WP2 IMPACT

Task 2.2 Gfg2 Training Needs Analysis – Action plan

Gfg2 strives to promote and foster GNSS know-how among the GEEO community and will impact the GEO activities through training activities and collaboration with GEO tasks. There is a need to train those GEEO experts not familiar with GNSS in the capabilities of this technology in order to exploit GEOSS societal benefits.

Objective 5: To promote the public understanding of GNSS for GEEO and GEOSS research and use within the GEO community, providing support to GEO tasks.

To achieve this objective we need to ensure that training is seen as a form of knowledge transfer which directly influences industrial competitiveness. Training of new high-tech skills is essential for European business excellence.

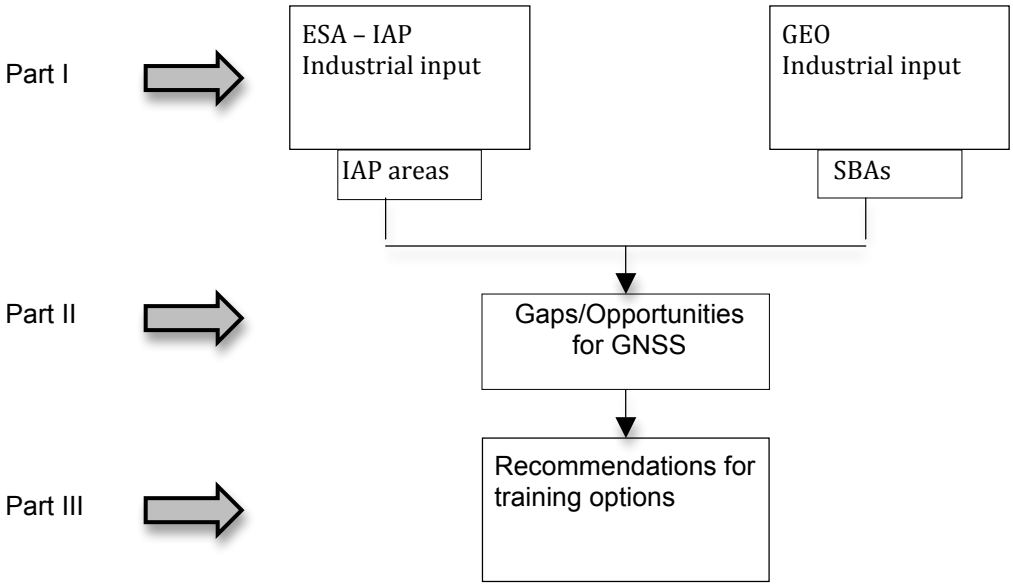
There are two focus areas, both equally important: (1) to spread the general knowledge of the possibilities for Earth observations based on GNSS signals through timing/positioning and remote sensing, and (2) to make the community aware of the limitations, in terms of accuracy and availability, of the technique.

Training Needs Analysis - Methodology

The methodology of training needs analysis is based on a systematic, iterative, output-based approach that provides an audit trail of analysis to determine the requirement for training and, if required, enables design of specialist training and acquisition of training services.

A three-phase process of this activity resulted in the following outputs:

Part	Aim and activity	Output	Additional documents
Part I	Scoping study (desk review)	Scoping report	IAP projects (Annex 1), GEO reports, GEO Report on progress
Part II	Operational task analysis and training gap analysis (interviews, feedback forms, desk review)	Competence Framework; Statements of training gaps	GRACE training modules; Training material on Gfg2 portal http://www.gfg2.eu/bibliotheque
Part III	Training options analysis	Recommendations	



I. SCOPING REPORT

The scoping study identified programming and resourcing issues, assumptions and constraints relevant to the proposed GNSS training activities.

Management of the activity is performed by STARLAB, with the ULEIC as Task Leader. Partners whose input is included: UNOTT and CHALMERS.

Assumptions: there is an assumption that:

a. High-tech training is essential for European business excellence.
b. GNSS technologies can provide important inputs and are capable of addressing GEOSS societal benefit areas.
c. GNSS training resources and packages already exist and can be used in a programme of education.

Constraints:

a. GNSS training for the purposes of the Gfg2 project should be free of charge.
b. Training modules should be available online

Industrial input in ESA-IAP and GEO

ESA Integrated Application Programme areas

Industry stakeholders involved in ESA-funded integrated projects and major Integrated Application Programme areas (IAP) are listed in Annex 1. The IAP projects are subdivided into themes: water, health, energy, food, transport and maritime. In each of these themes industry players can be service providers and/or target users.

The largest number of projects (16) is listed under the **Transport theme** covering aviation, road, rail and marine transport. Various combinations of Earth observation, satellite communications and satellite navigation systems are explored to develop integrated systems for:

- rail services (train control and management systems)
- support of multimodal transport of dangerous goods
- optimizing freight transport through ports
- increasing safety and reduce costs of services in small and regional airports
- providing localized and real-time information for end-users (e.g. travel information for vehicle drivers or in-flight information updates on weather conditions and hazards to airspace users)

Several projects aim to integrate space-based systems and EO data to deliver real time and forecast models. One example of this is a bird migration model to improve bird-warning systems in civil aviation and for military Air Force operations. Others include feasibility studies which combine EO data sets and GNSS data sets for the development of an intelligent transport management system taking into account air quality data, and another for the prediction and monitoring of landslides and subsidence.

Social Benefit Areas (SBAs) to which the **Transport theme** projects may contribute are: **Disasters, Energy (consumption), Health and Weather**. Industry input: transport operators, aviation, ports, railway operators, telecommunication, and IT system developers.

The **Energy theme** projects explore opportunities to integrate space technologies and data for forecasting energy production for a specific solar plant, surveying and maintaining oil and gas pipeline integrity and monitoring and predicting water flow for water power generation companies. A project using space-borne radar interferometry and navigation is being developed for monitoring carbon capture and storage sites.

The Energy theme projects to contribute to the **Energy SBA**. Industry input: oil and gas pipeline operators; oil and gas exploration and production companies; and Unmanned Aerial Vehicle (AUV) developers.

Projects under the **Food theme** focus on precision farming and contribute to the **Agriculture and Biodiversity SBAs**. Industries: farmers, agri-food businesses, natural park managers, AUV developers and geospatial technology engineering.

Projects in the **Health theme** can be grouped under the topics of telemedicine (satellite-based technologies to compliment Information and Communications Technology (ICT) in health services, health care for people on the move, integration of satellite networks with other types of networks, etc.), air pollution monitoring, health warning services (animal health surveillance; managing the arrival of invasive mosquito species, ticks) and tracking pharmaceuticals. These contribute to the **Health** SBA. Industries: telecommunication companies, hospitals, pharmaceutical companies.

GEO and GEOSS

The GEO Report on progress (published by GEO Secretariat, Group on Earth Observations, 5 November 2010) includes brief descriptions of the contributions made to GEOSS by hundreds of government agencies and national and international agencies and organisations. The report shows that satellite data, maps and technologies of Global monitoring for Environment and Securities have been employed in all SBA areas, and that *industry* plays the role of a stakeholder in GEO in most SBAs.

Energy. The ***energy sector*** increasingly relies on sustainable sources of energy supply. GEO develops tools for better management, monitoring and forecasting capabilities for the energy production. Before 2015, GEO's strategic target for GEOSS is to "close critical gaps in energy-related Earth observations and increase their use in all energy sectors in support of energy operations, as well as energy policy planning and implementation, to enable affordable energy with minimized environmental impact while moving towards a low-carbon footprint".

Disasters. In order to expand the use of satellite images and maps for managing the risks posed by fires, floods, earthquakes, and other hazards. User needs and requirements for satellite data for various types of disaster have been analyzed by the Committee on Earth Observation Satellites. Amongst the users are not only civil protection authorities, but also ***insurers*** who require more reliable tools and data for building risk models.

Ecosystems, Biodiversity, Agriculture. Earth observation data are increasingly used to improve the management of ***fishery resources***; the SAFARI initiative (Societal Applications in Fisheries and Aquaculture using Remote Sensing) and the new FARO project (Fisheries Applications of Remotely-sensed Ocean colour data) and other initiatives continue to organize workshops and information sessions on fisheries and Earth Observations. *GEO EcoNET* deals with global ecosystems classification and mapping. It also develops and expands the Chlorophyll Global Integrated Network (ChloroGIN) that uses satellite data for estimating phytoplankton biomass and primary production. In **forest monitoring**, Landsat data for over 13,500 sites from 1990, 2000 and 2005 are incorporated for the Global Forest Remote Sensing Survey to monitor forest distribution and estimate changes in forest areas. Monitoring of other terrestrial and marine ecosystems has shown that environmental changes, e.g. sea-level change in certain regions can potentially adversely affect **agricultural production, fisheries, water supplies**, **tourism**, **manufacturing**. Global Biodiversity Observation Networks and Global Agricultural Monitoring System of Systems are being developed by GEO.

Health. Environmental Earth observation data are increasingly used to address health risks and to monitor and predict environmental impacts on health, e.g. risks of epidemic outbreaks due to mosquito

or tick propagation, or health effects associated with air pollution. Research is demonstrating that there are important links between the transmission of vector-borne disease and land use and biodiversity, as well as environment changes. The **Food industry** is one of the stakeholders, especially in evaluating and mitigating risks from vector-borne diseases in cattle.

Climate, **Weather**. GEO organizations collaborate in areas for joint research into weather and climate. The climate-observing component of GEOSS is the Global Climate Observing System (GCOS). It aims to accelerate efforts of GEO community to meet the increasing demand for long-term, sustained, climate-related observations for policy makers and researchers. Space agencies contribute by providing access by all countries to relevant satellite products, by filling expected gaps between satellite missions, by improving calibrations systems and by maintaining the archives, data records and metadata from past and current missions.

In understanding the global carbon cycle, EO satellite data are increasingly used for improving the spatial coverage of the in-situ networks.

Various regional projects and international initiatives focus on weather-prediction models and forecasts, building a common toolbox that can be used to develop early warnings (tropical cyclone and extreme-precipitation forecasting). The water vapour content is highly variable and it is the short term forecasting (called nowcasting) associated with convective thunder storms where GNSS can provide a new type of observations. **Farmers**, **water managers**, health planners, as well as decision makers, already benefit from improved weather prediction, but there is room for large further improvements.

Water. A range of initiatives, networks and joint projects in GEO bring together the water research and user comminutes and expand the use of satellite data for better managing of extreme events (e.g. floods, droughts) and water resources (including freshwater quality information, soil moisture maps, precipitation etc.).

II. STATEMENT OF GAPS AND COMPETENCE FRAMEWORK

GEO supports regional training programmes in **Disasters** to develop individual capacity for drought, desertification, landslides and earthquake management (Latin America); **Climate and Health** – summer courses on data, methods and tools for integrating climate change and climate variability into public health decision-making (US). **Monitoring tropical forests** – training programs for students from developing countries, especially in Africa and South America. Receiving data via **GEONETCast** – the GEONETCast Training Channel.

The **GEO** community realizes that analyzing and modelling data from different sources can enhance their usefulness for decision making. As the GEO Report on progress emphasizes, "GEO has made significant progress in binging together many diverse datasets and engaging scientific and technical experts to generate this added value. Continuing progress will require more and more agencies and organizations to work together to adopt common standards for integrating and analyzing all types of data". However, GNSS is featured in the GEO Report only in one instance (in relation to the efforts led by the International Association of Geodesy to achieve highly consistent and interoperable geodetic reference frames, p. 39 of the *GEO Report on progress*, Group on Earth Observations, November 2010), and *no training activities related to the use of GNSS signals and applications* are promoted as part of GEO.

As shown by the ESA IAP projects, there are opportunities for GNSS to contribute to the GEOSS SBAs, and these opportunities are being explored in more depth by the Gfg2 project (see Roadmap Workshop 1 and Roadmap Workshop 2 http://www.gfg2.eu/events/gfg2-first-roadmap-workshop).

For building capacity in **GNSS** for GEEO, training should be seen as a form of knowledge transfer which directly influences industrial competitiveness. Training in GNSS will increase the pool of industry players aware of the opportunities of GNSS technologies and able to use them for their needs.

Information from interviews and feedback forms distributed at GNSS related events showed that several industry sectors, such as **energy, transport, agriculture, food industries, water management**, etc. already employ satellite navigation systems. These sectors are aware of current GNSS applications.

Training for **those industries that already use** GNSS technologies should focus on

(1) Fundamentals of the technology (improving the understanding of how it works may help application implementation that would lead to more responsible use and better informed procurement).

(2) Limitations and vulnerabilities (i.e. to understand the problems that can be caused by the use of these technologies).

(3) Integrity monitoring (i.e. how users can check the accuracy and reliability of the information received).

(4) Next generation signals and applications (users may provide feedback to manufactures on how to improve their products.

From analysis of the feedback data at GENIUS Professional Training events and market research done in France, the UK and Italy, a profile of how GNSS companies want to use the training has been created:

- The majority of companies will be SMEs, but there is interest from multi-nationals, start-ups, public institutions and research organisations; who want to have a better understanding of the technology that they are involved with.
- The company will send managers who oversee GNSS related work, engineers who use GNSS in the course of their work and software engineers who are developing algorithms etc.
- The (typical) individual put forward will be educated to at least first degree level, with a 60 % probability of postgraduate studies, although the subjects studied will not include GNSS directly The training will be to bring up to date existing knowledge of GNSS, acquired informally.

It is very easy to operate and process data from GNSS equipment with very little training or knowledge of the technology. Most of the people involved have been using standard equipment with the standard processing software and company support. GENIUS has responded to the need for companies to keep up to date with technological developments in the sector and create bespoke equipment and software "in-house".

Training for **those industries that do not use GNSS technologies** should focus on raising awareness of the different applications available: what their benefits are, where and how they can be applied.

Competence framework: What do you need to know

This framework, developed as part of an FP7 Project GENIUS, with the participation of GRACE, University of Nottingham, has proven to be efficient as a professional training programme providing GNSS training to employees of industry, research centres and institutions. The first five courses to be delivered in 2013 cover the following topics:

1. Fundamentals of GNSS
   A beginners' guide to GNSS technology: current systems available; concepts of global positioning, how the signal is used to determine location by the receiver and its accessibility. Sources of errors are discussed. An outline of future systems is given.
2. GNSS Receiver Signal processing for current and future signals
   Processing of GNSS receiver signal: the GNSS signal structure and the general architecture of a GNSS receiver. Fundamental principles of receiver signal processing for the acquisition and tracking of the current GPSL1 C/A signals. Presentation of the receiver signal processing adapted to the structure of the future GNSS signals, including those from the European Galileo system
3. GNSS Integrity Monitoring: An overview of why and how integrity is monitored, system architecture and future evolution.

4. Introduction to the vulnerabilities of GNSS. Overview of GNSS systems and technologies. Vulnerabilities of GNSS to interference, failures and errors. Overview of how the satellite navigation system architecture may be designed in the future to overcome these vulnerabilities.
5. GNSS Principles and Differential GNSS: An overview of the principles of Differential GNSS and its performance especially the treatment of errors.

There will be another five courses to be held in 2014. The programme will reflect user demand from the feedback from the first five courses or specific requests from industry.

Training options analysis

Current training at Gfg2 portal

At the time of completion of this report (March 2013), the following list of training material was available at the Gfg2 portal:

Training material		
Author	**Title**	**Date**
Jan Van Sickle, Penn State Univ.	GPS and GNSS for Geospatial Professionals	July, 2011
Thomas Herring, MIT	Principles of the Global Positioning System	September, 2011
Thomas Herring, MIT	Modern Navigation	September, 2011
Prof. Thomas A Herring, MIT	Seminar: Where are you?	September, 2009
Dr. Jan Johansson, CHALMERS University	Satellite Positioning	January, 2013

The GEOG 862 (Jan Van Sickle, Penn State Univ.) is an elective course for Penn State's Online Master of GIS. This course cultivates a working knowledge of current and future capabilities of GPS and the emerging Global Navigation Satellite System.

Principles of the Global Positioning system (T. Herring, MIT) is designed for undergraduate students to introduce the principles of the Global Positioning System and to demonstrate its application to various aspects of Earth Sciences. http://geoweb.mit.edu/~tah/12.540/

Modern navigation course and *Seminar: Where are you?* (T.Herring, MIT) were offered at MIT. The course looked at the evolution of navigation methods with concentration on the developments and applications of the Global Positioning System (GPS). http://www-gpsg.mit.edu/~tah/12.215/ The Seminar lasted several weeks and explored how positions on the Earth were determined before GPS; how GPS itself works and the range of applications in which GPS is now a critical element. This seminar is followed by a UROP in the spring semester where results from precise GPS measurements will be analyzed and displayed on the web.

Satellite Positioning (J.Johansson, CHALMERS University), a series of three lectures that (1) introduce the principles of the operation of GNSS and its limitations and applications. All currently known GNSS systems are included. Generic topics include millimetre accuracy positioning and kinematic GNSS, Atmospheric monitoring, GNSS Reflectometry. (2) Give overview of fundamentals of GPS, method of encoding GMS signals, fundamentals of correlation methods, specifics of the GPS system and (3) discuss receivers, observables and error sources.

An additional lecture was received from Kristine Larson, professor at University of Colorado at Boulder, USA, in March 2013, and it was agreed that it will also be available through the Gfg2 educational web page. The lecture deals with the use of ground-based GNSS (GPS in this case) to study important observational components for the Earth's water cycle. By studying the interplay between direct and reflected (off the nearby ground) signals, parameters such as the snow depth, the soil moisture, and state of vegetation, lake and sea level, can be inferred. Of course, the parameters to be studied must be relevant for the actual location of the antenna/receiver.

CONCLUSIONS AND RECOMMENDATIONS

Knowledge, skills and attitudes: the current training provision on the Gfg2 portal gives access to various training material including fundamentals of GNSS, current systems of GNSS, information about uses and applications, signal processing, error sources. It covers some gaps in training in terms of knowledge, skills and attitudes and can be used by those who have no prior knowledge of GNSS.

Delivery method: downloadable pdf files and/or MS PowerPoint presentations can be used by the target audience (industry employees).

Language: English

Recommendations:

1. Improve 'searchability' of the GNSS training material page in search engines.
2. Publicise to potential industry users.
3. Include a separate section on potential vulnerabilities (jamming, spoofing, ionospheric disturbance) to raise awareness of industry users that the technology could damage business operations
4. Highlight what benefits would accrue from having access to more than one satellite navigation system in terms of mitigating against system failures and vulnerabilities.

Annex 1

Source document: http://iap.esa.int/

Model table for Task 1.1, completed as part of the Scoping study. Full table is available from the Task leader, ULEIC.

Project title	Lead partner	Web link	Topic	Examples of Industry partners - some need to be verified if they are industry or services…	Theme	Target market
Savewater	VITO, Be	http://www.vito.be/	a feasibility study for integrated Satellite – AUV (autonomous underwater vehicle) applications in the field of water management.	www.waternet.nl/about-waternet ; www.microlan.nl/ ; www.argoss.nl/ (consultansy?)	water	Env agencies, coastal agencies, port authorities, ICT industry, AUV suppliers…
T4MOD-Remote assistance for medical teams abroad	Telespazio S.p.A, Italy	http://www.telespazio.com/	a user friendly Telemedicine system	http://www.gmv.com/ (Spain) R&D ICT solutions; http://www.ndsatcom.com/en/ (Astrium) ; http://www.covalia.com/ (France)	health	Hospitals, military health services
Sahel - Satellite African e-Health validation	Astrium Casa Espacio, Spain	http://www.astrium.eads.net/	satellite-based technology to compliment ICT in health services	http://www.ses.com Luxembourg, sat telecom ; http://www.oneaccess-net.com (France) telecom solutions ; http://www.indracompany.com/en (Spain) industry solutions	health	Medical staff
UASatcom - Geophysical and pipeline monitoring services	Barnard Microsystems Limited, UK - AUV design and manufacture	www.barnardmicrosystems.com/	AUV based airborne geophysical survey and oil and gas pipeline monitoring	http://www.inmarsat.com/ UK, mobile satellite company; http://www.ansur.no/ design innovative solutions for sat and mobile communications	energy	Oil & gas exploration and production companies (BP, Exxpn, Statoil etc.)
SpaceMon - Carbon capture and storage - Integrated Spaceborne Site monitoring	Infoterra GmbH, Germany	www.infoterra.de/	spaceborne radarinterferometry and navigation	http://www.axio-net.eu Satellite Positioning services Germany ;	energy	Operators of future CO2 storage sites