors provided with ArcCatalog one can create metadata content following the FGDC CSDGM or ISO 19115 standards.

[10] http://www.gmes.info/
[11] http://www.thegigasforum.eu/
[12] The GIGAS Forum, Project Final Report – Publishable Summary

The metadata created by ArcCatalog is stored in an ESRI-defined XML format. This format currently combines FGDC-, ISO-, and ESRI-defined XML elements.

The current format as ArcGIS stores metadata, will change. ESRI will develop a standard neutral format that is a superset of the FGDC and ISO 19115 metadata content standards. It will let you provide any FGDC or ISO 19115 metadata content and will support customization for specific profiles of those standards (ArcGIS 9.3.1. Desktop Help).

ESRI ArcEditor, ArcGIS etc. products seem to be a reasonable to choose as a software (.shp – file format) solution to handle the managed/generated data during ImpactMin project lifetime.

5 RECOMMENDATIONS FOR IMPACTMIN

The objective of this chapter is on one hand to make practical recommendation and set up guidelines for ImpactMin project partners regarding the operation of the project implementation. On the other hand the aim is to support the long term goals of ImpactMin project proposing contribution to GEOSS. The practical points mainly concern data management by giving recommendations for internal and external data sharing, rule the data format in general and to formulate the outlines for integrated data handling (e.g. common coordinate system).

5.1 GEO(SS)

For ImpactMin, there is no clear Mineral Resources GEO Task. However, a number of SBAs would benefit from the development of observation and analysis tools for exploration and exploitation of Mineral Resources.

ImpactMin is a unique position, together with EO-Miners project (both co-financed by the EC under the same call), because the topic of the project can't really be assigned to one specific SBA. Although it can be the case with other projects as well, ImpactMin by definition has very broad context and has the specialty to formulate a research field in applied sciences. Being a small scale research project, ImpactMin carries the characteristic being on the technology edge with state of the art tools and technology and the need to deliver applicable EO solutions for impact monitoring of mineral resource exploitation.

GEOSS is primary about to group ready-to-use EO tools that can serve decision making for the benefit of the society. In this respect ImpactMin's objectives are:

- to create a knowledge pool of EO application
- to demonstrate EO assets and resources of the Consortium
- to align the Project's operation to global initiatives
- and to create tools and services appropriate to end users needs.

In order to create a knowledge pool, the members of the Consortium accomplished a comprehensive literature study and translate the findings and the Consortium capabilities into implementation plans that will be demonstrated in different sites. In the meantime, the Project investigated the recent actions that are happening in the wider geographic information community. A review has been performed regarding standards and protocols that concerns geoinformatics. Project members were supported by the EC with information about GEO and GEOSS and proceed of the initiative is monitored since the Project's start. ImpactMin project partners are aware of the objectives and goals of GEO. On the other side the Consortium meant to build an end-user community to gain feedback of their needs. The gap between science and the industry and society needs therefore should be revealed and narrowed. However also the scientific community can be the beneficiary of the Project since the created foreground (being data provision or knowledge for instance) can be exploited through sharing and disseminating the relevant information.

It is important for ImpactMin to coordinate efforts with other European projects and programmes:

- EO-MINERS[13] (same call, BRGM coordinator)
- Other EC GEO projects

Finally, Impactmin can support to international programs and initiatives and to European policies:

- International Strategy for Disaster Reduction
- European Community Communication on an approach to the prevention of natural and man-made disasters

[13] http://www.eo-miners.eu/

Impactmin liaises with EO-Miners consortium to raise awareness and achieve a larger impact among the stakeholders and end-users. European initiatives and directives are also the subject of investigation to keep track with the Commission needs.

ImpactMin was presented at several GEO European Project Workshops (GEPW) and keeps update with GEOSS process constantly. Furthermore ImpactMin was in the EC's "ecosystem brochure" prepared for the Ministerial Summit in Beijing. The final phase of GEO Work plan 2005-2015 falls within the Projects lifetime thus the updates and improvements should be followed by ImpactMin partners.

GEOSS Common Infrastructure is in a mature stage now and there are several possibilities to use it by the Project. The GEO Portal powered by ESA and FAO is now selected being solely access point to GEOSS services thus it can be easily followed now how it evolves throughout time. GEOSS components and service registry offers possibility for ImpactMin partners individually and also jointly to register their services and make use of disseminating their capabilities on the field of earth observation. Final project outcomes of "tools and services" will only be possible to register when the demonstration phase will be over in the Project and when it proved to be viable for the purposes. It will also require joint will from one or more Consortium members, if the project succeed, to maintain on a long term beyond the end of the Grant Agreement.

ImpactMin can also benefit from the Best Practices Wiki[14], because practices can be sent in for review them. It can be a dissemination activity targeting the scientific community, which is additionally a possibility to gain feedback and refine or modify the approach developed by the Project.

Multimedia and showcase material that can be offered by ImpactMin e-training can contribute to capacity building that is a transverse area of GEO. ImpactMin findings, best practices and development can be disseminated in a digestible form with the help of the planned trainings.

5.2 Standards

The following guidelines and recommendations are meant to support the operation of ImpactMin activities related to data collection/acquisition, processing and management. The following points provide steady base for integration of data into the common project database, managed by Partner No.2 Geosense and the Coordinator, thus eventually help integrated data analyses.

5.2.1 General

a. Data formats

The standardized data formats in general do not require too much effort to be adopted by ImpactMin partners. Conventional raster and vector formats are suitable to serve interoperability, and consortium Partners are aware of the most used and commercial ones. Also the software that are possessed by the Partners limits the flexibility of the Consortium. A cross comparison of widely accepted and used raster data formats can be found in Annex IV (by ISO/Technical Report 19121) which is in GEOSS standards registry.

The Consortium is prepared to format the pertinent results (maps) to appropriate data format (GeoTIFF, HDF-EOS) instead of the already preferred ENVI header that so far satisfied the needs of the Partners. During the Project discrete features (roads, power-lines etc.) were transformed into ESRI Shape file format and it is suitable for data exchange internally (among Consortium members). ESRI shape file is widely recognized in the geographic information society and edit the features' metadata that is inevitable following the global initiatives, is easy by using ArcGIS (chapter 4.3).

[14] http://wiki.ieee-earth.org

b. File naming conventions and version numbering

File naming, concerning the shared geodata on Partner No1- Geonardo FTP, for the operation of the Project is agreed to manage by Partner No. 2 Geosense who is overall manage the common project database. Version numbering, for datasets, is also the responsibility of Geosense. Separate folder serves the sharing of new vector or raster data and finalized datasets put in respective folder thus data maintenance is secured and manageable to date for internal needs. Protocols will be developed for external data sharing in a later stage of the Project when the Project generates the results of the implementation activities.

5.2.2 Data acquisition

The most important protocols and guidelines for earth observation are appearing in CEOS supported QA4EO (see §3.3.1 p.18). A key requirement of QA4EO is that the procedure (acquisition, processing) must be documented as evidence to support any quality statement.

a. Coordinate systems

ISO 19111 contains general guidelines to design a suitable referencing system by coordinates (Coordinate reference system, coordinate system, datum package) and define a minimum data required to define a 2 or 3D spatial coordinate reference system.

ImpactMin Consortium has chosen UTM as conform geographic coordinate system and WGS 84 as the datum for the data to be stored in the common database.

b. Metadata

Based on the INSPIRE Metadata Regulation (2008) ImpactMin Partners in WP4 developed and conveyed metadata questionnaire for data collection purposes (**Annex I**). It was distributed among the partners to provide information about the available geographic datasets.

Project Partners will continue to use INSPIRE metadata guidelines because:

- it is commonly used in Europe
- it is easy to adapt
- it is based on ISO standards
- it is suitable to be applied for geographic information (e.g. describe geographic features including pollutants, contamination).

All Partners should maintain metadata of the generated data by themselves. The metadata should be edited together with the core data (ESRI Shape file) or if it not feasible due to technical reasons the pertinent information should be sent to Partner No 2 Geosense who is responsible for to coordinate the efforts of data management.

5.2.3 Data processing and analysis

a. Data quality

The consortium members, who ought to deal with data processing, need to consider basic QA/QC measures. The fundamental of quality evaluation procedures (and principles) are laid down in two ISO standards: 19113 and 19114 (see §3.1.1c p.14).

The principles for describing the quality of the geographic data (imagery or map data products) should follow a very simple scheme to be compliant with ISO and generally conform to general procedure on the field of geospatial data management:

This international standard can be used when:

- Identifying and reporting quality information
- Evaluating the quality elements of a dataset
- Developing products specification and user requirements

During ImpactMin (WP6 and WP7) proper data quality (sub)elements are foreseen to be identified. In association with Geonardo, collaborative Partners will be asked to contribute to data quality elements identification and evaluation procedure (defined by ISO 19113 and 19114) in order to achieve the goals of this activity.

It is the decision and the knowledge of the Partners what data quality elements will be identified , but they must be appropriate for the purpose. The results of this activity will then be included in D6.3 Report with the input of WP6 and WP7 leaders, GEOS and UBB respectively.

5.2.4 Data sharing

The GEOSS data sharing principles claim the full and open exchange of data and metadata. The (geographic) information that will be generated during the Project course will be mostly public and shared among the parties concerned (external/internal).

There are internal data sharing policies and the Consortium needs to consider the aspects of disseminating project's results to a wider community. There are a couple of frameworks that generally guides releasing geographic information. The result of ISO and OGC "activity" that SDIs (in a wider sense, not just database, but with service functions e.g. WMS, WFS etc.) and geoportals could have been established along the standards and protocols of services.

a. Internal data sharing

Internal data sharing primary concerns the data exchange between Partners. Protocols for sharing geodata are established (both raster and vector formats) and the Consortium is mainly using Partner No1 Geonardo server for this purpose.

For more details see §5.2.1 (file naming, version management and conventions).

b. External data sharing

The main viewpoint must be here for ImpactMin project to keep track with new developments (Web Map Services, Web Coverage Services) in order to enable the consortium to share the data products in a conform way. This can be mostly ensured following ISO/TC 211 series of standards (see §3.1.1) and by using recommended coordinate system, by applying and editing metadata appropriately and by managing spatial datasets with proper data formats (both vector and raster data) with software that are conform to handle geographic information. ImpactMin partners ensure the interoperability with geographic community.

Accepted and applied standard like KML or GML can be used to widely disseminate ImpactMin map products ("results").

Alternative solution, to support ImpactMin "presence" on the web, can be an open source application developed during GMES – Geoland2 project. The name of the application is AGI SDI Server (support for instance CSW, WMS, WFS, WCS, WPS)[15]. Considering the fact that the Coordinator had dealt previously with open source web map service (UMN web map service, PostgreSQL, PostGIS) and has a capability deploy system in Linux environment (from system administrator side) give future potential in this direction. The Coordinator will take care of this aspect of data management activities to the extent it is useful for the Project.

5.2.5 QC/QA

ImpactMin must ensure QC/QA during the project course, moreover seamless GIS integration of data (obtained and produced/generated), is required. Being secured the geographic information management compliant with ongoing international "trends", the Consortium chose to assess the international standards on the field of geographic information. ISO and OGC standards will be carefully evaluated for the purposes of the Project and an application level will be defined for each of the analyzed standards.

[15] http://www.agi.lt/sdi-iso/agi-sdi-server-2009-manual-draft-20100413.pdf

The review of international standards was undertaken not from ―all system design point of view. Originating in the nature of this project (small scale research) the extent and magnitude of the research does not require re-inventing new means of data processing, management and publication means. However, cutting-edge technologies (gamma-ray spectroscopy) and state of the art EO tools (HSI, WorldView2 imagery) will be applied in the frame of the project, thus conformity must be warranted.

This means that ImpactMin consortium does not intend to design and implement new systems for its internal operations but the Consortium will use the existing IT infrastructure (software, hardware and the Internet), "deployed" standards/guidelines (e.g. Suggested coordinate system, metadata schema etc.) and commercial data processes and data formats to be conform with global initiatives (Inspire, GEOSS).

The application of standardized system nods are three folded:

1. Planning procedures and data acquisition
2. Data processing and analyzing
3. Data sharing

While ImpactMin primary deals with geographic imagery (e.g. satellite and airborne), the basic imagery scenario's (ISO/TC 19101-2) are key points to conceptualize standardized procedures and protocols. ImpactMin data handling should be conform with the selected ISO and OGC standards, however due to institutional and technical limitations the application level in the Project is uncertain .

From the second year on, the Project activities (field work, image analyses etc. – WP 6/7) are conducted along the findings of this report. Established protocols to bring information into digital environment (GIS) and standardized data formats will be ISO compliant. This will allow the development of thus systematic and repeatable observation and monitoring programs .

Future deliverables will contain the specification that can be compiled, based on this report. The implementation of work package (WP 7) will result in detailed implementation plans. These implementation plans will be guided and strictly controlled by standard procedures and protocols. Moreover during the execution of WP 6, where ImpactMin tools and services will be developed, constant governance will be applied to focus on QC and QA and to deliver useful and utilizable geographic information for decision makers and stakeholders.

6 COMPLIANCE ASSESSMENT AND CONCLUSIONS

The Group on Earth Observation is providing a framework (GEOSS) by a coordinated effort to enable decision makers to use it for the benefit of the society. Earth observation has the capacity to provide tools and services to assess, monitor and manage the environment and natural resources. The concept of ImpactMin is to develop and demonstrate the capability of EO tools to monitor mining related environmental impacts in a coordinated manner.

However and although there is no clear Mineral Resources GEO Task, there are a couple of SBAs that could benefit from the development of observation and analysis tools for exploration and exploitation of Mineral Resources.

While ImpactMin is a small scale research project, it won‘t produce large volume of data. However there are couple of standards, guidelines and objectives to consider during the course of the Project for practical reasons. The data, that are collected and will be generated by ImpactMin, are mostly geodata or geographic information. As such, several recommendation, guidelines and protocols can be applied to them during their acquisition, processing and management. The GEOSS common infrastructure is demanding in terms of representation of geographic information and data quality that are eventually addressing interoperability and transparency in general.

ImpactMin will address interoperability with the commonly used, standard data formats (vector and raster) and will aim to address transparency by applying CEOS guidelines for GEOSS EO data documentary procedure and quality evaluation (QA4EO). ImpactMin demonstration sites and the selected EO imagery allow testing the protocols for different purposes, on different scales with different EO assets.

Moreover the Project implementation will enable the Consortium to evaluate the applicability of various imagery (Landsat, ASTER, WorldView2, SPOT) to monitor environment impact monitoring of mining. Having in mind data sharing the Consortium will make an experiment to apply open source software (chapter 5.2.4) to compile, present and publish the resulting datasets via standard web service tools.

The topic of the Project is unique on its own however it touches several Societal Benefit Areas from the GEO work plan 2009-2011. Generally mining activity can be delineated very precisely (boundary of operation) but the environmental impact can affect larger areas because the unavoidable pollutants of the extraction activity that can be taxied further away by a medium (air, water). Additionally, mining can be associated with alteration (damage) of the ecosystem, being the root cause of disasters and influencing the health and living conditions of the surrounding area. Thus mining can be considered as a hazardous activity and should be treated and monitored accordingly.

EO has tools to provide solutions in regional or local scale. Many of the impacts of mining activity fall in this range (local to regional). Furthermore EO assets and the EO products can serve multiple purposes. Imagery data and products can aid environment baseline studies (for later ecosystem recovery activities) such as for example recording the state of the environment (vegetation health) and mapping the spatial extent of different features (forests). Combining data and creating information is also possible with EO tools for instance to predict hazards, forecast disasters (land cover map + DEM + stream network + location of pollutants/contaminant).

Recent research activities and results can have an impact on future monitoring possibilities and response coordination. When ImpactMin tools and services demonstrate a solution for environmental monitoring of mining impacts, the feasibility of continuation of services become reality by assessing the limitations and potentials of satellite systems/constellations and/or make recommendation for future developments. Depending on the spatial and temporal scale of the environmental phenomena/variables/observables, satellite system characteristics can be evaluated against the criteria (temporal, spatial, spectral resolution) to determine applicability. Obviously the characteristics (temporal, spatial, magnitude) of mineral resources exploitation must be revealed. WP6 and 7 will be the demonstration of the strengths of EO tools and services thus final conclusion for GEO(SS) purposes can be made after their closure.

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ANNEXES

Annex I - Parts of INSPIRE Metadata Regulation (2008)

Part B

Interpretation

1. The following definitions shall apply:

- ‘character string’ means the value domain of metadata elements expressed as a set of characters treated as a unit,
- ‘free text’ means the value domain of metadata elements expressed in one or more natural languages,
- ‘lineage’ means the history of a data set, and the life cycle from collection and acquisition through compilation and derivation to its current form, in accordance with EN ISO 19101,
- ‘metadata element’ means a discrete unit of metadata, in accordance with EN ISO 19115,
- ‘namespace’ means a collection of names, identified by a uniform resource identifier (URI) reference, which are used in extensible markup language (XML) documents as element names and attribute names,
- ‘quality’ means the totality of characteristics of a product that bear on its ability to satisfy stated and implied needs, in accordance with EN ISO 19101,
- ‘resource’ means an information resource that has a direct or indirect reference to a specific location or geographic area,
- ‘spatial data set series’ means a collection of spatial data sets sharing the same product specification.

References to the validity of spatial data sets shall be understood as relating to any of the following:

- the range of space and time that is pertinent to the data,
- whether the data have been checked to a measurement or performance standard,
- the extent to which the data are fit for purpose,
- where appropriate, the legal validity of the spatial data set.

1. IDENTIFICATION

- Resource title
- Resource abstract
- Resource type
- Resource locator
- Unique resource identifier
- Coupled resource
- Resource language

2. CLASSIFICATION OF SPATIAL DATA AND SERVICES

- Topic category
- Spatial data service type

3. KEYWORD

- Keyword value
- Originating controlled vocabulary

4. GEOGRAPHIC LOCATION

- Geographic bounding box

5. TEMPORAL REFERENCE

- Temporal extent

- Date of publication
- Date of last revision
- Date of creation

6. QUALITY AND VALIDITY

- Lineage
- Spatial resolution

7. CONFORMITY

- Specification
- Degree

8. CONSTRAINT RELATED TO ACCESS AND USE

- A constraint related to access and use shall be either or both of the following:
- Conditions applying to access and use
- Limitations on public access

9. ORGANISATIONS RESPONSIBLE FOR THE ESTABLISHMENT, MANAGEMENT, MAINTENANCE AND DISTRIBUTION OF SPATIAL DATA SETS AND SERVICES

- Responsible party
- Responsible party role

10. METADATA ON METADATA

- Metadata point of contact
- Metadata date
- Metadata language

PART C

Instructions on multiplicity and conditions of the metadata elements

The metadata describing a resource shall comprise, as regards a spatial data set or a spatial data set series, the metadata elements or groups of metadata elements listed in Table 1 and, as regards a spatial data set service, the metadata elements or groups of metadata elements listed in Table 2

PART D

Value domains

Where specified in the description of the metadata elements in Part B, the value domains described in Part D.1 to D.6 shall be used with the multiplicity expressed in Tables 1 and 2 of Part C. In relation to a particular domain, each value is defined by:

— a numerical identifier,

— a textual name for humans which may be translated in the different Community languages,

— a language neutral name for computers (the value expressed between parenthesis),

— an optional description or definition.

Annex II – ESRI supported OGC Specifications as of 2008

Specification: Web Mapping Service (WMS) 1.1.1

Provider: ArcIMS® 9.2, ArcGIS® Server 9.2, ArcIMS 9.3, ArcGIS Server 9.3

Specification: Web Mapping Service 1.3

Provider: ArcIMS 9.2, ArcGIS Server 9.2, ArcIMS 9.3, ArcGIS Server 9.3

Specification: Styled Layer Descriptor (SLD) 1.0

Provider: ArcIMS 9.2, ArcIMS 9.3, ArcGIS Server 9.3

Specification: Web Feature Service (WFS) 1.0

Provider: ArcIMS 9.2, ArcIMS 9.3

Specification: Web Feature Service 1.1

Provider: ArcIMS 9.3, ArcGIS Server 9.3

Specification: Web Feature Service 1.1 (Transactions)

Provider: ArcGIS Server 9.3

Specification: Filter Encoding 1.0 • ArcIMS 9.2

Provider: ArcIMS 9.3

Specification: Filter Encoding 1.1

Provider: ArcGIS Server 9.3

Specification: Web Coverage Service (WCS) 1.0

Provider: ArcGIS Server 9.3 WCS capability available with/without Image Server extension

Specification: Web Coverage Service 1.1, 1.1.1

Provider: ArcGIS Server 9.3 WCS capability available with/without Image Server extension

Specification: Catalog Services 1.0—Z39.50

Provider: ArcIMS 9.2, ArcIMS 9.3

Specification: Web Catalog Service (CS-W) 2.0.1

Provider: ArcIMS 9.2, ArcIMS 9.3, GIS Portal Toolkit 3.1

Specification: Web Catalog Service 2.0.2

Provider: ArcIMS 9.3, GIS Portal Toolkit 3.1

Specification: Simple Features 1.1

Provider: ArcSDE®, ArcGIS

Specification: Geography Markup Language (GML) 2.x

Provider: ArcIMS 9.3 WFS Connector

Specification: Geography Markup Language 3.1.x

Provider: ArcGIS Data Interoperability 9.2, ArcGIS Data Interoperability 9.3

Specification: Simple Features GML

Provider: ArcGIS Desktop 9.2, ArcGIS Data Interoperability 9.2, ArcGIS Desktop 9.3, ArcGIS Data Interoperability 9.3, ArcGIS Server 9.3

Specification: Interoperability 9.3 KML Version 2.1

Provider: ArcGIS Server 9.2, ArcGIS Server 9.3, ArcGIS Desktop 9.3

Specification: OGC KML Version 2.2

Provider: ArcGIS Server 9.3, ArcGIS Desktop 9.3

Annex III – ESRI supported ISO/TC 211 International Standards

ISO 19106:2004—Profiles

ISO 19107:2003—Spatial Schema

ISO 19128:2005—Web Map Server Interface

ISO 19136:2007—Geography Markup Language

ISO 19108:2003—Temporal Schema

ISO 19109:2005—Rules for Application Schema

ISO 19110:2005—Methodology for Feature Cataloging

ISO 19111:2003—Spatial Referencing by Coordinates

ISO 19112:2003—Spatial Referencing by Geographic Identifiers

ISO 19113:2002—Quality Principles;

ISO 19114:2003—Quality Evaluation Procedures

ISO 19115:2003—Metadata

ISO 19139:2007—Metadata: XML Schema Implementation

ISO 19118:2005—Encoding

ISO 19119:2005—Services

ISO 19123:2005—Schema for Coverage Geometry

ISO 19125:2004—Simple Feature Access—Parts 1–2

In addition, ESRI is participating in the review, development, and/or test implementation of many of the Draft ISO Standards (DIS) and Final Draft ISO Standards (FDIS) being finalized in ISO/TC 211. These include

- ISO 19137—Core profile of the spatial schema
- ISO 19138—Data quality measures
- ISO 19142—Web Feature Service
- ISO 19143—Filter encoding

Annex IV - Cross reference of characteristics of standards (ISO/TR 19121)

Name	Liaison	Geo Content	Metadata	Encoding [a]	Compression [a]	Services	Data Model (object/entity relationship)	Interchange Format	Impact on ISO/TC 211
1	2	3	4	5	6	7	8	9	10
DIGEST	Y	Y	Y	E	R	N	N (not Raster)	Y	Y
IHO	Y	Y	Y	S	S	N	Y	Y	Y
IP-IIF	Y	N	SOME	S	R	N	N	Y	Y
BIIF	Y	Y [b]	Y	S	R [c]	N	N	Y	Y
NITF	Y	Y	Y	S	R [c]	N	N	Y	Y
SQL/MM Image	Y	Y	N	N	N	Y	Y	N	Y
OGC	Y	Y	Y	E	[d]	Y	Y	[e]	Y
SC29 JBIG	N	N	Y	S	S	N	N	Y	Y
SC29 JPEG	N	N	Y	S	S	N	N	Y	Y
SC29 MPEG-2	N	N	Y	S	S	N	N	Y	Y
T4&T6	N	N	N	S	S	N	N	PART	N
TC130 TIFF	N	N	N	S	R	N	N	PART	N
GeoTIFF	N	Y	Y	S	R	N	N		Y
SDTS raster	N	Y	Y	R	R	N	Y	Y	Y
CEOS CIP	Y [f]	Y	Y	R [g]	N	Y	Y [g]	Y [g]	Y
CEOS Super Structure	Y [f]	Y	Y	S	N	SOME	Y	Y	Y
HDF	N	N [h]	Y	S	Y	Y	Y	Y	Y
HDF-EOS	N	Y	Y	S	Y	Y	Y	Y	Y

NOTE 1 "Impact" means that ISO/TC 211 should consider the standard identified as a source of requirements for ISO/TC 211 development. The standard may be referenced in the ISO/TC 211 development or effort may be expended to harmonize with it.

NOTE 2 There has been no effort to assess the level of authority of the various standards identified in the table. There is a range from proprietary standards and standards managed by a single government agency to ISO/IEC standards.

NOTE 3 Column 7 indicates that the referenced standard specifies services. The DIGEST standard doesn't directly specify services, but the DGIWG committee responsible for DIGEST has developed a suite of services to support DIGEST.

NOTE 4 Column 8 indicates that the standard is supported by a conceptual schema written in a conceptual schema language.

a Some of the Encoding and Compression methods identified in column 5 and 6 indicate that a standard specifies an encoding or compression method. Others simply reference external standards for the methods used. These are broken down into the following: R – references specification, S – contains specification, N – none, and E – provides instructions on how to apply external specifications.

b BIFF uses the Geo Content from DIGEST (Annex D).

c This standard allows many formats, including JPEG and VQ.

d OGC has not yet specified any particular compression service, but such specifications are expected as progress is made in the Image Exploitation Working Group of OGC.

e The focus of OGC, relative to exchange formats, has been upon structures that support the dynamic exchange of feature information between client and (a potentially remote and heterogeneous) server during an interactive session.

f CEOS WGISS is in the process of developing a Class Liaison.

g Metadata only.

h The format allows users to put in the Geo Contents.