GMOSS: A NETWORK OF EXCELLENCE PROMOTING EO FOR SECURITY AND STABILILITY

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ABSTRACT

GMOSS is a network of excellence in the Aeronautics and Space priority of the 6th Framework Program of the European Union lasting from 2004 to 2008. Being part of the GMES program, GMOSS aims to "integrate Europe's civil security research so as to acquire and nourish the autonomous knowledge and expertise base Europe needs if it is to develop and maintain an effective capacity for global monitoring using satellite earth observation". The objective is, starting from a joint program, to establish links between researchers and their organisations that will sustain beyond the projects lifetime while identifying the gaps to be addressed by future research projects such as benchmarking of services, analysis of security scenarios, early warning indicators and reliable vulnerability assessment methodologies.

In this paper, the specificities of the network of excellence, its precise objectives, work plan, and achievements will be presented. The activities will be first described for the three supporting pillars of GMOSS: the first one dealing with security concepts, the second devoted to some selected security applications, and the third one concerning generic tools and methods more specifically designed for security applications. The horizontal work packages, aiming at the facilitation of partnership integration, will then be presented. In this respect, we focus on three activities that are considered as the core element of GMOSS: the setting up of common test cases, the participation of the network in a real-time exercise and the creation of an overall "benchmarking" concept. Last but not least, the training activities that have contributed to capacity building for EU and non-EU institutions are summarized, together with the outreach measures taken, and the Gender Action program established.

INTRODUCTION: THE GMES CONTEXT

More and more, citizens require their governments to make evidence-based policy decisions about the environment, including better predictions of natural disasters, epidemics, the impact of energy choices, and variations in the climate. Today there is much evidence that these issues should be addressed at a global scale, in a worldwide perspective.

Several initiatives have been made to assist governments in these tasks. In particular, the intergovernmental Group on Earth Observations (GEO) established in 2005, including 68 member countries, the European Commission, and 46 participating organizations, is leading a worldwide programme to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years (see http://www.earthobservations.org/).

GEOSS will work with and build upon existing national, regional, and international systems to provide comprehensive, coordinated Earth observations from thousands of instruments worldwide, transforming the data they collect into vital information for society. GEOSS is an ambitious pro-

gramme of information for ecological security and durable development intended for mankind. It principally foresees the monitoring and understanding of nature, the extent of disasters due to human activities, the impact of global warming, desertification, erosion and deforestation.

While the worldwide programme GEOSS seems more focused on environment related issues, the "Global Monitoring of Environment and Security" (GMES) programme, as its name suggests, also addresses the security aspect. The GMES initiative, developed by the European Space Agency and the European Union in 1998, thus seven years before the creation of GEO, is to establish a coherent, operational, long-term and user-dedicated information system that meets the specific needs for policy making and research in several fields such as environment, agriculture, regional development, security, and transport. The GMES initiative aims at supporting Europe's leading role in the monitoring of the global environment and provides support to policy makers in the fields of hazards and crisis management (see http://www.esa.int/). GMES has been a key item of the Aeronautics and Space priority in the Community's Sixth Research Framework Programme (2002 – 2006) and will remain so in the Seventh one (2007-2011). GMES will be built up gradually: it starts with a pilot phase which targets the availability of a first set of operational GMES services by 2008 followed by the development of an extended range of services which meet user requirements (see http://www.gmes.info/) [8].

In its environment dimension, GMES has adopted the priority areas of the 6th Environmental Action Program: climate change, biodiversity, environment and health and sustainable use of resources. In the security dimension, GMES focuses on conflict prevention and crisis management: civil protecting, humanitarian aid and the EU Common Foreign and Security Policy (see Global Monitoring for Environment and Security Final Report of the GMES Initial Period 2001-2003). These two dimensions are related in the sense that environmental problems may generate conflicts between nations and endanger security of individuals.

GMES consists of four main components: the space component, the in-situ component, the data harmonization and standardization component, and the user oriented services. The European Union makes uses of various tools such as Integrated Projects, Networks of Excellence (NoE), Strategic Targeted Research Projects and Specific Support Actions in order to address the various aspects of the four GMES components. The NoE has been introduced as a tool for the 6th framework programme. It is specific in the sense that its programme is updated every year and that it aims at the integration of the partners rather than on the creation of products.

In this context, the NoE GMOSS, lasting from 2004 to 2008, has been created in order to address the Security aspect of GMES. GMOSS is aiming at integrating Europe's civil security research so as to acquire and nourish the autonomous knowledge and expertise base Europe needs if it is to develop and maintain an effective capacity for global monitoring using satellite earth observation. The objective of the network is to get a critical mass of resources and experts in order to reinforce the scientific and technologic excellence for the benefit of the individual on the one hand, and a socio-economic stability on the other hand. The purpose is, starting from a joint program, to establish links between researchers and their organizations that will sustain beyond the projects lifetime while identifying the gaps to be addressed by future research projects such as benchmarking of services, analysis of security scenarios, early warning indicators and reliable vulnerability assessment methodologies.

In the following, we outline the objectives of the network, its work package structures (WP) and the involved partners. The various results will then be presented. The last section is devoted to the recent activities and to future perspectives.

GMOSS OVERVIEW

The specific objectives of GMOSS are the following:

- Share expertise and knowledge within the network

- Assess the current methods, algorithms and software required for the automatic (or semi-automatic) image interpretation and visualization of security applications

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Coordination	DLR

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- Provide best practices concerning the specific science and technology for treaty monitoring protecting from the proliferation of weapons of mass destruction, the estimation of population and their dynamics at a global scale, the infrastructures and borders monitoring, and the rapid damage assessment

- Finally, propose EO means and methods for the analysis and the understanding of threats on the civil society, in order to incite reactions adapted to the crisis evolution and to prevent conflicts.

The network GMOSS, coordinated by DLR, involves 22 Institutions and 13 associated partners as shown in Figure 1.

Figure 2 GMOSS partners.

The core of the network is made of three research pillars, represented in Figure 2. On the left, the security concepts, in the middle, the applications and on the right the generic tools more specifically designed for security. At each side of the core one can find the horizontal WPs that aim at a better partner integration, and the training and outreach activities.

Figure 2 GMOSS working structure.

SECURITY CONCEPTS

The report of the European security strategy [1] mentions terrorism, proliferation of weapons of Mass destruction, regional conflicts, state failure, and organized crime as the threats on our civil society.

The partners of the WP " Issues and Priorities" agreed on a classification and ranking of key threats and risks and the possibility to deal with these issues using Earth Observation. They identified the geographic localization of these key threats and risks by drawing on ESS and getting greater specificity by using UN/OSCE activities and NATO peacekeeping missions as indicators of areas of risk. This work has then been used by the "Scenario Analysis" Work package, and for the specification of the some test cases on which all partners could work. This is how test cases located in Irak, Iran, Zimbabwe and Kashmir have been identified by the network.

The WP "Responding to crisis" proposed to the network a real-time exercise simulating a nuclear accident. The goal of this exercise was to assess the workflow, identify gaps and shortcomings and improve effectiveness and methodology of the whole network while addressing a specific security problem. The three teams composed of GMOSS partners with complementary experience, were asked , to produce, a list of products within 36 hours. The operational base of each team was located at three different GMOSS institutions, gathering the most important task forces of the teams which were observed by some researchers, while some other partners were working remotely. The end users seemed to be very pleased by the results produced by the teams. This exercise on the one hand showed how partners from different cultural and technical background could integrate and use new methods answering some end-user needs, and on the other hand convinced the GMOSS partners that indeed games may be interesting tools for integration, analysis and training, as recommended by the WP "Scenario Analysis".

APPLICATIONS

The applications considered by GMOSS are Treaty monitoring, early warnings, damage assessment, population, infrastructure and border monitoring. The "Treaty monitoring" WP focused on nonproliferation of nuclear weapon treaties and on the verification of nuclear sites ([6], [7],[3]). The systematic development of keys for the nuclear fuel cycle [9], brought up thanks to image processing methods, is the core of their research and has been used to study the Esfahan test site. This site monitored by the International Atomic Energy Agency (IAEA) is Iran's largest nuclear research center and represents a key infrastructure of the Iranian nuclear programme. In particular, the estimation of building height thanks to stereoscopic satellite data combined with semi-automatic segmentation enable to establish the role of the buildings in the site.

The detection of rapid changes and hostile events in near real-time is of concern for any security system. The WP "Early warning" is using a unique and robust technique characterized by a high temporal and a low spatial resolution (MSG/SEVIRI: 15 minutes and 3 km) in order to identify hot spots, would they be from a natural origin such as a volcano, or criminal, as pipelines attacks. These hot spots are then used as indicators in conflict zones; they may also be used to analyze the scenario of the attacks.

The WP "population and border monitoring" is summarized as deriving indicators for the presence and characteristics of populations. It is done by using VHSR, medium resolution, night-time and possible UAV images in combination with various algorithms. These techniques have been used in the test case of Zimbabwe and Iraq ([5], [10]). The applications are focused on detection of dwellings in refugee camps, damage assessment in settlements in mountainous rural areas of Kashmir [4]and man-made infrastructures at the border of India and Pakistan.

The WP "monitoring infrastructure and damage assessment" worked on cases caused by natural as well as human origin. Indeed, the analysis of satellite images on the one hand enabled to estimate the damages in Kashmir and in Iran after the earthquakes of 2005, and the Tusnami at Sumatra in 2004 [2], and on the other hand to study the military operations in Iraq, the Ryongchon explosion in 2004 in North Korea, and the conflict in Darfur.

Finally, Swisspeace made its early warning forecasting tool "reporters" available (http://fastserver.unibe.ch).

METHODS

A feature catalog for security applications has been produced by the WP Feature extraction. A processing chain, valid for any image processing application, is completing their contribution. The latter involves pre-processing, optimization, segmentation, classification, and object detection, each module being discussed and compared inside the network. Moreover, the partners of this WP have proposed to share several toolboxes for this processing chain.

The WP Data visualization and integration has defined a Common Operational Picture and analyzed data mining, data access and visualization, and user interfaces, including webGIS applications. The team is also evaluating common tools such as Google Earth and Virtual Explorer in order to build a prototype of a virtual globe based search engine

Another catalog has been produced by the "Change Detection" WP. The latter lists the methods, sensors, resolution, etc., better suited for specific security applications. Several methods have been shared among the network and tested in particular on the Esfahan test case. In this example, volume detection computed from very high stereo pairs enable to hypothesize the building up of buried infrastructures.

HORIZONTAL ACTIVITIES

The network has organized many workshops. Initially, these workshops were gathering partners in-

volved in the same work package, in order to learn about each others expertise and share techni-cal details. By and by several common themes have been proposed to gather partners involved in different workpackages. For example, partners of the feature recognition WP, Change detection WP and infrastructure and damage assessment WP met at a Tsunami workshop.

The reviewers of the Network of Excellence GMOSS also suggested the use of common test cases on which partners could use and compare their tools, thus leading to the creation of a new work package "Test cases". In Irak, the security problem is related to the pipeline network that is subject to many attacks. In Iran, the main concern is to provide proven evidence on the existence or devel-opment of weapons for mass destruction and in particular nuclear weapons. Zimbabwe on the other hand is an example of monitoring an internal conflict by assessing the scale of destruction in urban settlements and by providing evidence on a government resettlement program; damage as-sessment and support to humanitarian action is the main focus in Kashmir.

Most applications assume data pre-processing: atmospherical corrections, data registration be-tween similar or different modalities, and ortho rectification. Now the working conditions in security applications are often sub optimal, as no ground control points are available, and viewing angle may be far from nadir thus introducing large deformation in hilly areas. The first task assigned to the benchmarking activity of the standard and benchmarking work package is to analyse and com-pare existing tools in a zone where ground control points are available, and to set up a concept of benchmarking task.

In the work package "sharing infrastructure", a tool has also been proposed by a partner for data management. Thanks to this tool partners have access to all meta data related to data available in-side the network.

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TRAINING AND OUTREACH ACTIVITIES

Outreach has been performed through various means.   GMOSS has a web site (http://gmoss.jr-c.it/) which will be maintained by the Joint Research Centre after the life of GMOSS. Quite a num-ber of joint publications have been produced by the network and the publication of a book is fore-seen in 2008. GMOSS has also been presented at several conferences and international events. Finally, the network has a specific gender action program. "Gender Actions", recommended by the EU, aim not only to encourage women activities in Sciences, especially in managing positions but also to consider the impact of the phenomena analyzed by the IP, NoE or SGE on female popula-tions or their specific role in the considered domain. In this context, GMOSS organized a workshop where the gender dimension of security has been addressed through a multidisciplinary approach.

As far as training is concerned, GMOSS is organizing every year a summer school for young reasearchers and future decision makers. The schools provide a spectrum composed of lectures on political context and technology, practical exercises in the form of lab-sessions and near real-time assignments, interactive working groups and panel discussions with users. The topics cov-ered so far are 'Rapid Information Extraction' (2005), 'Monitoring for Human Security - People, Homes and Infrastructure' (2006) and 'Early Warning and Monitoring of Agreements' (to be held in Madrid from Sept. 2-9 2007). Training courses devoted to specific techniques are also organized on a regular basis. The training coordinator of GMOSS, Z_GIS, also provides an e-Learning plat-form for security research.

GMOSS is also part of GMES, and thus has specific links with the several projects such as LIMES, TANGO, RESPOND, PREVIEW, etc. Other potential end-users are also contacted: UNOCHA, UN-OOSA, and OCDE, IAEA, FAO, ESA and NATO. The various ministries of Research, Technology, Foreign Affairs and Defense have been involved as potential end-users at various stages.

ACTUAL AND FUTURE GMOSS PLAN

For its last year of existence, the network is planning to concentrate its activities around horizontal

activities such as test case studies, scenario analysis, and its common repository containing data, publications, tools and methods.

As far as outreach activities are concerned, the network will use its last year in order to strengthen its links with GMES and potentials end-users, to publish a book in which each WP will have a con-tribution, , and finally continue its training activities.

The network will survive after its term in the fp6 program, thanks to its common repository, fed by all partners on a regular basis and maintained by JRC. No collective effort will be made in order to continue the network experience as such, mainly because of the administrative burden and the lack of funding devoted to common scientific research activities. Nevertheless, several cells involv-ing GMOSS partners have been created and will apply for the FTP7 program, in order to build on the developments produced thanks to the NoE. Some partners have also signed some bilateral agreements at their management level, insuring future collaborations.

Finally, the JRC has proposed to organize a series of security conferences, open to the whole community, thus proving an excellent opportunity for the researchers to meet at these events and exchange results or prepare future collaborations.

CONCLUSIONS

The GMOSS experience has been quite interesting so far. It enabled many European partners to set up a common research program, to jointly identify problems and challenges encountered by EO in dealing with existing and emerging threats to our civil society, and to compare their approaches and respective methods. Although at the scientific level all partners seem quite satisfied with the collaborations and exchanges brought in light by a long list of joint publications, the common activi-ties such as the real-time exercise, and training seminars, the administrative burden and the lack of funding for realizing the joint work is damping the partners enthusiasm.

GLOSSARY OF TERMS

GEO Group on Earth Observations

GEOSS Global Earth Observation System of Systems

GMES Global Monitoring of Environment and Security

GMOSS Global Monitoring for Security and Stability

IAEA International Atomic Energy Agency

IP Integrated Projects

JRC Joint Research Centre

MSG/SEVIRI: Meteosat Second Generation Spinning Enhanced Visible and Infra-red Imager

NoE Network of excellence

UAV unmanned aerial vehicle

VHSR Very High Spatial Resolution

WP Workpackage

Z_GIS Centre for GeoInformatics at Salzburg University

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