Project No.	SNE3-CT-2003-503699
Project acronym	GMOSS
Project title	Global Monitoring for Security and Stability

Instrument	Network of Excellence
Thematic Priority	Aeronautics and Space

Final Report

Period covered: *from 2004-03-01 to 2008-02-29*
Date of preparation: 2008-04-09

Start date of project: *2004-03-01* Duration:*48months*

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Project coordinator organisation name: *DLR* Revision V1

File name final_report v1.doc

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Executive Summary

Networks of Excellence were introduced in the 6th framework programme as an instrument designed to strengthen scientific and technological excellence on a particular research topic through the durable integration of the research capacities of the participants. They aim to overcome the fragmentation of European research by gathering the critical mass of resources and the expertise needed to provide European leadership. This excellence should also be spread beyond the boundaries of its partnership.
The initial proposal for the Network of Excellence GMOSS responded to a call of the Aeronautic and Space Priority of the 6th Framework Programme. The proposal, coordinated by the Joint research Centre JRC, was submitted in March 2003 and positively evaluated in May 2003. However, the evaluators recommended to reduce the consortium members from 52 to 24 and to refocus the work programme likewise. The total budget was defined to be six million Euro for four years duration.
Due to an internal policy decision the JRC abandoned the coordination of the Network for the operational phase and this responsibility was handed over to the German Aerospace Center, DLR. Negotiations with the European Commission started in October 2003 on the base of the revised work programme. The Consortium Agreement was agreed upon by the partnership in January 2004, and the contract with the Commission was signed in February 2004.
Finally, the Network of Excellence was launched on March 1st 2004. Unlike other remote-sensing-focused projects GMOSS is characterized by the end-to-end integration of political/socio-economic aspects of security with remote sensing capabilities and end-users support.

The aim of the GMOSS network of excellence has been 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 output and the impact can be evaluated with respect to their effectiveness and efficiency:

1. Expertise and knowledge of the partners is made available within the network and on European level (addressing the synergy)
2. The present and future generic methods, algorithms and software needed for the automatic interpretation and visualization of imagery for security applications, including feature recognition, change detection and visualisation are addressed
3. Best practises concerning the specific science and technology for:
    a. effective monitoring of international treaties protecting against proliferation of weapons of mass destruction;
    b. better estimates of static and dynamic populations on a global scale;
    c. better monitoring of infrastructure and borders;
    d. rapid remote assessments of damage;

   are compiled and disseminated.
4. Security threats are monitored and analyzed in order to incorporate information from EO for effective crises management and prevention

During the four years of the duration of GMOSS the consortium pursued to achieve these goals. It proved to be very effective that the planning had to be revised on an annual base, following the critical evaluation of work, thus allowing the network to react to new developments and to counteract possible shortcomings. These

capabilites were for example used to restructure the integration cluster, which in the end turned out to be central for the success of the NoE.
This cluster included the Test Cases, Workshops, Standards and Benchmarking, Sharing Infrastructures, and Staffing exchange.

In order to obtain a complex picture of the situation within the **Test Cases** the socio-political and socio-economical context was elaborated and discussed. This challenging task was successfully performed utilizing the interdisciplinary character of the network. The compilation of test case specifics regarding economic, political and social aspects, is a valuable compilation of relevant facts and background information. It provides a clear, profound picture of the situation at place, by highlighting the interrelationships of factors, the broader context and some key figures. Testcase-related scenarios could draw relevant information from this source. In this context respective envelope stories were elaborated for each testcase with input from other intelligence sources; drawing a comprehensive picture, especially for the presentation and dissemination tasks to the users and decision makers.

In the course of the investigations on different issues the partners realized that the variety on techniques, algorithms and software packages applied by the members of the network needed a common and thorough understanding. In order to fulfill this requirement, several benchmarking activities were proposed as a new approach in the late phase of the project lifetime. **Benchmarking** was applied in the testcases, too.
A short summary of achievements within each test case are given below:

- For the **Iraq** test case the attacks on Iraqi oil infrastructure and the instability in the Baghdad region were analysed. Attacks on the oil infrastructure are studied using hot spots observations from satellites with a high temporal resolution (SEVIRI, MODIS). These observations were compared with reports about pipeline attacks. Geospatial trends and social-political aspects were studied using geographical (GIS) data about pipelines, land cover, population density, and ethnic distribution and indicated which pipelines are most vulnerable to terrorist attacks. The Baghdad region was studied by monitoring the developing situation during and after the war in 2003 using (radar) change detection. Radar images can observe the Earth's surface even when smoke or clouds are present and can efficiently monitor changes. Also 3-dimensional data extracted from high resolution optical satellites are studied. The 3-dimensional data are used for situational awareness and to characterize changes obtained with the radar. The changes are related to damage, infrastructural change and economical.

- The objective of the **Pakistan/Kashmir** testcase was to analyse the impact of the strong earthquake that occurred on 8th October 2005, and in which the GMOSS partners were heavily engaged in providing information for the different phases of disaster management. After the conclusion of the first phases of humanitarian relief new developments and modifications of existing algorithms were applied in terms of landcover classification, generation of high resolution Digital Surface Models (DSM) from spaceborne imagery, change detection techniques, identification of damaged zones in urban areas from nighttime imagery, the assessment of damaged areas (infrastructure, houses, etc.), and some tests were carried out for 3-D modelling and 3-D change detection. It could be demonstrated, that remote sensing imagery is an important tool to assist the rescue and planning teams in the aftermath of the earthquake.

- The **Zimbabwe** testcase focused on means for monitoring humanitarian crisis situations and providing evidence for human rights violations, in order to support informed decisions on human security in a prevention phase. The so-called 'Operation Murambatsvina'f forced mass evictions, the demolition of homes and informal trading stores. High resolution satellite imagery has been used to gain evidence of such operations' impact on human rights and human security. Whereas satellite imagery can hardly answer the question why something has happened, image analysis and GIS techniques help analyzing both number and type of structures destroyed, and provide estimates about numbers of affected people and provide visual evidence of the scale of destruction. In addition to damage assessment, remote sensing capabilities can be used to monitor progress made on reconstruction efforts and the effectiveness of humanitarian support. The proposed methods show great potential in supporting focused reactions during emergencies, yield rapid identification of affected areas and contributed evidence for legal action in situations where ground truth information is difficult to obtain.

- The test case on the **Iran** investigated whether automated computer-based satellite imagery analysis could help to verify the Non-Proliferation Treaty (NPT). Taking the Iranian nuclear programme as an example, different automated pre-processing, change detection, classification and visualisation techniques were applied to optical, thermal and radar satellite imagery. The aim was to monitor the development of some relevant sites in the Iran: Arak, Bushehr, Esfahan, Natanz and Saghand. Using (very) high resolution optical imagery, small-scale structural features of interest, such as construction and shape of buildings, were extracted. Changes of the operational status were detected by using thermal infrared data. 3D modeling based on very high resolution stereo imagery helped to analyse building constructions and underground activities. The information gathered from automated satellite imagery analysis could be used to verify the correctness and completeness of the NPT Member States declarations. Moreover, EO data provides preparatory information for inspection and other technical visits on-site. We have shown in the Iran test case that nuclear safeguards-relevant information can be (semi-) automatically extracted from EO data. (Semi-) automatic algorithms are essential for wide-area monitoring and facilitate the detailed detection and analysis of small-scale features of interest.

Part of the success of GMOSS was due to **workshops and conferences**. On average, GMOSSorganized two overall integration workshops a year, thus involving all partners and all WPs. These overall workshops were opportunities to meet other partners and propose new activities. In particular, the suggestion to start common activities on Test Cases, on benchmarking algorithms and on the GMOSS Near Real-Time Exercises (GNEX) was instrumental to facilitate integration. Apart from GMOSS internal meetings, some of the events were opened up for project externals. These were mainly possible end-users or project responsibles of other GMES and security projects. This information exchange was leading to the integration of GMOSS partners and/or ideas in related research initiatives, where GMOSS members are in the core of relevant activities. This is a clear indication for sustainable strengthening of this research area.

The network intended to engage partners of respective consortia in training measures as a way to stimulate the exchange of expertise. Users from the communities-of-practice had been involved in training events (such as GNEX, summer schools and seminars) to increase the awareness about the benefits of using spatial information for decision making in security situations. The activities of the training program cater not only for outreach, but also strongly facilitate the integration within the partnership. The year 2007 may serve as an example: following the presentation of the test cases in an integrated analysis framework during the Review Meeting in The Hague (April), the third Summer School on ‘Early Warning and Monitoring of Agreements’ in Madrid (September), and a Seminar on ‘Environment and Conflict’ in Bonn (October) provided platforms for exchange between different communities. It is by these ‘interfaces’ that the network attracted a substantial number of institutions from sectors such as policy analysis, science and technology and service providers to apply for associated partnership.

Another achievement of GMOSS was the development and setting-up of the so called **GNEX exercises**. The exercises were set up such, that the teams were confronted with challenging, rapid response (matter of hours and days) analysis task on a predefined scenario, which no single network partner could handle alone or manage directly. The primary objective of this type of exercise was to strengthen integration and coordination among the partners and associated organizations, by being forced to split a complex analysis task into subtasks, distribute and share the processing and interpretation work and finally compile the individual results into a common answer to the scenario questions. Furthermore, the exercise aimed at helping to assess and demonstrate the state-of-the-art of satellite imagery analysis and handling by the GMOSS NoE partners and teams. In addition, the exercises should help to involve users and decision makers in the domain of civil crisis response into the work of GMOSS and to demonstrate to them the added value of EO based information in civilian crisis response using GMOSS methods. In doing so, the exercise supported the political process for paving the way for the operationalization of these new developments.

A very specific achievement of GMOSS is the **Gender working group** that managed to address gender issues in the network both thematically and institutionally by organising on the one hand a conference on gender-specific issues of security and on the other hand by highlighting the importance of work-life balance also in research environments resulting in arts exhibition.

The integration and dissemination activities for gathering a critical mass of resources and the expertise were only one part of the objectives of the network. A central part of the network was the **development of generic methods**, algorithms and software needed for the automatic interpretation and visualization of imagery including feature recognition, change detection and visualisation. Using these tools **best practises** for areas such as effective monitoring of international treaties protecting against proliferation of weapons of mass destruction, better estimates of static and dynamic populations on a global scale, better monitoring of infrastructure and borders and rapid remote assessments of damage were designed and tested. All this was supported by **investigations of present and future threats to security** and the needs for exchange of information between stakeholders during crises.

1. Cross cutting activities

1.1. Work Package 10000: Integrating activities

1.1.1. Executive Summary

The integration pillar in GMOSS includes most of the NoE horizontal activities. The latter involved Test cases (WP 10100), workshops (WP 10200), Standards and Benchmarking (WP 10300), Games (WP 10400), Sharing Infrastructure (W 10500) and Staff exchange (WP 10600). The focus of these activities evolved during GMOSS lifetime:

- the tasks of WP 10300 moved to WP 21 200 Responding to Crisis which set up two real-time exercises;
- the focus of WP10100 changed to Test cases when, after two years, the NoE felt the need of real-time problems within which the applications, the technical tools, and the security concepts could be co-addressed;
- the benchmarking component of WP 10300 has been introduced when the partners wished to establish a benchmarking of the generic tools necessary for security applications.

The choice of test cases in Kashmir, Iraq, Zimbabwe and Iran has been made on the basis of a list of criteria. Partners were then able to address all issues related to the selected events, including the socio-political aspects, the pre-processing phases and the analysis. On similar data, partners could compare their methods and tools.

There were different types of GMOSS workshops: overall integration workshops, cluster-based workshops, Test case workshops, WP workshops, or meetings involving externals. All these events were opportunities to present new methods, to compare results, to set up a common road map, to meet some end-users, and to keep track of the activity of the NoE.

The early work of WP 10300 showed that partners were not very concerned by standards. The real-time exercise (GNEX'07) however showed their needs, in particular in the domain of land cover for example. QinetiQ, responsible of this WP, nevertheless identified relevant geospatial standards for GMOSS activities and recommended the use of JPEG2000 imagery standards. As far as the benchmarking component is concerned, a top-down and a bottom-up approach have been used. A theoretical concept has been set up by Joanneum, listing all modules to be benchmarked. On the other hand, several partners' teams concentrated on the benchmarking of some of these modules such as pan-sharpening, and counting dwellings.

The WP Sharing infrastructures dealt with shared satellite data and shared software and produced a catalogue. Finally, WP 1600 promoted and monitored staff exchanges during then GMOSS life, identifying and setting up the methods to make them happened.

1.1.2. Introduction

WP 10000 was assigned to Harald Mehl, DLR, the first year of GMOSS funding and to Vinciane Lacroix, RMA, during the last 3 years.

According to the gmoss technical annex, the initial role of the WP leader was:

1. define success criteria for the network and steps towards reaching these goals
2. define and update indicators to measure the overall integration of the Network
3. organizing the collection of these indicators from the managers of workpackages
4. rethinking the partnership based on the degree of integration

After the first year, the role of the integration coordinator has been modified so as to:

- share the first three responsibilities together with the research coordinator (WP 20000) , the training coordinator (WP 30000), the GMOSS Coordinator (WP 40000), and the executive committee
- keep track of the activities of all the integrating WPs and to some extend, of the technical WPs
- follow the participation of the partners
- suggest WP modifications (merging, suppression, leadership change) based on the degree of integration and of activities
- provide recommendations on the focus of the activities (Test Case, users focus, gender issues, benchmarking)
- assist the GMOSS Coordinator (WP 40000) together with the research coordinator (WP 20000) and the training coordinator (WP 30000) in particular with respect to the organization and contents of integration meetings, technical seminars and summer schools
- transmit reviewers' recommendations to the consortium

1.1.3. Achievements

Indicators of integration

After the first year, an agreement within the management team led to some table of indicators. However, these indicators did not satisfy the reviewers and the EC officer responsible of the NoE. The discussion between all parts went on during one year, and even further to finally come to a final table. At that point, still some figures were very difficult to extract from the reports as information was spread and duplicated in several work packages. It was finally suggested that each partner contribute to the table, but even as such, the process had difficulties in converging to a satisfying state.

The final indicator table shows that after 4 years, the network:

- produced a large compendium of knowledge under various forms (GMOSS book, JRC Report, test cases documentation, brochures, etc.)
- during its last years took much benefit of the staff exchange possibilities
- trained many researchers and students thanks to technical workshops and Summer Schools
- shared data (meta-database at QinetiQ, image repository and test case data base at JRC, benchmarking data base at JR, GNEX data base at DLR), and software tools (RSG from JR, MAD from TUD, ORFEO-toolbox from CNES, LULC from Z_GIS, Xdibias from DLR, etc.)
- was able to re adjust its work thanks to a flexible WP structure

- deepened integration thanks to many workshops, games (real-time exercises) and joint publications
- generated subgroups proposing new joint research or training network (SAFER, LIMES, G-MOSAIC, GEMOSEC, etc.)
- produced a concept for benchmarking and produced recommendations for standards
- realised well documented join-work on Test cases (workshops, publications, dissemination meeting, etc.)
- linked to other GMES programs, and to end-users (through several meetings and workshops)
- is broadly known thanks to dynamic outreach activities (book, brochures, flyers, website, publication, gender exhibition)
- had an interesting Gender Action Program through a "Gender and Security Conference" and an artistic exhibition on the work-life balance of some GMOSS researchers
- will survive after the funding period, thanks to the living website, yearly conferences organized by JRC, and to the several agreements of cooperation and memorandum of understanding signed by several partners.

Integration WPs

Several suggestions have been made during the course of GMOSS life with respect to integration WPs, such as the creation of a Test Case WP, with a shared responsibility, so that each test case could be followed by some partner, and the creation of a benchmarking WP. The horizontal integrating WPs thus became: Test Cases, Workshops, Standards and Benchmarking, Sharing Infrastructures, and Staffing exchange. All these WPs provided interesting results and most of them succeeded in making GMOSS partners integration a true story!

1.1.4. Conclusions + recommendations + impact

According to the table of indicators, after 4 years of existence, the initial integration objective has been reached, and the horizontal WPs have been well designed to achieve this goal. However, WP10400 on Sharing Infrastructure, and part of the WP10300 on Standards, despite the work done in these WPs, did not reach the foreseen impact. One reason for this was that their work was not enough integrated in the overall structure, and that the WP leaders were quite isolated in their work. All other WPs were indeed involving the work of other partners: WP 10100 was directly connected to partners involved in the analysis of test cases, WP 10200 was dealing with all workshops, and thus with all WPs and partners, the part of WP 10300 dealing with benchmarking required tests to be performed on algorithms shared by partners, and finally WP 10600 had to deal with all staff exchanges and was thus in touch with all partners. Another reason was the lack of awareness of partners with respect to the importance of the issues dealt in these WPs.

A recommendation would thus be to create horizontal WPs having a direct and explicit connection with other WPS or partners, and to suggest, when applicable, a team of partners under the responsibility of a leader, as for the technical WPs, or explicit links to the network activities.

1.2. Work Package 10100: Test cases

1.2.1. Executive Summary

The concept of human security, while unified by a common focus on humanitarian crisis and disasters, covers a wide spectrum of crisis-related issues, ranging from natural hazards (e.g. earthquakes, floods, droughts, etc) to human-induced threats (like terrorism, proliferation of nuclear weapons) and protracted crises as being triggered by civil wars or state failures. The four GMOSS test cases, i.e. Kashmir, Zimbabwe, Iraq and Iran, were selected by the premise to address this variety of possible scenarios within human security, while at the same time considering actual or recently past security-related events and disasters. The test cases, to different degrees, represent instances of rather complex, protracted crisis, but for the sake of clarity and demonstration, the NoE has focused on specific aspects in each test case.

The purpose of the test cases within GMOSS was to provide a real-life context within which to place and apply the technical methods and tools being developed and shared. Furthermore, the test cases to a great degree supported the integration activities between the GMOSS partners, since sharing and deepening technical and socio-political experiences was a prime objective.

Kashmir was selected as a test bed for the installation, completion and exercising of the GMOSS expertise in the field of remote sensing and crisis management. After the strong earthquake in Pakistan on 8th October 2005, falling into the duration of the project, the partners decided to work on this application case. Zimbabwe was chosen in order to demonstrate the importance of a crisis-alert system with a focus on monitoring humanitarian crisis situations and providing evidence for human rights violations. In addition to overall damage assessment, remote sensing capabilities can – and should be – used to monitor progress made on reconstruction efforts and the effectiveness of humanitarian support. Iraq was focused on to demonstrate the use of remote sensing for the monitoring and analysis of pipeline attacks (thus affecting the country's economy) and the unstable situation in Baghdad. Finally, the case of Iran, discusses the potential of EO based techniques for treaty monitoring, in this case the treaty of mass destruction weapons, by providing evidence on the refinery of nuclear material in dedicated plants and other activities as controlled by IAEA.

1.2.2. Introduction

The GMOSS network started in 2004 as a large (and rather lose) group of partners from very different scientific fields and backgrounds. In the initial phase an intensive discussion took place how to better integrate work in such a network and how to make it to a success. Based on these discussions, and especially during the meetings in Brussels/B (14/15 November 05) and Graz/A (13/14 December 05), it was decided to establish a test bed for intensifying integration and research activities. The working meeting in Graz was arranged to consist of three splinter groups focusing on following main issues: visibility, integration, feasibility. After intensive discussions the group results were presented and showed a ranking of the test cases according to the group internal arguments. Finally, three test cases (Iraq, Kashmir and Zimbabwe) were chosen. A number of tasks have been defined for the following three months in terms of data and user selection, feature identification, etc. The next planned workshop for the test cases should take place before the concerted work on the testcases start. With respect to the defined deadlines this workshop took place in April 2006 in Salzburg/A. During the meeting in Belgirate/I (7/8 March 2006) a test case team was determined by the consortium and the partners elaborated a working programme. The testcase team consists of Klaus Granica (Joanneum Research) for Kashmir, Bert van den Broek (TNO) for Iraq, and Stefan Lang (Z_GIS) for Zimbabwe.


Results of the testcase workshop in Graz December 2005 and the test case coordinators during the final meeting in Brussels 2007.

During the Integration Meeting in Farnborough/UK (21-23 November 2006) preliminary results were presented by the partners and further integration activities were discussed. The relevant research topics for each test case were identified and the GMOSS partners have organised themselves according to them. The Farnborough meeting was considered a significant milestone with regard to the integration activities getting ‘materialised’. During the meeting, it was decided that Iran should become one of the GMOSS test cases. The Iran test case was co-ordinated by Irmgard Niemeyer (TUBAF).

On February 15/16, 2007 a dedicated test case workshop was organised in Torrejon/E for the final years planning and to obtain a comprehensive overview of the work done by the partners including integrated activities for GNEX and benchmarking. On March 16/17, 2007, a workshop was held among test case coordinators and other experts from the NoE in London/UK. The purpose was to establish scenarios and to link the thematic focus of the test cases with the prevailing socio-political background.

Throughout the remainder of the GMOSS project, the test cases were a dedicated session topic in all dissemination activities. Starting with the Integration Meeting in The Hague/NL in April 2007, two events in Brussels were organised. Facilitated by the Commission project officer, a meeting for the EC members the Dissemination Meeting in Brussels (Oct 2-3, 2007) addressed representatives from DG Enterprise, DG RELEX, GMES Bureau, and several GMES projects (LIMES, BOSS4GMES, Preview) participated. The final project meeting was held 11-12 December 2007 in Brussels. An overview on the test case activities for the whole GMOSS lifetime was given by the coordinators, including concluding remarks and outlook comments.

1.2.3. Achievements

In order to achieve a thorough understanding of the pursued test case tasks and to obtain an overview of partner interests and respective experience, a questionnaire was sent out in early 2006. According to the response the topics were extracted; by this the coordinators could condense the planned work to the main integration and research issues. During the meeting in Salzburg in April 2006 an evaluation was performed for defining appropriate data sets and planned activities. Sets were acquired starting in May 2006, and research work could started on the testcases.

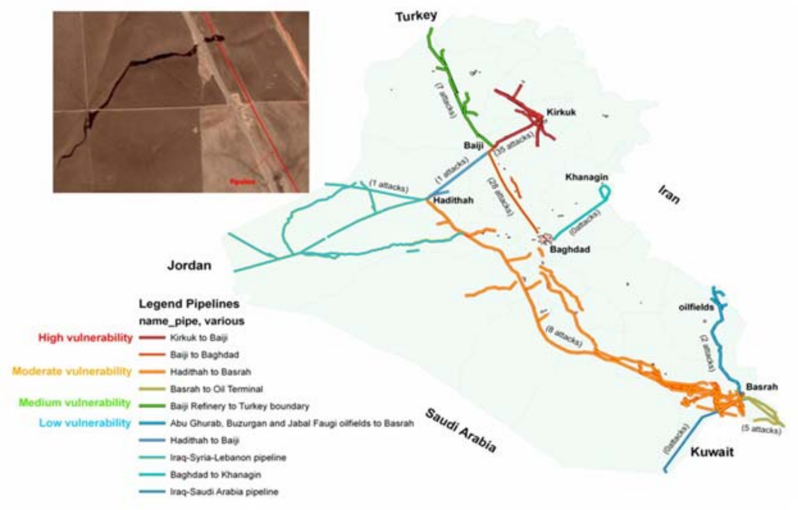
The testcase teams identified their research topics and organised their integrated working procedure in the following months.

In order to obtain a complex picture of the situation within the testcases the socio-political and socio-economical context was elaborated and discussed. This challenging task was successfully performed utilizing the interdisciplinary character of the network. The compilation of test case specifics regarding economic, political and social aspects, is a valuable compilation of relevant facts and background information. It provides a clear, profound picture of the situation at place, by highlighting the interrelationships of factors, the broader context and some key figures. Testcase-related scenarios could draw relevant information from this source. In this context respective envelope stories were elaborated for each testcase with input from other intelligence sources; drawing a comprehensive picture, especially for the presentation and dissemination tasks to the users and decision makers. During the meetings in The Hague, Farnborough and Brussels an information market was organized to provide condensed to and trigger feedback from the users.

In the course of the investigations on different issues the partners realized that the variety on techniques, algorithms and software packages applied by the members of the network needed a common and thorough understanding. In order to fulfill this requirement, several benchmarking activities were proposed as a new approach in the late phase of the project lifetime. Benchmarking was applied in the testcases, too. Short summery of achievements within each test case are given.

Iraq

For this test case two main topics are studied: 1) attacks on Iraqi oil infrastructure and 2) instability in the Baghdad region.



Overview of pipeline vulnerability in Iraq on basis of a GIS based study and impact of oil spill in a high resolution optical image.

Attacks on the oil infrastructure are studied using hot spots observations from satellites with a high temporal resolution (SEVIRI, MODIS). High resolution optical imagery can be used to observe the impact of attacks on the environment. These observations are compared with reports about pipeline attacks. Geospatial trends and social-political aspects are studied using geographical (GIS) data about pipelines, land cover, population density, and ethnic distribution. Such a GIS-based analysis can indicate which pipelines are most vulnerable to terrorist attacks.

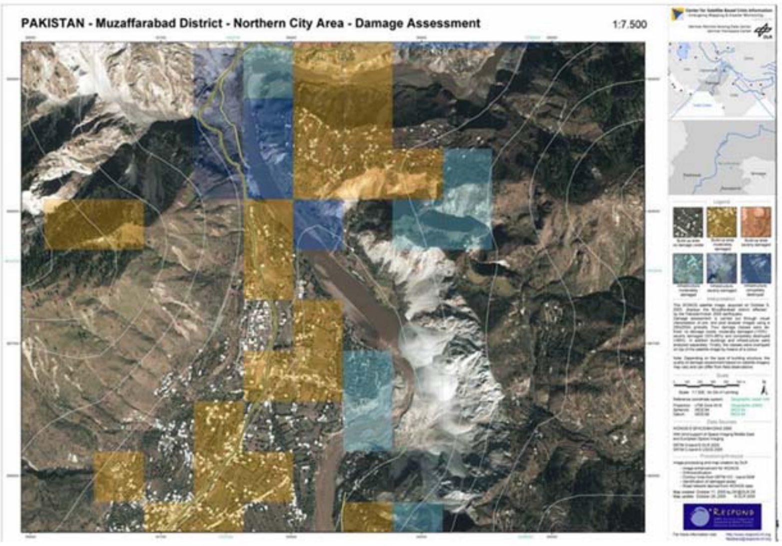
The Baghdad region is studied by monitoring the developing situation during and after the war in 2003 using (radar) change detection. Radar images can observe the Earth's surface even when smoke or clouds are present and can efficiently monitor changes. Also 3-dimensional data extracted from high resolution optical satellites are studied. The 3-dimensional data are used for situational awareness and to characterize changes obtained with the radar. The changes are related to damage, infrastructural change and economical activity.

Multi-temporal Radarsat image of the Baghdad area from 23 April 2003 (blue), 17 July 2005 (yellow) and 2 April 2007 (red). Colours indicate change.

Other work comprises a GIS based study of cancer incidences in Iraq after 1991 and GIS development and webGIS server issues for data integration.

Kashmir

In the Kashmir testcase a strong earthquake occurred on 8th October 2005, and the GMOSS partners were heavily engaged in the phases of disaster management. For crisis management and recovering tasks the use of satellite imagery has proved to be of high importance. Especially, in the aftermath of the earthquake there was a disruption of the information channels for about ten days. In this critical status quick information was delivered by the team of ZKI RESPOND (see figure) using spaceborne data.



Example of a map from Muzzaffarbad showing the degrees of damage for settlements and infrastructure.

In the later phase new developments and modifications of existing algorithms were applied in terms of landcover classification, generation of high resolution Digital Surface Models (DSM) from spaceborne imagery, change detection techniques, identification of damaged zones in urban areas from nighttime imagery, the assessment of damaged areas (infrastructure, houses, etc.), and some tests could be applied for 3-D modelling and 3-D change detection.

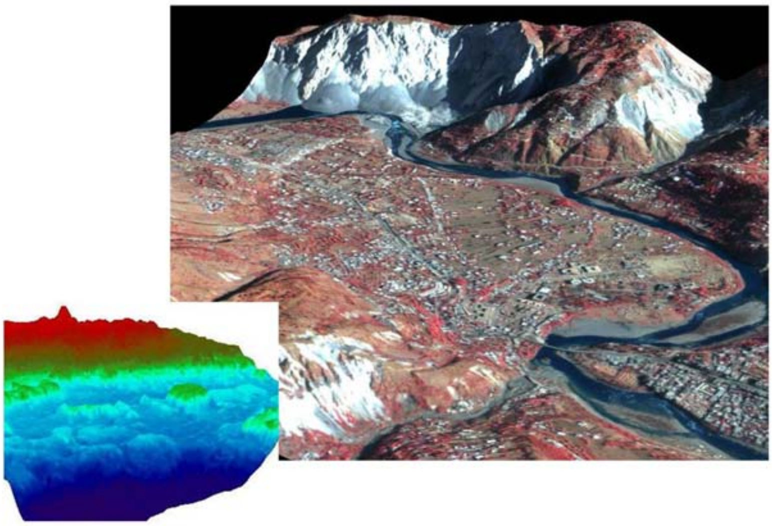


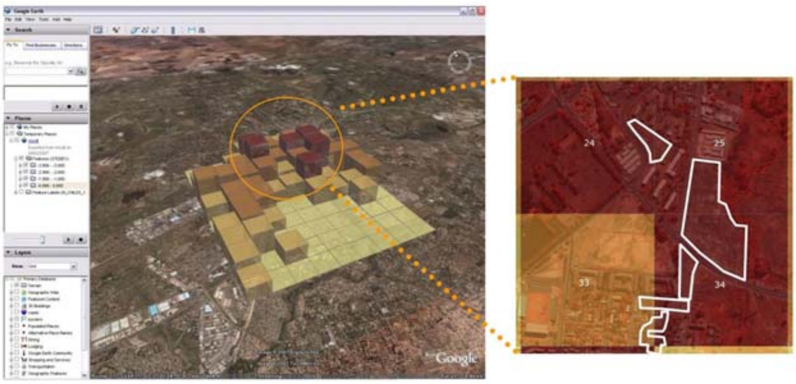
Figure 5. A 3-D view from IKONOS imagery based on a high resolution DEM (left image).

It could be demonstrated, that remote sensing imagery is an important tool to assist the rescue and planning teams in the aftermath of the earthquake.

Zimbabwe

The Zimbabwe testcase focused on means for monitoring humanitarian crisis situations and providing evidence for human rights violations, in order to support informed decisions on human security in a prevention phase. Operation Murambatsvina, also known as Operation Restore Order, was a country-wide operation, carried out by the Zimbabwean Government, of forced mass evictions, the demolition of homes and informal trading stores. The United Nations (UN) has estimated that in six weeks between May and July 2005, 700,000 people across Zimbabwe lost their homes and their livelihoods as a consequence of Operation Murambatsvina. In some areas entire settlements were razed to the ground. While the demolitions took place right across the country, the majority of the destruction occurred in high density urban areas in Harare, Chitungwiza, Bulawayo, Mutare, Kariba and Victoria Falls. When Murambatsvina was still going on, the Zimbabwian Government officially launched a reconstruction effort, called Operation Garikayi (Reconstruction/Resettlement). This operation involved financing for the construction of houses, factory shells and market stalls. While the Government will provided stands (plots), those rendered homeless will build their new homes supported by loans. Evidence on the ground however suggests that the operation was hastily put together, did not meet the immediate needs of the people affected, and progress against the planed objectives was slow.

High resolution satellite imagery has been used to gain evidence of such operations' impact on human rights and human security. Whereas satellite imagery can hardly answer the question why something has happened, image analysis and GIS techniques help analyzing both number and type of structures destroyed, and provide estimates about numbers of affected people and provide visual evidence of the scale of destruction. So far, the assessment of damaged areas was accomplished by visual interpretation of corresponding before and after images. In addition to damage assessment, remote sensing capabilities can be used to monitor progress made on reconstruction efforts and the effectiveness of humanitarian support.



Left: Aggregated change of urban area between 2004 and 2005. Dark values indicate areas with a higher higher probability of change (3D analytical view on placed on Google Earth). Right: Cells corresponding with the destroyed area of the township Mbare.

Detected sites (including townships of Mbare and Glen Norah) were investigated further by comparing visual inspection and automated delineation: in a section of the test site of Mbare 98 shacks have been detected visually and 102 shacks have been detected automatically. After a presumption of Brown (2001), up to 12 people live in one single shack in these areas; this number seems to be too high because of the small size of the buildings, so we limited the number to 8-10 people per shack. This would lead to a population estimation of 800-1000 people for this test site. In an area of the Glen Norah test site 63 shacks could be visually detected and 135 were detected automatically. In this study area the automatic extraction of buildings seems to be harder, because of the low spectral difference within the informal settlement. Especially in the transitional zone of the shacks, bare soil and respectively the non-asphalted streets were often classified as shacks. An overall population number 7160 people (visually) and 8690 people (automatically) has been estimated for the area of Mbare. For the second test site Glen Norah, visually 3060 people and automatically 5620 people were estimated.

To obtain accurate figures of buildings built up during operation Garikayi, change detection analysis were carried out on QuickBird scenes from 2004 and 2006 (Hacliffe Extension), 2005 and 2006 (White Cliffe) and 2005 and 2007 (Hopley Farm). In Hatcliffe Extension the situation before operation Murambatsvina and after operation Garikayi was analyzed. Manual counting of buildings in 2004 and 2006 delivered the following figures: small, bright roofed buildings: 460 (2004) and 998 (2006); small, dark roofed buildings: 286 (2004) and 320 (2006); elongated structures: 60 (2004) and 191 (2006). Change detection analysis showed that there are only few structures left from the previous ones.

This corresponds to the situation in other operation Murambatsvina sites, like Mbare and Glen Norah in Harare. In White Cliffe, former barren land was used for operation Garikayi reconstruction efforts. In this case IKONOS images from June 2005 and August 2006 were acquired. In August 2006, 346 buildings were detected visually and 393 were classified automatically. These numbers correspond roughly to figures published by Amnesty International and other NGO´s members, which visited this site in May 2006. The actual state of development of this plot of land would be very interesting and should be subject of further research. The Hopley Farm resettlement area is built on former agricultural used land. In April 2005, one month before operation Murambatsvina, there was no single building in this area. 1507 buildings were detected visually and 1726 were automatically classified on the March 2007 scene.

In these test areas QuickBird images were used for our analysis. For comparison reasons, certain spatial statistics like mean patch size, mean nearest neighbour distance and proximity, were calculated based on the classification results. By this we could verify some of the reported grievances (lack of infrastructure, small building size, high density…) as indicators for the unplanned nature of these settlements.


Results of the visual detection (left, 346 buildings) and the semi-automated extraction (right, 393 buildings).

The proposed methods show great potential in supporting focused reactions during emergencies, yield rapid identification of affected areas and contributed evidence for legal action. Additional indicators were investigated for monitoring the stability of livelihoods in rural areas, land-use changes (e.g. agricultural activity, water availability, patterns of subsistence farming).

Iran

The test case on the **Iran** investigated whether automated computer-based satellite imagery analysis could help to verify the Treaty on the Non-Proliferation of Nuclear Weapons, also referred to as Non-Proliferation Treaty (NPT). The Treaty has established a nuclear material safeguards system under the responsibility of the International Atomic Energy Agency (IAEA).

IAEA inspections since 2003 have revealed two decades' worth of undeclared nuclear activities in Iran, including uranium enrichment and plutonium separation efforts. Iran says its nuclear ambitions are peaceful. It is a signatory of the Non-Proliferation Treaty (NPT); its nuclear programme began in the Shah's era, including a plan to build 20 nuclear power reactors. Iran also signed the important additional protocol of the NPT safeguards agreements, however, this was not ratified by the Iranian parliament.

Given Iran's insufficient uranium reserves, Iran cannot achieve its goal of nuclear energy independence. Moreover, indigenous fuel cycle costs are substantially greater than importing nuclear fuel at market prices.[1] The country has an abundance of energy resources, with reserves of natural gas and substantial oil reserves. However, Iran's uranium reserves could give Iran a significant number of nuclear weapons. [2] Iran's facilities are scaled exactly like another state's facilities that were designed to produce fissile material for nuclear weapons.[3]

Overview on some Iranian nuclear facilities: Arak, Bushehr, Esfahan, Natanz, Saghand © Forschungszentrum Jülich

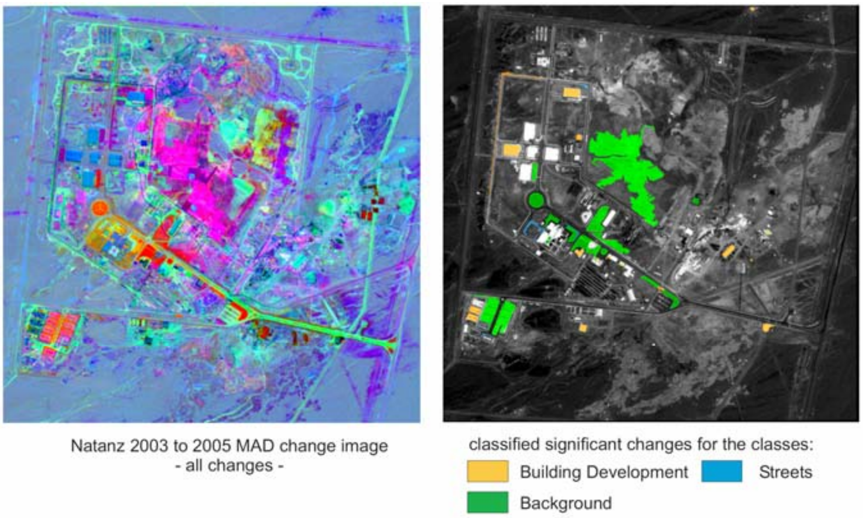
The aim of the Iran test case was to monitor the development of some relevant sites in the Iran: Arak 40 MW Heavy Water Reactor, Bushehr Power Plant, Esfahan Nuclear Technology Center (ENTC), Fuel Enrichment Plant (FEP) Natanz and Saghand Uranium MIne.

Using multispectral, radar, and hyperspectral satellite imagery, such as QuickBird, ASTER, Radarsat and HYPERION, it was investigated:

- what significant features of nuclear facilities / activities / processes are identifiable from space?

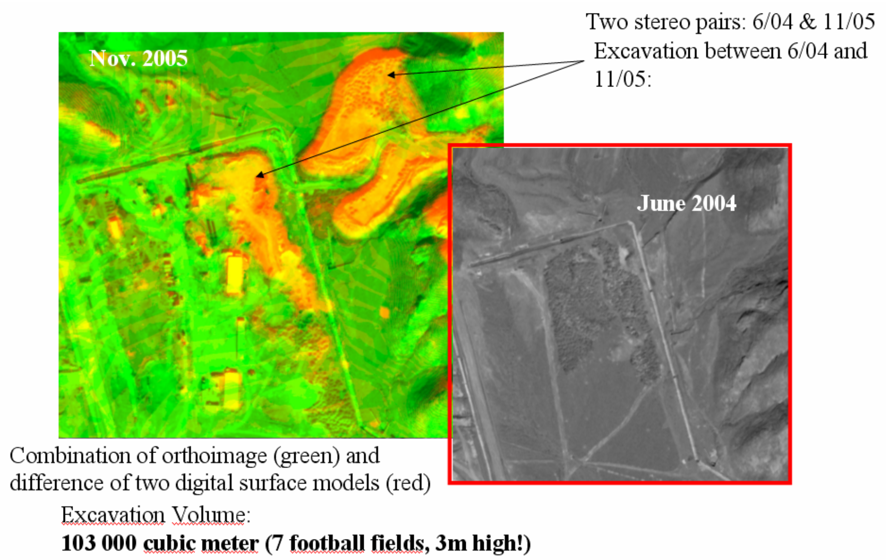
[1] US Department of State: Iran's Nuclear Fuels Cycle Facilities: A Pattern of peaceful Intent? Briefing slides presented by the US to foreign diplomats in Vienna, September 2005
[2] http://www.globalsecurity.org/wmd/world/iran/nuke.htm
[3] US Department of State, ibid.

- how these signature could be utilised for image analysis (visual interpretation / semantic modelling)



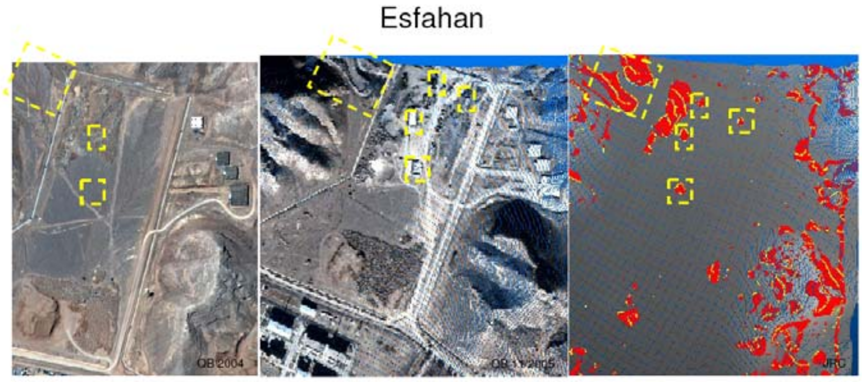
Detection (left) and classification (right) of changes at Natanz between June June 2003 and August 2005 © Forschungszentrum Jülich

(Very) high resolution optical imagery were analysed using pixel- and object-based change detection and classification techniques. Thus, small-scale structural features of interest, such as construction and shape of buildings, were extracted.



Subsurface constructions, underground activities at Esfahan. 3D change detection using stereo pairs of June 2004 and November 2005 © DLR

Changes of the operational status were detected by using thermal infrared data. For monitoring uranium mining activities, hyperspectral imagery was investigated. 3D change detection based on digital surface models from very high resolution stereo imagery helped to analyse building constructions and underground activities.



3D Change detection (right) using QuickBird stereo pairs of June/July 2004 (left) and November 2005 (middle), Esfahan © JRC

The information gathered from automated satellite imagery analysis could be used to verify the correctness and completeness of the NPT Member States declarations. Moreover, EO data provides preparatory information for inspection and other technical visits on-site. We have shown in the Iran test case that nuclear safeguards-relevant information can be (semi-) automatically extracted from EO data. (Semi-) automatic algorithms are essential for wide-area monitoring and facilitate the detailed detection and analysis of small-scale features of interest.

1.2.4. Conclusions + recommendations + impact

Following the ideas of networking as a main driver of the NoE, it was a big challenge in the GMOSS NoE to find powerful means, instruments and facilities for a successful performance. It turned out that one of the key ideas was the initialization of a testcase bed for the integration of research topics. The 22 partners and 14 associate partners were interested in a diversity of fields, and consequently a process had to be triggered for finding a common understanding how testcases could be arranged. In thorough discussions of some working groups an agreement was found to concentrate the network activities on the GMOSS testcases, whereas work on other focus areas was also continued (e.g. Sudan/Chad, Palestine, …). Information exchange and cooperation between the labs was supported by regularly meetings, intensive e-mail and phone conversation, and finally resulted in an intensive exchange of knowledge and software products. This development determined the widening of perspectives and skills, supported by staff exchange, and increased the networking performance.

However, another ambitious objective was to synthesize the technical achievements and results with the socio-political-economical factors to obtain a comprehensive picture in each testcase. This transdisciplinary approach increased the common understanding of the research community for each testcase topic, and inherently enriched the individual views of ubiquitous phenomena. A variety of representatives from DG Enterprise, DG RELEX, the GMES bureau, other GMES projects, military, and UN were invited to meetings and dissemination activities. The information served as a platform for discussions with the end-users. The feedback of these potential users was highly acknowledged by the partners and was considered for the ongoing applications and investigations.

Altogether, the 'test case approach' followed by the NoE GMOSS proved to be both productive and integrative: EO algorithms, methods and workflows were tied to particular scenarios and the technology-driven work was embedded in a broader framework of policy research, political science and disaster management issues. A synthesis on notions and insights has been presented in various dissemination workshops, reporting on experiences of the works carried out in the test cases, including experiences in the application of EO technology trying to answer questions raised by a comprehensive review of the prevailing socio-political background. Finally, it can be concluded that the testcase approach proved to be a powerful instrument for guiding the networking tasks within the GMOSS NoE into a successful outcome for the partners as well as for the reviewers and end-users. Highlighting the particularities of each case showed the complementarities of the entire GMOSS approach and its relevance and contribution to security-related research in Europe and on global scale.

1.3. Work Package 10200: Workshops

1.3.1. Executive Summary

The objective of the WP 10200 was to "foster increased integration of the scientific community by organizing and disseminating information on workshops and events on themes relevant to EU security and space".
At this aim, during its 4 years of existence, the GMOSS NoE organized different types of meetings:

- intra-WP workshops: at a pace of about two workshops per year on average, the WPs have initially met in order to learn about the expertise of the other partners, then to share results, identify gaps and plan a research road map;
- intra-cluster (technological, applications, and socio-polical clusters) workshops where WPs met to compare their approaches and problems and put them in a larger perspective.
- horizontal WP workshops, such as Test cases workshops in which security problems have been identified in all their aspects, (social-political and technical ones), and solutions proposed and shared by partners.
- overall integration workshops, where all partners met.
- meetings open to researchers outside GMOSS
- simulation exercise called GNEX'XX (GMOSS Real-Time Exercise) where partners met in order to participate to a simulated scenario, and acting as a provider of services and tools for decision makers.
- gender workshop where the focus was put on the perspective of women in conflict, post conflict reconstruction and peace building.

1.3.2. Introduction

WP 10200 was assigned to Vinciane Lacroix, RMA, during the 4 years of GMOSS funding. Through GMOSS life, the role of the work package leader was:

- to maintain a web page of the all past and future workshops and meetings.
- to disseminate information about workshops
- to monitor the workshop activity of all the technical WPs and the participation of the partners
- to transmit reviewers' recommendations on workshops to the consortium
- to provide recommendations

- o on the type and frequency of meeting to organize (internal WP meeting, internal cluster meeting, overall integration meeting)
- o for the schedule of meetings so as to reduce the travel time of partners, based on the WPs plans for workshops for the next months

1.3.3. Achievements

Part of the success of GMOSS Integration certainly happened thanks to workshops, at least during the first years. On average, GMOSS was having two overall integration workshops a year, thus involving all partners and all WPs. Three of such workshops have been organized by RMA, two by JRC, while TNO, Z_GIS and QinetiQ respectively organized one by or near their premises.
These overall workshops were opportunities to suggest integration activities. In particular, the suggestion to start common activities on Test Cases , on benchmarking algorithms and on organizing a game on a "responding to crisis " scenario came out the integration workshop in November 2005.

Worshop Webpage

In order to feed the web page hosted by RMA organizers were asked to provide for future meetings: a contact person, a draft agenda, the foreseen participants list, information and administrative forms. For passed meetings, partners were asked to update the above information, add presentations, minutes and pictures. Reviewers then asked to specify clearly the objectives of the workshops and to provide action items. Partners also asked to include administrative meetings (see WP40000) in the web page.
As the updating time of the web page was considered to be too slow, the second year of GMOSS, RMA added resources to this task. Arnaud Hincq has thus been in charge of the workshop web page until March 2007. This solved only partly the problem, as organizing partners were still very slow in providing the needed information. Partners were then asked to enter themselves all the documents in the new designed GMOSS website (see WP 30200) under the "Document" tab, but that solution lacked of visibility. Finally, a specific workshop index tab was added in May 2007.

Today on gmoss website http://gmoss.jrc.it/, a "Report" tab provides access to

- the Workshop Document Library where 10 workshops/events/meetings from 2006 to 2008 are documented
- a ftp site is available to download large documents related to some workshops from 2006 to 2007
- a link to the RMA workshop web page providing a list of all workshops up to March 2007 and their related documents

Under this tab, partners could also advertise their own workshop and event ; during the last year 6 of them have been announced.

Monitoring activities

Two tables, one listing the reported meetings of the WPs during the year, and another listing the partners participation to these events, were useful tools to monitor the GMOSS workshop activity. Some suggestions concerning WP leader change, WPs mixing or withdraw could be formulated to the overall management based on the first table, while indicators concerning a lack of involvment of one or another partner could be derived from the second one.

Starting from the third year, the monitoring of WP activities through summarizing tables did not make sense anymore as many meetings were involving many WPs, and did not explicitly referred to the WPs joint program. Moreover, the GMOSS site made each partner responsible of advertising his own workshop and meeting activities.

GMOSS workshops and meetings

During the first year (2004), most meetings were involving only one WP, as researchers had first to learn about each other expertise. Most WPs were having about two reported internal meetings per year. Two WPs were even meeting more often, while some other WPs reported fewer meetings. Despite the fact that no inter cluster meeting happened during the first year, the integration between the technological and the application cluster happened thanks to researchers involved in both clusters, and to the work that some WP had undertake in their joint work in order to address specific applications. In this landscape however, at that time, the socio-political cluster seemed to set outside of these interactions.

During the second year (2005) more meetings involving several WPs took place, but the true integration really came during the third year, when test cases were introduced. At that point, the socio-political WP started to be involved and very active multidisciplinary meetings involving all clusters and mixed WPs took place.

Starting on the second year, several attempts have been made to involve end users and other GMES projects at the integration meeting, with a moderated success.

After 3 year of duration the GMOSS website was listing 56 documented events, without counting the "administrative meetings" which were the annual governing board meetings and the semi-annual executive meetings. During the last year, only the large integration meetings have been reported and documented, as more and more informal meetings were taking place, and results of collaboration rather reported in scientific papers.

1.3.4. Conclusions + recommendations + impact

The workshops and meetings were definitely useful tools to first learn about each other's expertise, to foster partner integration, to discuss scientific issues, and to integrate the various disciplines needed to address security issues. They were also a good place to meet some end-users and other GMES projects.

Despite a highly competitive environment, thanks to the friendliness atmosphere present at these meetings, partners showed willingness to show their work, methods and algorithms, discuss important issues and make plans for the future. The outcome of these meetings was the feeding for new FTP projects and GMES fast track services.

The gmoss collaborative platform installed by JRC in 2007 is an excellent tool to share knowledge by hosting all documents related to gmoss events, and to announce them. However, the workshop visibility was quite small until May 2007 so that only few partners make use of this opportunity. Such a platform should be used as soon as the network starts, so that it could also be a monitoring tool. Indeed, if the possibility to register on line to a given event, the management team could automatically keep track of partner participation, and WP meetings.

1.4. Work Package 10300: Standards & Benchmarking

1.4.1. Executive Summary

The original objective for the 10300 Workpackage was "To monitor the use of standards in the Network and progressively move towards adoption of a common standards base for the network and subsequent European networking. The workpackage was subsequently expanded to include Benchmarking activities.

Benchmarking

The aim of the "Benchmarking" work package was to set up a concept for benchmarking in the field of security and safety applications. Furthermore it should stimulate and coordinate benchmarking activities to be carried out by GMOSS partners. This included inventory of data requirements, the specification of study areas for the benchmarking, data acquisition and/or preparation and reporting of applied test.
To meet the above mentioned objectives two dedicated benchmarking workshops were held and additionally meetings of other WPs were attended. Results of a first benchmarking task (pansharpening) were presented to the NoE at the The Hague meeting. For other benchmarking tasks an Ikonos stereo scene was acquired over the neutral testsite "Graz". The data with ancillary information was provided to the NoE. Results of several benchmarking working groups/tasks (sensor characteristics, pansharpening, stereo, house counting) were presented to the NoE at the final meeting in Brussels.
In addition benchmarking topics were discussed during two training courses on geometric pre-processing which were held at Joanneum premises in summer 2006 and 2007.

Standards

The Standards activity has analysed the use of standards in the network and also compiled a list of potentially relevant standards for current and future activities. A note on the use of standards in GNEX'06 and GNEX'07 was also compiled. One conclusion is the advantage of using interoperable standards was fairly limited within the confines of the well defined GNEX scenarios with most of the participants being able to handle existing proprietary standards (such as Shape files). However, in a real-life scenario, with a broader context and broader participation, then the benefits of standards-based software and better support for interoperability will be more important.

1.4.2. Introduction

Benchmarking

At the GMOSS integration workshop in Belgirate in spring 2006 the existing GMOSS work package 10300 "Standards" was extended to "Standards and Benchmarking". Joanneum was assigned to coordinate this part of the work package.

The first idea was to apply the benchmarking aspect only to the work covered by the GMOSS generic tools work packages. Thus, in summer 2006 a software/algorithms questionnaire was designed and distributed among the NoE to get an idea about the software tools and algorithms used by the partners. The evaluation of the feedback can be found in the first report on benchmarking (D15).

After some discussions the scope of the benchmarking was enlarged as it is now described in the same report. This concept was presented to the NoE, to EC project officer and reviewers at the Farnborough meeting in autumn ´06. As the aims of the benchmarking work package were seen as very important but on the other hand also as very ambitious the WP team was increased both persons involved at Joanneum and RMA as additional WP partner in Jan´ 07.

Standards

QinetiQ have held the overall lead for the 10300 Workpackage from its inception, although the actually Lead Point of Contact changed several times over the Project lifetime. A number of staff in the QinetiQ Space Division have supported the workpackage activities.

1.4.3. Achievements

Benchmarking

- Progress of work

In summer 2006 a software/algorithms questionnaire was designed and distributed among the NoE to get an idea about the software tools and algorithms used by the partners. The evaluation of the feedback can be found in the first report on benchmarking (D15).

Two dedicated benchmarking workshops were held (at JRC in spring 2007 and in combination with the The Hague meeting in April 2007) and additionally meetings of other work packages attended.

For other benchmarking tasks an Ikonos stereo scene was acquired over the neutral testsite "Graz". The data with ancillary information was provided to the NoE in summer 2007. One main application of this data set was the comparison of different DEM generation methods and software tools. Thus, a very high quality reference data set (terrain model and building models) covering an area of 2 by 2 square km was also prepared. During the lifetime of the GMOSS project JRC, Joanneum and TUBAF analysed this dataset in detail and produced several DSM utilizing various commercial and non commercial SW packages. First results are presented in the diploma work of T. Hollands (TUBAF) and will also be published in a joint paper.

Results of a first benchmarking task (pansharpening) were presented to the NoE at the The Hague meeting in April 2007. Finally, results of a several benchmarking working groups/tasks (sensor characteristics, pansharpening, stereo, house counting, etc) were presented to the NoE in a dedicated benchmarking session during the final meeting in Brussels in December 2007.

- Results - Highlights

Benchmarking of Remote Sensing Systems versus Security Applications
CRPSM – Sapienza University of Rome

CRPSM concentrated on the identification of needs or requirements which, in common opinion, are posed by security issues, and which should be compared with the actual information obtainable by satellite images. The aim was to attempt the definition of a way for evaluating the effectiveness of each present and future space-based Earth observation system.

The evaluation should provide a way for judging the suitability of a given sensor (assigned spatial resolution) on board of a given satellite (assigned orbital characteristics) taking into account also, in an objective way, the quality of the sensor from the point of view of the quality of the images that it can provides.

This approach is needed as a consequence of the present availability of several sensors with the different spatial resolution, number of bands, band characteristics, etc. Anyhow, the myriad of applications of spectral imagery and the dependence of perceived quality on the interrelationships of parameters make the task of assigning a single quality measure to spectral imagery very difficult.

The concept of image quality has an extensive history. In particular, the National Imagery Interpretability Rating Scale (NIIRS) was developed several years ago to have a quantitative scale by which EO imagery is rated. This scale rates an image from level 0 to level 9 with increased interpretability corresponding to the higher levels. The NIIRS was developed by using image analysts subjectively evaluate the quality of sample EO imagery, order the imagery from least to most useful, and then overlay a quantitative scale to the ranked imagery. Subsequent to this subjective development, the sensor parameters for a sample set of images were regressed against the NIIRS values and the General Image Quality Equation (GIQE) was generated. In the work of CRPSM different parameters (entropy, variance, contrast) and indices have been introduced for predicting the NIIRS rating of an image given the sensor characteristics.

Reference

[1] SPASEC, “Report of the Panel of Experts on Space and Security”, March 2005
[2] J. Leachtenauer, “National Imagery Interpretability Rating Scales: Overview and Product Description,” *ASPRS/ACSM Annual Convention and Exhibition Technical Papers*, Vol. 1, pp. 262-272, 1996.
[3] J. Leachtenauer, W. Malila, J. Irvine, L. Colburn, and N. Salvaggio, “The General Image Quality Equation,” *Applied Optics*, pp. 8322-8328, 10 November 1997.
[4] J. P. Kerekes, S. M. Hsu, “Spectral Quality Metrics for VNIR and SWIR Hyperspectral Imagery," Proceedings of the SPIE, Vol. 5425, pp. 549-557, 2004.

Benchmarking ‘Extracting Dwelling Structures’
Z_GIS

The rationale of the GMOSS benchmarking activity on the **Extraction of Dwelling Structures** was

- to test and compare different algorithms for dwelling extraction in informal and ephemeral settlements,
- to evaluate the results against visual interpretation and/or ground-based evidence, and
- to go beyond sensors and derive information products which are independent from the type of sensor and resolution,

with the purpose of deriving the number of dwellings and some basic spatial descriptors (size, shape) and utilize sources/hints regarding average occupation in order to estimate population distribution.
As part of these benchmarking activities, studies on visual counting and automated detection of dwelling structures were carried out among the partners. Test areas in the Darfur region (Western Sudan, villages of Bindizi and Mukjar), in Zimbabwe (operation Murambatsvina and Garikayi around the capital of Harare) and two refugee camps in Chad (Goz Amer) and Tanzania (Lukole) were selected.
The aim of the studies was on the one hand to identify numerous villages and huts damaged or destroyed during the humanitarian crises in these areas and on the other hand to gain population estimates in refugee camps and shanty towns. Since manual counting takes excessive time we were testing the potential of automated delineation in order to estimate the margin of error of the results. To this end, QuickBird (Sudan, Chad, Zimbabwe) and Ikonos (Tanzania, Zimbabwe) scenes were shared among the partners and analyzed.

Image analysis and GIS techniques provide means for estimating both number and type of structures destroyed and the scale of destruction. So far, visual interpretation and manual delineation have been the main techniques to fulfill this task. Due to the complex microstructure and high variance in geometrical features the automated, machine-based detection of such small structures faces high degree of freedom and the determination of distinct cues is often hampered; automated detection is therefore sometimes limited, despite the high technological standard available. Though any help in detecting and delineating may be very supportive to manual work, producing too many false positives is counter-productive, since this would cause extra work for checking quality of the results.

We used mathematical morphology (Matlab-based algorithms) and class modeling (as realized with Definiens) as automated delineation approaches. Comparing results with visual interpretation revealed that automated extraction could reach similar results as the visual interpretation in cases where structures of the dwellings were clearly visible (and describable). In this case automated extraction proved superior in terms of the number of dwellings detected per area unit. However, if – as in many cases – the structures are more or less imperfect the visual interpreter is much more flexible and the detection rate is in these cases much higher. Additionally, there were some specific pros and cons found for each of the automated approaches.
Thus, a targeted combination of automated extraction and visual interpretation could be an improvement for the future: automated extraction could support fast extraction of the unambiguous structures, with the visual interpretation focusing on more ambiguous structures.

Standards

- Progress of work

  After the first year, a report on Standards in the Network was produced. This concluded that many researchers didn't see the need for standards at that time, however, it was recognised that emerging open standards could be useful, particularly those coming from the Open Geospatial Consortium.

  After maintaining a watching brief on emerging standards throughout the project, in the final year, a document listing the potentially relevant standards was compiled; and a Note on the use of Standards in GNEX'06 and GNEX'07 was provided. A report on the status of the software support for JPEG2000 and GMLJP2 was also produced at the end of the Project.

- Results - Highlights

Highlights include the identification of relevant international geospatial standards for GMOSS-type activities and the recommendation to further support the use of JPEG2000 imagery standards.

1.4.4. Conclusions + recommendations + impact

Benchmarking

As already seen by the reviewersin summer 2007 the objectives of the work package "benchmarking" were very ambitious. Two quite opposite trends could be observed: The ambitions were quite limited to give feed back to the theoretical framework and fill in the proposed hierarchical benchmarking concept.
On the other hand, several groups working on dedicated benchmarking topics (e.g. pan-sharpening, stereo-3D, house counting, sensor ,DEM, ...) were very active. The only challenge here was if they could finish their work until the end of GMOSS. E.g. the pan-sharpening results could not be presented on the benchmarking homepage as the quality criterions are still under discussion.
Last but not least it was and is still very unclear how the benchmarking work (maintaining of the benchmarking homepage, preparation of datasets and results) will be continued after the end of the GMOSS NoE.
The practical benchmarking faced also the problem of the definition of suitable datasets. This included the availability of reference data if necessary and the uncritical image content which was a major problem of dataset the GMOSS NoE was using. Furthermore the data policy of the data providers made this issue a challenging task. Thus finally a "neutral" test site over the area of the city of Graz, Austria was selected for different practical benchmarking aspects.

Standards

The use of standards within the GMOSS network has been relatively limited. However, this is mainly because the participants were operating within their individual domain of knowledge and were expert at using complex software tools. As the scope of future GMOSS-type activities expands to address real-life situations, then the need to interact with other stake-holders (such as decision-makers) will increase and the benefits of the use of interoperable standards will become more apparent.

However, it is recognised that the benefits of the use of standards are maximised when they are supported by powerful software tools. Some of the emerging standards, such as the use of GMLJP2 within the JPEG2000 imagery standard, do not yet have mature supporting software. The use of standards needs to be encouraged in order to create an incentive to improve the software tools.

Increased use of emerging standards will certainly help end-users in the exploitation of GMES services etc., and increase the potential for interoperability with other information services.

1.5. Work Package 10400: Sharing infrastructure

1.5.1. Executive Summary

The objective of the 10400 integrating workpackage was to monitor, facilitate and promote the sharing of data and infrastructure between members of the GMOSS Network of Excellence (NoE). The tasks proposed for this workpackage were as follows:

1) facilitate sharing of satellite images through negotiation of licences from the image providers on behalf of the NoE.
2) monitor sharing of software for example an algorithm developed by one partner used by another
3) develop a common catalogue to allow NoE members to access a common portal to discover what data is available
4) look after intellectual property rights on behalf of the partnership.

The workpackage addressed these tasks by designing, developing and deploying several online applications to record and publish the availability of and mechanism for sharing data and software between the NoE members. An online standards based catalogue for upload of metadata and thumbnails of data resources available for sharing within the NoE. Minimal use of these tools was made by NoE members despite numerous attempts at publicity of their existence. Consequently the focus of the workpackage was reassessed and in the final year work was undertaken to create a standards based metadata profile specific to GMOSS.

Negotiations were undertaken as required with the commercial imagery providers to arrange multi-user imagery licenses both during and beyond the duration of the project. Support was also made available to address any IPR issues that may arise within the NoE.

1.5.2. Introduction

WP10400 is a workpackage that integrates the tools and applications workpackage activities by promoting, monitoring and facilitating the sharing of relevant data and infrastructure between GMOSS partners. Sharing of resources was seen as one key measure of the success of the network in terms of the integration achieved.

The key achievements of this workpackage have been:

1) development of an online software application to record the sharing of data and software between partners;
2) implementation of an online standards based catalogue to enable discovery of data resources;
3) development of a standards based GMOSS metadata profile;

In addition, the workpackage has included negotiation of imagery licensing for the NoE and a detailed technical contribution to the Standards and Infrastructure chapter of the GMOSS book.

1.5.3. Achievements

The initial focus of this workpackage was the development of a tool to help record the sharing of resources between partners. A web based software application was developed to enable NoE members to log any data or software that they shared. Users of the tool were required to fill in the online form with details of the data or software shared and the individuals, organizations and workpackages involved (see Figure below).

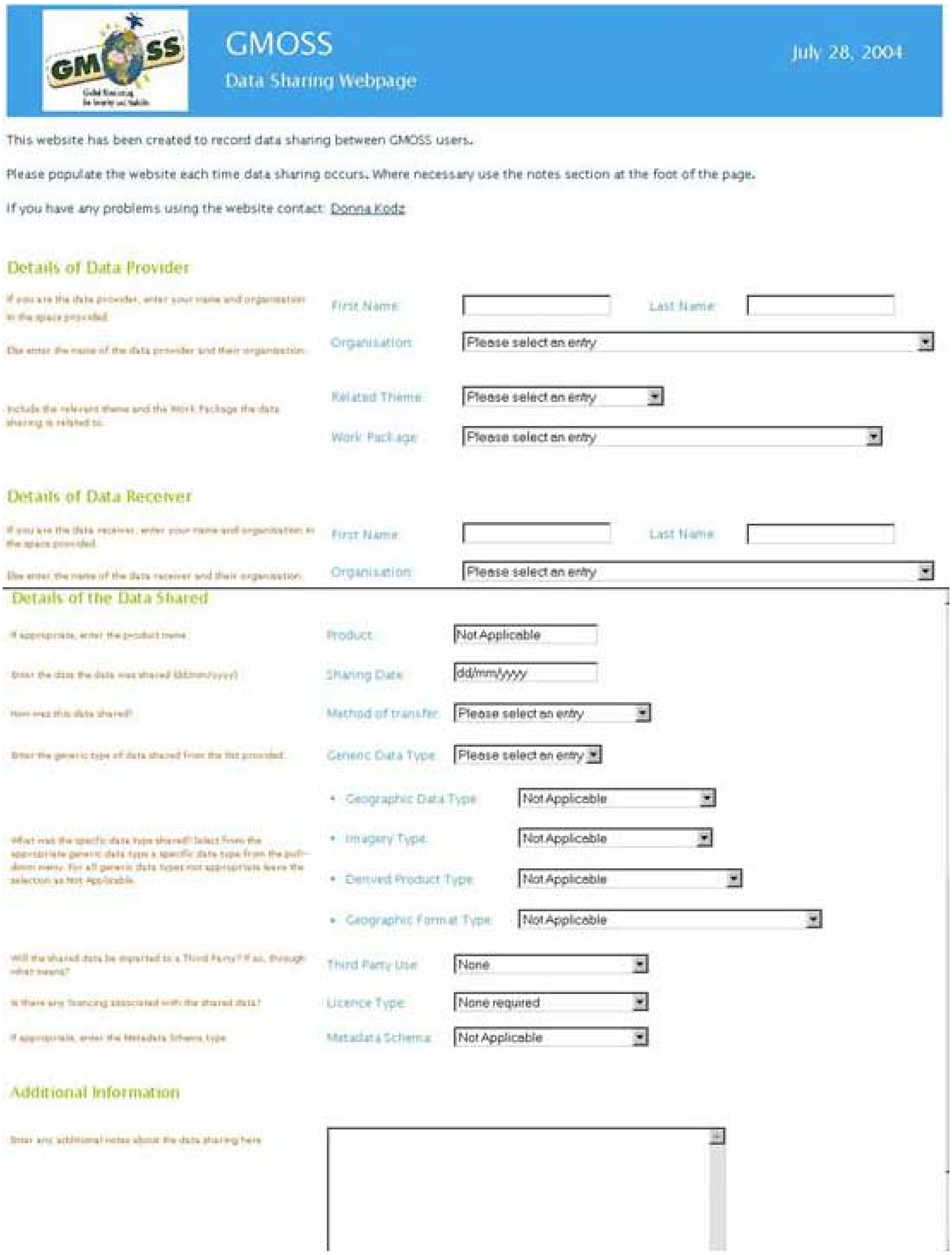
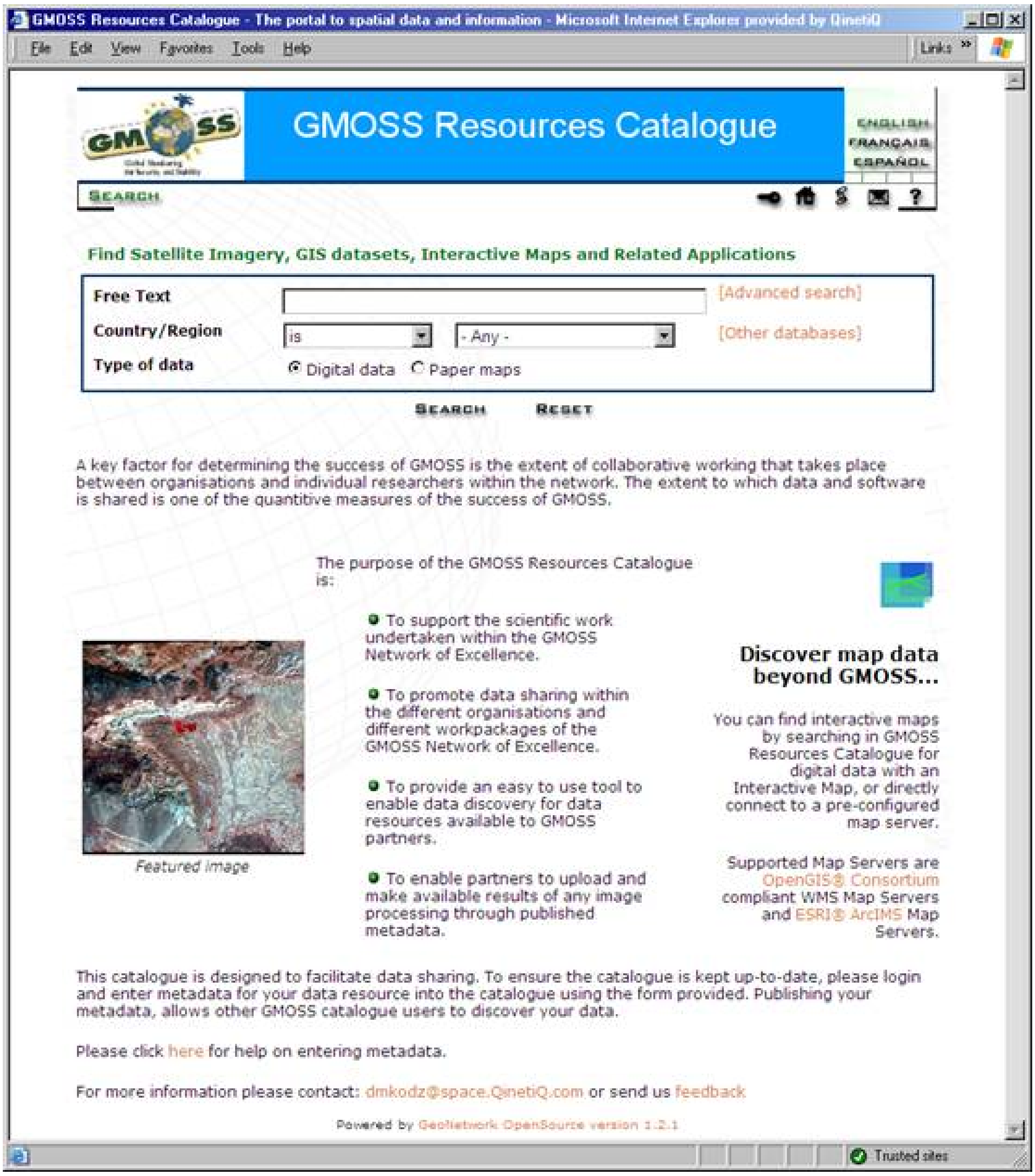


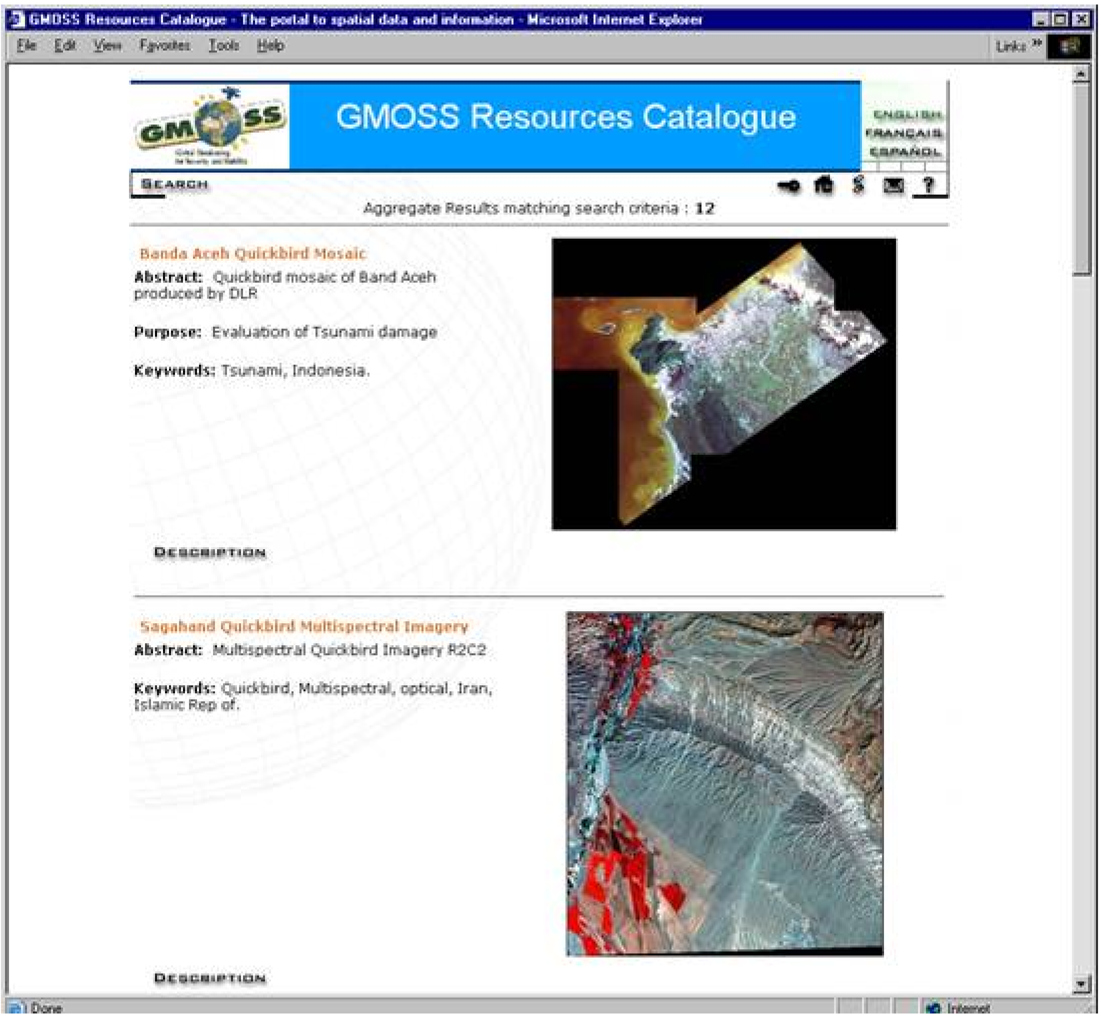
Figure: Application for Recording Data / Software Shared

Once submitted the details would be logged in a database hosted by QinetiQ for reporting purposes. This tool was made available from a link on the GMOSS website at the end of September 2004. Despite emails, online training material, promotional flyers and presentations at GMOSS workshops to encourage use of the tool, it was hardly utilised. Instead this information was collated as part of the 6 monthly reports.



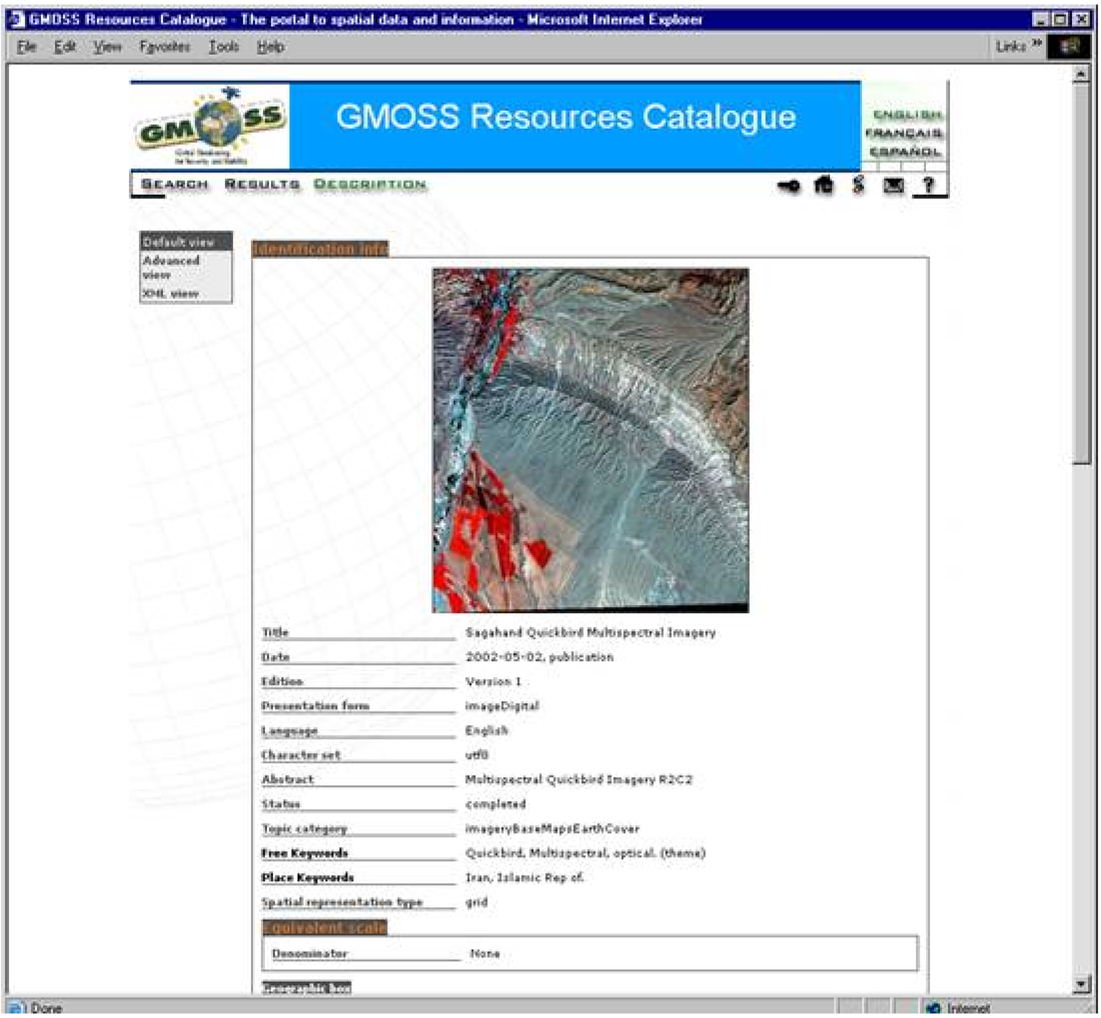
Front Page of GMOSS Resources Online Catalogue

From the beginning of the project a server repository accessible via FTP was made available by JRC for storage of all the shared electronic resources. The activity under this workpackage was the implementation of a resources catalogue to enable better discovery of the GMOSS resources such as imagery and derived products. An initial proposal and functional design document was made for the development of a catalogue application. Some initial work was undertaken to develop the catalogue however it was discovered that an open source catalogue 'GeoNetwork' was available built on open standards which provided the functionality required. Work on the bespoke catalogue was therefore abandoned and Geonetwork implemented and customized for GMOSS. The figure on the previous page shows the front page of the catalogue where fee text searches can be performed or based on location.



Results of a Search for Data within Indonesia

The next figure shows an example of a metadata record for Quickbird imagery over Sagahand, Iran.



Metadata Record for Selected Imagery

GeoNetwork is an open source web based data catalogue developed by the Food and Agricultural Organisation of the United Nations (FAO-UN), World Food Organisation of the United Nations (WFP-UN) and the United Nations Environment Programme (UNEP). Version 1.2.1 of the software was implemented. The advantages of utilising this freeware catalog application over the initial design proposed in the functional design specification were:

- compliance to ISO 19115 Geographic Metadata and ISO 23950 (Z39.50) and OGC Web Map Server (WMS) standards. This also enables the workpackage to address the comment made by the reviewers 12 Month Activity Report for GMOSS highlighting that they "encourage the WP10400 manager to continue to be pro-active in this [the standards] area, as indicated in the proposed work programme. 'Standard' means a lot more than 'sharing' ";
- the ability to draw upon greater development effort to enable utilisation of a more comprehensive and robust solution;
- to enable thumbnails to be viewed of the geographic datasets;
- support is provided through a network of developers and other users in addition to QinetiQ staff. This enabled quicker resolution of any issues / bugs;
- that the solution makes use of more of the latest technologies including SOAP and XSL;

- translations are provided for the user interface into French and German to support the multi-lingual network.

GeoNetwork was implemented as the GMOSS Resources Catalogue available online as a hosted service by QinetiQ. An overview of the catalogue, username / password and the user guide was emailed to NoE members at the beginning of November 2005.

Metadata templates were uploaded into the catalogue for the GMOSS purchased imagery and data products hosted on the JRC FTP server. This involved downloading all the imagery, importing / loading it into an image processing package to create thumbnails and to obtain the coordinates for the geographic extent. Only limited metadata was entered into the ISO 19115 template based on what was available to the 10400 workpackage leader.

The catalogue was provided for GMOSS NoE members to upload metadata relating to data holdings acquired and / or products derived that were available for sharing within the NoE. The NoE members had the responsibility to enter the metadata rather than the 10400 workpackage leader, as the data custodian has the knowledge of the metadata information required. The 10400 workpackage leader did not have visibility of all products created so once the catalogue was implemented the workpackage 10400 role focused on providing help and advice in the use of the catalogue.

Flyer created to promote the data and software logging software and the GMOSS Resources Catalogue

It was recognised that the catalogue would only prove useful if NoE members used the catalogue for this purpose but would only be as good as the quality of the metadata that was entered.

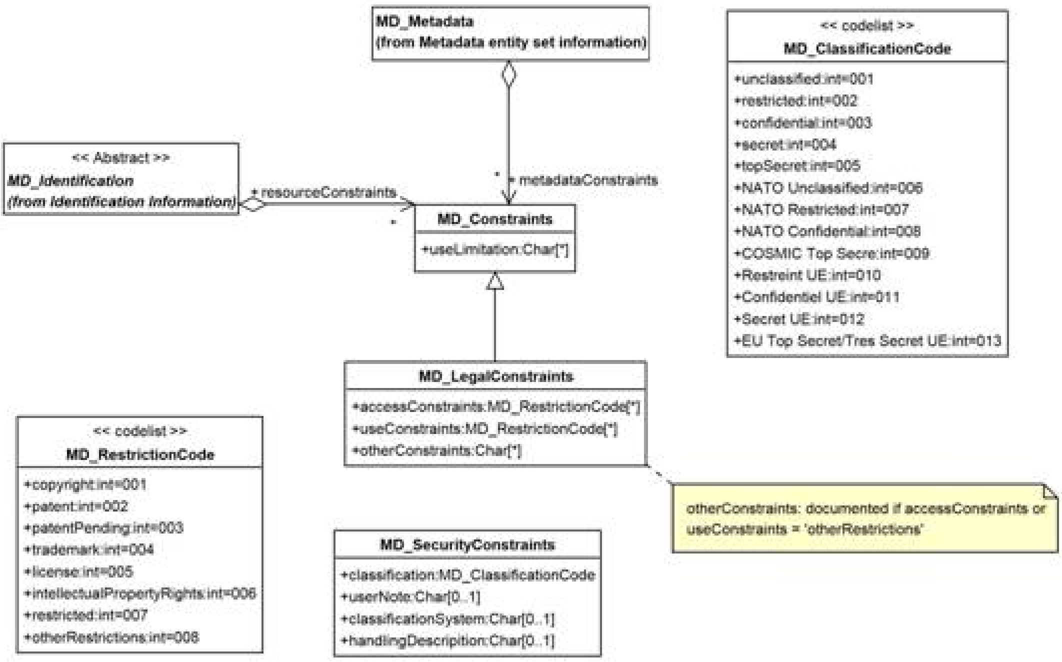
The figure above is a flyer put together to promote the use of both the software to log data and software shared and the GMOSS Resources catalogue. The flyer was made available at the Integration Conference in March 2006 in Belgirate. A market stall was also set up with a demonstration and an informal presentation made to the conference attendees.

The catalogue now provides 108 entries for imagery or derived products available for sharing within GMOSS, however the majority have been input by the 10400 workpackage leader and only a few of the metadata fields have been completed in each case. The GMOSS resources catalogue and data / software sharing application can be accessed from a link on the right hand side of the 'Documents' page of the new GMOSS website. The link to these tools have not always been highly visible on the website which may have contributed to their lack of use.

After the end of the third year feedback was received from the reviewers that despite publicity the GMOSS Resources Catalogue was not being fully utilized so consideration should be given to discontinuing the workpackage. In agreement with the GMOSS management it was decided to change the focus and instead concentrate on the development of a standards based metadata profile specific to GMOSS. The definition of a GMOSS profile was seen as a requirement for GMOSS as the full ISO 19115 metadata profile used in the catalogue was seen as being too onerous to fill in by NoE members due in part to the large number of metadata elements within the form. To promote this activity a presentation on metadata was given to attendees at the biannual integration conference held by TNO in The Hague in April 2007.

The metadata profile was required to have a balance between providing the elements required for discovery and end user interpretation but incorporating sufficient technical metadata elements to provide information on aspects such as accuracy and how the product was derived, typically required by the GMOSS technical experts or service providers. Definition of the profile involved reviewing all elements of the ISO 19115 geospatial and the ISO 19115-2 imagery and gridded data metadata standards to determine which of the optional elements should be included.

The profile has been developed to include the minimum number of elements that allow conformity to the standard but covers the needs of security activities within the GMOSS project. The GMOSS metadata profile has also been extended according to the extension rules defined in Annex F of the ISO 19115:2003 standard. This includes for example extension of codelists to address GMOSS categories such as border monitoring, treaty enforcement etc. which capture the activities of the workpackages. The GMOSS metadata profile document includes UML diagrams of the included elements. An example UML diagram is provided below for the constraint information required for managing rights to information including restrictions on access and use. In this example the codelist MD_ClassificationCode (shown on the right hand side of the diagram) has been extended to include the EU and NATO security classifications which are of relevance to GMOSS activities.



Example UML Diagram for the 'Constraint' Metadata Elements

The document was circulated by email to all GMOSS users with a request for comment and has also been made available on the GMOSS website under Documents à Metadata. Despite a reminder email no comments have been received to date.

Under this workpackage negotiations have been undertaken with commercial imagery providers to enable imagery to be shared by the partner organizations of the NoE. Imagery has been used within the NoE under multi-user licenses. These agreements are in place with SPOT, Eurimage for Quickbird imagery and MDA Corporation for Radarsat imagery. Arrangements are now in place to enable continued use of GMOSS purchased imagery under the multiuser licenses for research purposes beyond the end of the project. Further information about the licensing can be found on the GMOSS website under Documents à Imagery Licenses. An email with a summary presentation has been sent out to all NoE members to ensure they have been informed of the requirements of these licenses.

1.5.4. Conclusions + recommendations + impact

A challenge for this workpackage has been to encourage participants of the NoE to use the tools that have been provided to 1) log the data and software shared and 2) to enter the metadata for data and products available for sharing. Use of the GMOSS Resources Catalogue and entry of metadata about data and products has proved to be an overhead for imagery users in the NoE. Consequently the catalogue has not been fully utilised in the way it was originally intended e.g. for data discovery. Instead data sharing has primarily been via the JRC FTP site data repository or on an ad hoc basis between a relatively small number of individual partners who are aware that the data exists.

A recommendation is that the implementation of the catalogue should be more closely tied to the data repository. The data catalogue should be a single user interface onto the data repository for data upload and download to ensure its user. One issue for GMOSS was that the catalogue and data repository were hosted by different organisations. A further observation is that the link to the catalogue was difficult to find within the main GMOSS website. In hindsight higher visibility within the website may have resulted in greater use. As a result the effectiveness of the catalogue was reduced. A catalogue would be of greater use in an operational environment particularly where larger numbers of non expert end users are involved and for accessing data archives as the repository grows.

Promoting the use of metadata within the NoE and creating interest in adopting a GMOSS metadata profile was a further challenge. Within a research environment metadata is typically not considered a priority as the imagery is often well understood and therefore the creation of metadata is seen as an onerous task. This was clearly demonstrated within GMOSS. For example metadata was not created as part of the GNEX exercises simulating real time disaster response scenarios. Metadata tended to be exchanged in an ad hoc manner as required.

In response to the EU legislative framework of INSPIRE and the resulting operational services which will evolve out of programmes such as GMES, the role of metadata becomes increasingly important to enable interoperability and is fundamental for the creation of data catalogues to allow data discovery. It is recommended that in the future information provided within the GMOSS catalogue and other GMES catalogues such as REPOND should be accessed through an over-arching GMES metadata catalogue portal. A GMES catalogue may in turn be registered on a number of relevant international data registries / clearinghouses concerned with environmental / remotely sensed data such as ESA EOLI, GEO/GEOSS, NASA GCMD etc. This will provide easy discovery of GMOSS data and avoid it being un-necessarily published in multiple locations.

1.6. Work Package 10600: Staffing exchange

1.6.1. Executive Summary

The purpose of this work package was to provide a structure which would support the establishment of a community of researchers by facilitating short-term exchanges of staff between partner institutions. The expectation was that such an activity would enable the participants to become acquainted with each other's skills, resources and available infrastructures at a deeper and more sustained level than could be expected from short ad hoc visits or brief encounters at workshops and conferences.

From the very beginning of GMOSS, all members of the partnership expressed willingness to allow their researchers to spend working visits at other laboratories in the network. It was hoped that particularly close collaboration could be developed between those laboratories working on a common work package. It was also agreed that a report would be prepared at the end of each year indicating what staff exchanges had taken place and were planned to take place for what specific purpose in the network, and summarising the evaluations of sending and receiving partners. This original idea evolved into the establishment of a dedicated work package with the expanded objective to monitor and promote the short-term exchange of staff within the entire network for purposes of

1) acquainting partners with each other's work, facilities and expertise;
2) enriching specific aspects of the GMOSS work package activities;
3) laying a foundation for future intensified cooperation between the exchanging organizations.

Various efforts were undertaken in the course of the four years to acquaint the partnership members with this option, to encourage their participation, to streamline its financing, and to provide feedback about the results. The 41 exchanges which took place over the course of the four years involved 31 different visiting scientists making 50 contacts. Most were for visits of one to four days. However, thirteen visits were substantive, extending from two weeks to three months. All participants gave very positive evaluations of the experience.

1.6.2. Introduction

History

When GMOSS began, the first step was to arrange for discussions at all thematic workshops as they started to take place by directly contacting the conveners. Agreement was quickly reached to include a workshop agenda item "staff exchange" to identify specific benefits to both hosts and visitors in the context of the workshop theme. This approach was fruitful in that it promptly led to a number of exchanges and a testing of the basic idea, but most of the visits were brief and issue-oriented, rather than involving a workload for an extended period of time, in keeping with the original intention. However, all participants reported (they were contacted individually) that the visits had been worthwhile, and that they had made plans to continue them. Activities often included training in the use of specific tools developed by one of the partners for purpose of evaluating its usefulness or to work on a jointly defined project. Other visits were set up to discuss how a difficult technical challenge could best be tackled by the two organizations concerned.

Despite this encouraging start, there was considerable and continuing hesitation on the part of the partners to arrange for more ambitious staff exchanges. The reason did not seem to be because the theoretical advantages were not well appreciated, nor because concrete ideas were lacking as to how a host or visitor could benefit by a particular exchange. Thanks to a flexible and pragmatic approach to financing the exchanges from the unallocated budget, the financing was not a disincentive either. The major problem was that the scientists who could benefit from an exchange in either direction felt that they were simply too busy, with their time already fully booked with activities involving a variety of different projects, business travel and ongoing responsibilities at their home institutions. They were not eager for suggestions about additional employment of their time, either as visitor or host.

One attempt to address this barrier was to put more emphasis on recruiting for exchanges young scientists and PhD candidates in the partner institutions, on the assumptions that they might not be quite so tied down to their schedules (although they are often under considerable pressure to finish their dissertations), and because they are just beginning their careers, so there could be high returns both for them and for "Europe" from an investment now in developing contacts and widening their experience.

It was proposed to offer stipends for a 1 to 3 month stay of a young researcher at the laboratory of another GMOSS partner in another country to help cover travel and accommodation as well as limited consumables, funding to be achieved by reducing all partner allocations by some proportional sum needed to adequately fund this staff exchange activity. This approach had the psychological advantage of underlining the importance placed on this activity by visibly removing it from the category of a nice option, if one has the time for it and putting it into the category of an activity which is being financed because it is essential, and which has its own budget line. It was accordingly the decision of the Governing Board on April 29, 2006:

"In order to encourage more active participation in staff exchanges, it was agreed that staff exchanges consisting of visits up to one week in duration be financed as heretofore from the contractors' GMOSS budgets. Applications for financial subsidy toward staff exchanges of longer duration are to be forwarded to the executive committee for decision."

Simple instructions and an application form were placed on the GMOSS web site, and an email announcement of this "new" opportunity was sent to all GMOSS partners. In practice all subsequent requests were approved, with the sum of NN euro granted for each exchange for travel, accommodation and incidentals. After this decision was made, 11 exchanges took place, with XX of them requesting the subsidy.

1.6.3. Achievements

The achievements of this work package are summarized in the document (linked) "Staff Exchangegmoss.jrc.it/group/gmoss_community/reports Reporting." It consists of three tables which reflect the three different viewpoints which must enter into any evaluation of this activity.

1. The "Chronological Summary" addresses the question of how many activities took place, and how they were spaced out over the course of the four years of the GMOSS consortium. It can be seen that they were maintained at a fairly constant level throughout, with a slight trend toward longer stays toward the end of the period.

2. The "GMOSS Partners" summary looks at the 41 exchanges as to which consortium partners were involved, and whether they were sending their staff to other institutions or hosting guest staff. The latter distinction is only significant in that it shows the variety of arrangements actually made, which reflects how the partners' very different situations, needs, and available options could be accommodated.

It is interesting to note how many partners became deeply involved in either sending staff or hosting visitors. For example, some sent members of their staff to partners on eight different occasions, or hosted as many as seven exchanges. A few partners were not involved in this activity, reasons often being the very small size of the organization, which precluded such activities, or difficulties associated with obtaining security clearances.

3. The "GMOSS Work Packages" summary is an attempt to determine not only which work packages saw a benefit in exchanges and how much use they made of the possibility, but also to what extent the exchanges involved different categories of work program activities.

As could be expected, most exchanges were between institutions working within the same work packages(s). The next most common number of exchanges was among the various application work packages. But a few exchanges did take place between partners not engaged in a common work package, and between the security concepts work packages and the other two categories.

1.6.4. Conclusions + recommendations + impact

This movement of staff across participating GMOSS institutions certainly contributed to establishing that common understanding without which any network of researchers cannot be effective. Most partners were involved in some fashion, and several were so convinced of the benefits after their first experience that they promptly arranged both for follow-up visits and for ways to involved other of their staff members, particularly the young scientists. There are also plans to still realize exchanges that for a variety of reasons could not take place before the conclusion of GMOSS.

However, if evaluated against the actual objective of longer term exchanges of staff (and not only short visits) to facilitate integration, the work package cannot be considered a success, which gives rise to the question of whether the concept is flawed or whether the approach was deficient. Other FP6 Networks of Excellence leaders who were contacted for the purpose of ascertaining their experience with this integration instrument also reported basic difficulties in meeting the objective. A wider evaluation should be undertaken.

It was particularly disappointing that several young scientists who were eager for the challenge of a staff exchange could not finally be placed in a hosting institution, and that several partners who offered to host an exchange could not be supplied. In all case the reasons related to scheduling difficulties in the light of other obligations, either at the home or host institution.

In two cases, what started out to be a lengthy staff visit turned out to be a permanent transfer of staff. This was not without hardship to the "sending" institution, which lost expertise for the sake of enriching the staff of a partner institution. However, it can also be seen as a deepening of the collaboration of the two institutions, as evidence of networking facilitated by GMOSS, and as a means of furthering the career of young scientists or expanding its breadth.

It was much easier to arrange for technical exchanges (for example between the applications and generic tools work packages, or within each of these groups) than for exchanges that would challenge the participants to address basic preconceptions behind the work being undertaken in these work packages (this refers to specifically to exchanges that would involve the security concepts work packages). It was however specifically desired that such exchanges take place, so that the broad complexity of the concept of security and its implications for the more straightforward technical activities would not be ignored. But how they might be accomplished is far less certain. In the specific GMOSS case, difficulties were also caused by uncertainty on the part of some partners at the very beginning about the basic goals of the security concepts work packages, a problem which could not be resolved at an early date and led to the disassociation of one of the members from the partnership. The replacement took time to accomplish, and when new partners were available who could represent this aspect, the technical work packages were already deeply engaged in their activities and had established a working style and set of priorities. Perhaps a better solution than a staff exchange or a discrete work package where security concepts were in danger of isolation would be for those adept in security concepts to rather “infiltrate” all the technical work packages with participants who could bring this aspect into discussions, (probably uncomfortably) broadening perspectives as this work package went about its technical tasks. But as this idea goes beyond a critique of the staff exchange concept, it is only mentioned here in passing.

2. Research: Generic Tools, Applications, Security Concepts

2.1. Work Package 20000: Research activities

2.1.1. Executive Summary

The research activities cluster includes the core activities of the NoE GMOSS, where also most of the effort by the network partners was spent. The workpackages were grouped into three sub-clusters, generic tools, applications, and security concepts.

This allocation of workpackages allowed all partners to contribute to the NoE according to their experience in the domain of security and stability ranging from purely remote sensing experience in the generic tools cluster to socio-economic/socio-political experience in the security concepts cluster, and finally the applications cluster.

The working focus was initially on the definition of common objectives and work. In the course of the project a positive incremental process of integration started between partners inside the single WP, then between closely related WPs mainly in the same cluster. The definition of common testcases (Iraq, Iran, Pakistan/Kashmir and Zimbabwe) and exercises (GNEX'06 & GNEX'07) finally fostered also the integration between different clusters. This collaboration tried to go beyond a request to have "requirements" made by a generic tool WP to an application WP. In the optimal situation fluxes go in both directions as described in the schema below with an example of pos sible cross-fertilizing fluxes.

		Fluxes		**Fluxes**	
GMOSS cluster	**Generic tools**		**Applications**		**Security concepts**
Typical Reasoning Model	*Problem solving*		*Case study*		*Problem setting*
	From requirements to optimized tools	← Requirements → Tools →	From a simplified verbal representation of the problem to formalized list of requirements ← Formalization ← → Integration → From available tools to integrated solutions	← Definitions Solutions →	From political debate to a simplified representation of the problem From the decision to the reformulation of the problem

The following describes shortly the work done in the research activities, more detailed information is provided in the relevant sub-chapters.

GENERIC TOOLS CLUSTER

The work of the generic cluster included two workpackages with a focus on image analysis tasks, namely feature recognition and change detection. The third workpackage dealt with the integration and visualisation of different data types.

The goal of the Feature Recognition work package was to establish methods, algorithms & software for automated feature detection. The work performed in this WP ranged from creation of new and improvement of existing methodologies and algorithms for feature recognition and automated image analysis over technologies for SAR image information extraction to standardization initiatives.

Change detection is one of the key Earth Observation technologies in security research. Within GMOSS it is one of the three generic tools that are used to gain information from satellite image data. The main focus of the work package on change detection was to analyse and compare different methods using a variety of data (Optical and Radar) with different spatial and spectral resolution, and to test the methods depending on the applications that are studied within the application themes of GMOSS. It could be shown that several methods, developed by different partners in the work package team led to very good and reliable results. There are mainly two prerequisites for this: firstly a good co-registration of the images and second a similar or better same sensor for the data acquisition of the two dates.

The key idea behind the establishment of the “Visualization & data integration” work package within GMOSS was that the users at large do not need data – they need information. The sources to provide information within GMOSS are data sets from remote sensing instruments, GIS-data bases, in-field measurements and other, e.g. text based, sources. One disadvantage of these sources is the complexity of their content as far as interpretation is concerned. Another aspect for limiting usability for the non expert user is the need to integrate different data sources and formats into one system to communicate the information and it´s content to the non expert users. The Visualization & data integration working package addressed exactly these challenges.

APPLICATIONS CLUSTER

The applications cluster comprises a range of applications relevant to the field of security including treaty monitoring, early warnings, populations and borders, damage assessment and monitoring of infrastructures. The applications cluster tried to develop applied research solutions that could be of use for potential users.

The treaty monitoring workpackage worked on the problems of verification of, particularly, two arms control treaties – the 1972 ‘Treaty on Non-Proliferation of Nuclear Weapons’ (NPT) and the 1996 ‘Comprehensive Nuclear Test Ban Treaty’ (CTBT). The worpackage focused on the development and applications of space-based remote sensing techniques to the verification of the NPT and the CTBT. The physical characteristics or the “key”, developed for the large part of the nuclear fuel cycle, was used to train a computer to detect facilities automatically in a large area image. For this purpose, an object-based image analysis method, that attempted to emulate an image interpreter who normally uses image colour, shapes of objects, textures and association of objects of interest within their surroundings, was developed and applied to a number of Iran’s nuclear facilities. Sensitive method for the use in change detection and image classification procedures was developed, evaluated and applied to a number of nuclear sites in Iran and to the Indian, Russian and the US nuclear weapons test sites.

The early warnings workpackage tested the ability of different techniques and sensors for providing early indications of disaster and conflict events that might pose a risk to civilian populations.Mainly two types of imagery were analysed: for armed conflict high spatial resolution images are needed, while natural disasters such as floods, fires or even fires caused by damaged oil pipelines due to terrorist attacks could be detected by images with very poor spatial but with very high temporal resolutions. For example, for possible armed conflict, estimations of military deployments along international borders and state of armed readiness at military airfields were shown to be feasible. On the other hand, very high temporal resolution images with low spatial resolution demonstrated to be very useful early warning tools.

The overall objectives of the populations and borders workpackage was to extract information from satellite imagery and geo-spatial information layers in order to derive population characteristics and activity at regional level in population density estimation and border permeability index and at local level in refugee camps population estimation and population behaviour patterns. Regional population density estimations were developed for Zimbabwe; a border permeability concept was applied to two regions in Eastern Europe at different scales and was compared to Central Africa. Another focus was on the automatic identification and enumeration of tents or shelters in refugee/IDP camps using EO data in Lukole (Tanzania), Goz Amer and Mille refugee camps (Chad).

Within the damage assessment and monitoring infrastructures workpackage partners worked together on different case studies such as the Bam earthquake (Iran 2003) and the South-east Asia tsunami (2004). In addition to this also the common testcases and the GNEX exercises were important case studies. Based on these experiences a critical infrastructure monitoring catalogue and a standard for damage assessment and reporting were proposed. Requirements and standards were identified (critical infrastructures) and established (damage assessment). The use of techniques as synthetic aperture radar (SAR) and interferometry (InSAR), and information from other sources was assessed (optical imagery, collateral data, open source intelligence).

SECURITY CONCEPTS CLUSTER

The security oncepts cluster comprises two workpackages with a focus on exercises, namely ‘scenario analysis’ and ‘responding to crisis’. The third workpackage focussed on issues and priorities in security. The emphasis in the GMOSS NoE has been on science and technology for monitoring through remote sensing/EO satellites. Most of the work packages have been dealing with such problem areas.

The scenario analysis workpackage had a more supporting character to the other workpackages; supporting with respect to the use of EO information in security analysis by furnishing analytical tools, which could be of use for GMOSS activities – primarily scenario techniques and gaming. The term scenario is here loosely defined as possible development(s) from today into the future for an area of interest or a description of a possible future without any reference to the path from today. For a science and technology orientated NoE both aspects of the tools are of great importance. The way of thinking has had an impact on the test cases and GNEX.

The main focus of the work package “Responding to Crisis” was to study and review the application of Earth Observation derived information for civilian crisis response within the European Union. Based on a review of relevant crisis types, key actors, response mechanisms and main policy drivers, the crisis response patterns related to Earth Observation derived information were identified. A survey showed that many work areas of the network partners still focused primarily on issues of natural disasters. These findings were used as driving force to steer the attention of the partners more to the technical and conceptual issues of security and stability related analyses. To support this process, two real-time functional exercises were prepared and executed. The goals of these exercises were to test and evaluate technology available in the context of realistic crisis scenarios, to provide the network partners with a common working platform, and to identify new research areas. Besides the two exercises, a scenario guide was developed for the network partners in order to support them in preparation of own micro-exercises/simulations.

The principal objective of the issues and priorities workpackage was to facilitate collaborative relations between the customers and suppliers of earth observation product by helping to bridge the different backgrounds, training and perspectives of the two communities. This was achieved by producing two substantial papers for the guidance of GMOSS participants on EU security policy and the potential role to be played by earth observation and by providing advice on potential topics to be addressed by the common test cases with respect to economic, political and security circumstances of the test case countries.

History

WP 20000 Integration of Research Activities was assigned to the Joint Research Centre JRC. Iain Shepherd was the responsible coordinator in the first year of GMOSS, followed by Martino Pesaresi during the last 3 years.

2.2. Work Package 20100: Feature recognition

2.2.1. Executive Summary

The goal of the Feature Recognition Work package is to establish methods, algorithms & software for automated feature detection. As a first step the partners work on establishing state of the art methodologies, furthermore will develop, evaluate and compare different software tools and finally test software and methodologies on security applications. Within the whole NoE the exchange of information on cognitive vision methodologies shall be improved and a contribution to establishing nomenclature and standards in feature recognition is already realized on a high level.

The work performed in this WP ranged from creation of new and improvement of existing methodologies and algorithm for feature recognition and automated image analysis over technologies for SAR image information extraction to standardization initiatives. Although quite a few key researchers changed throughout the duration of the project the partners kept their thrust in their respective field and aimed at supporting other WPs in their need for feature recognition tasks.

2.2.2. Introduction

At the beginning of the GMOSS NoE the Feature Recognition WP started out with 5 core member institutions under the lead of Definiens. The initial phase was used to established links with other the WPs and resulted in a number of well organized collaborations in theoretical and practical research. At that time the team consisted of 5 researches how were deeply involved in feature recognition research at their institutions:

After 2 years unfortunately a number of changes happed to the team which there had to be rebuild considerably. Quite a few researchers stopped working for the WP, Simon J. Casely took over at Qinetiq, at Joanneum Andreas Wimmer replaced Lucas Paletta.

As Definiens stepped back from its WP Lead Joanneum Research took over and rebuild the team with partners RMA (Charles Beumier), CNES (Jordi Inglada), QinetiQ (Simon J. Casely).. Associated Partners were Definiens (Ursula Benz) and the University of Pavia (Paolo Gamba)

In the final two years the partners in this considerably changed team tried to reestablish their links and to continue the fruitful work done in the first half of GMOSS.

2.2.3. Achievements

As Feature Recognition is seen as service for application oriented work packages much of the initial work was spent on evaluating and inquiring user requirements from from application partners as well as customers in the remote sensing and security area. This work resulted in a feature catalogue as well as a research roadmap which guided the future developments.

In conformance with these user requirements much of the work in feature recognition was spent in automatizing the services which are currently most of the time done manually by skilled human operators.

A first example consists in the localisation of industrial sites [1]. Industrial plants are sensitive areas and potential targets due to the technology and possibly dangerous products that they host. In the context of the Real-time exercise ‘GNEX 2006’, they were extracted thanks to the detection of long linear segments.

In the collaboration for the GMOSS test case ‘Iraq’, RMA developed a simple and fast disparity estimation based on edge magnitude and orientation. Applied to an Ikonos stereo pair of images, the algorithm returns the disparity of long linear edge segments which highlight elevated construction like buildings. Large or medium size buildings are indeed objects of interest in damage assessment of change detection applications [2].

As the work progressed it turned out that an important aspect for all the work was the quantitative and qualitative assessment and comparison of algorithms and methods of the individual partners. For this reason a benchmarking work package was created and the feature recognition work package spent a considerable amount of time in building up various supporting algorithms and methods for the construction and assessment tasks of the benchmarking activities.

Joanneum Research developed a number of pre-processing techniques to deal with the increased need for accurate image data sets for security applications. This need results from the current mainstream methods for change detection (comparison of pre- and post-event imagery) as well as the need for the highest possible level of detail required in certain other field in security relevant applications.

Since the Feature Recognition work-package is an important source for algorithms and methods used to obtain such highly accurate image data-sets different techniques have been developed and validated to reach this target.

A long known technique to increase the spatial accuracy of remotely sensed image data-sets is the fusion of a high spatial/low spectral resolution data-set with a low-spatial/high-spectral resolution data set into a high spatial/high spectral resolution image. The main application of such techniques is the fusion of the panchromatic and the multi-spectral data-set available from a number of satellite image provider.

QinetiQ has been developing and testing various techniques to extract feature information from various EO sources; including high resolution SAR, optical and aerial datasets. These methods include a technique based on the use of a spatial object orientated database system to develop methods for automatically extracting linear features. Most algorithms work at the pixel scale, but widening the approach to an object scale, supporting contextual information will increase the available information. These features can be represented in a hierarchical structure using an object orientated database. Rules and behaviours can be associated directly with objects allowing these objects to exhibit self-awareness. Using a set of object rules and behaviours, techniques have been developed to automatically differentiate between linear features. This approach was tested and applied to a combination of optical and SAR data with good results. It has been shown to be able to automatically detect, with high accuracy,

2.2.4. Conclusions + recommendations + impact

During the GMOSS project, within the Feature recognition working group an exchange of expertise and constructive comparisons were conducted in the field of automated image processing, benchmarking SAR image processing and standardization related to security applications and natural and environmental hazards.. In addition, in the course of the project, services methodologies and techniques probably useful in the context of GMES were created and improved.

The GMOSS project was successufll in creating solid bases for future future cooperations among different Institutes which will and has been used to create joint proposals within the FP 7. The aim is, in fact, to continue the collaboration started within GMOSS exploiting EC calls on security, environmental hazards and other topics under EC attention such as natural risk monitoring and space technologies Moreover, GMOSS represented also the occasion for starting new collaborations between partners in the training and benchmarking field.

The reserach impact of the work within the WP 20100 is clearly the improvments in handling very high spatial resolution data for basic feature recognition and image analysis tasks. In particular, improvements to preprocessing steps like data fusion and radiometric as well as topographic normalization processes were successfully implemented and tested.

Still the remaining challenges remain manifold. Automated process are still not able to fully compete with a skilled manual interpreted (which has been shown and proved in the GNEX exercises), but still the trend to automated processes with minimal manual interaction is unbroken, and the situations where skilled human experts are needed will decrease.

2.3. Work Package 20200: Visualization and data integration

2.3.1. Executive Summary

The key idea behind the establishment of the "Visualization & data integration" work package within GMOSS was that the users at large do not need data – they need information.
The sources to provide information within GMOSS are data sets from remote sensing instruments, GIS-data bases, in-field measurements and other, e.g. text based, sources. One disadvantage of these sources is the complexity of their content as far as interpretation is concerned. Another aspect for limiting usability for the non expert user is the need to integrate different data sources and formats into one system to communicate the information and it´s content to the non expert users.
The Visualization & data integration working group was integrated into GMOSS to specifically address these challenges. To achieve this, some major players in the field of data integration and geo data visualization were brought together within the work package.

As laid out in the first project planning the requirements of different user groups have been thoroughly scrutinized. For this purpose a questionnaire has been developed and distributed to the different working groups. The outcome led to the definition of a requirements list for the visualization of geo data. The list was mainly aimed at three scenarios – terrorist attacks, natural disasters, political crisis. Based on these a first model for a Common Operational Picture (COP) has been developed.

In the progress further discussion led to the conclusion, that the system definition should not be based on fixed scenarios – as they are mentioned above. To fulfill a more general approach and therefore meet other requirements, a new road has been taken.
According to the initial project proposal the development of a system to fulfill these requirements was planned. Discussions within the working group led to the conclusion, that a new development of such a system is not sensible.

According to this, three key problems have been targeted by the working group primarily through defining necessary contents and capabilities for a security oriented visualization system.

- Capability of available systems for integration and 3-D visualization of (mainly) GIS-data, Remote Sensing data, ground measurements
- Development of a general model for a Common Operational Picture (COP)
- Identification of the requirements for a spatial search engine for the internet

As a consequence this led to the need of evaluating suitable visualization systems for the requirements mentioned above. The focus was on tools for data integration and visualization available at the different partner institutions as well as other existing solutions addressing the problem.

The major results of the work package therefore include several analysis papers as well as software tools and components:

- Evaluation status report of the requirements in data integration and visualization technology for security applications
- Evaluation paper for the use of a Common Operational Picture (COP) model within the scope of GMOSS

- Requirements and benchmarking criteria catalog for 3-D visualization systems suitable for security applications
- Prototype spatial internet search engine for security applications
- Evaluation paper of available and suitable 3-D visualization systems

2.3.2. Introduction

In the security domain data needs to be retrieved from multiple sources, processed and integrated to provide a complete picture of a typically complex situation. Already the retrieval of data from very large database systems is often slow due to the fact that existing database indexing technology has its limitations in supporting complex search requests. Also the integration is difficult because of different formats and semantics. Even worse data is often incomplete, imprecise or even contradictory. Finally a fully automatic processing of data is often not feasible (e.g. interpretation of satellite images), even so tight response times would require such an automatic processing.

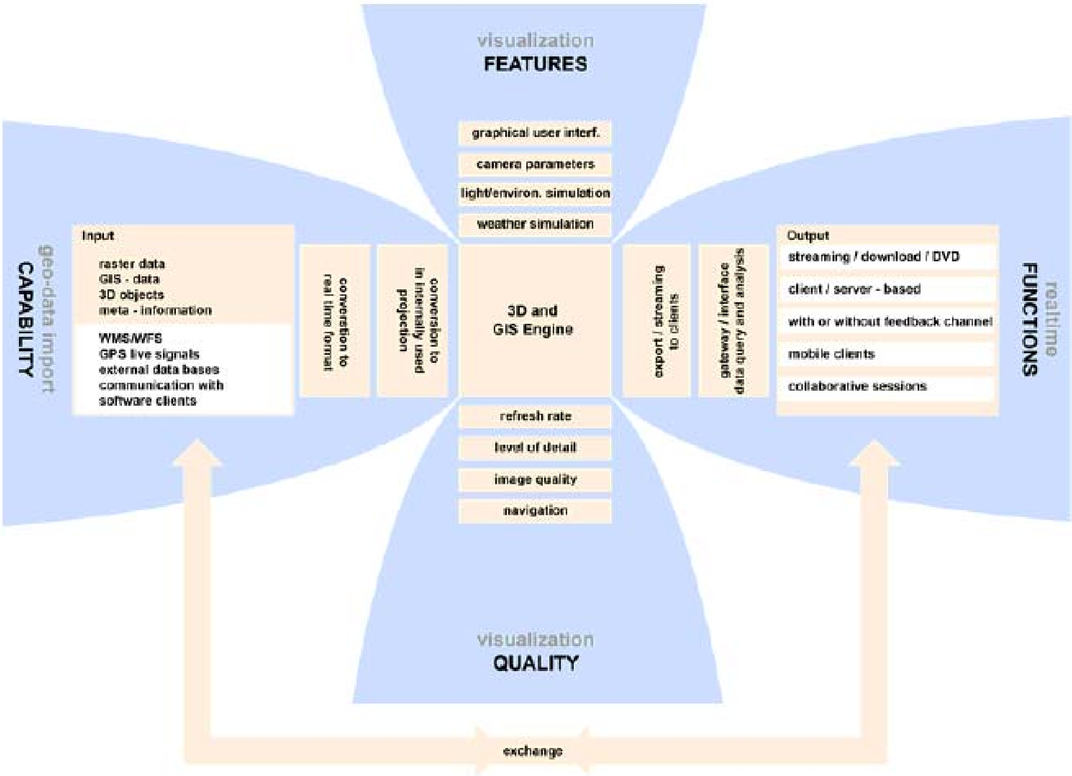
To overcome these challenges the work package developed out of the idea for a spatial search engine to be provided within GMOSS. The scope of the work package was extended in the pre-proposal phase concerning the aspects of data integration and visualization.
In the beginning the focus of the work package was on the principal situation analysis – mainly with a technological focus. This resulted in a status report on visualization technologies available and in the agreement to focus on the COP concept. In parallel real time visualization technologies were evaluated and tested and first data base driven approaches concerning the spatial search engines have been tested.
Initially the work package lead has been held by the Swedish Defense Research Agency (FOI) until the year 2007. After this the lead has been taken over by the Deutsches Zentrum für Luft- und Raumfahrt (DLR).

In the beginning of the project the work has been distributed between the partners. The allocation of tasks was done according to the partners involvement within other GMOSS work packages and – off course – according to the specific expertise available at the partners. The outcome of the project is mainly due to the combined expertise of all partners. A rough distribution of partners and main focus of expertise is listed below (in alphabetical order).

- Centre for GeoInformatics (Z_GIS) Visualization content analysis, realtime visualization of GIS and remote sensing data, visualization tool analysis and testing

- Deutsches Zentrum für Luft- und Raumfahrt (DLR) Remote sensing data pre processing, non-realtime visualization, visualization requirements definition, benchmarking criteria, WP-lead (2007/2008)
- European Satellite Center (EUSC) Real time data visualization (operational) and data integration, spatial search engine requirements definition, visualization tool testing
- Fachhochschule Hof (FH-Hof) Spatial search engine development, data base requirements definition, data integration
- Joanneum Research (JR), Graz Real time data visualization, visualization tool development, data processing, benchmarking criteria, testing
- Royal Military Academy (RMA) User requirements definition, user definition, COP-analysis, data integration analysis

- Swedish Defense Research Agency (FOI) Common Operational Picture model development, COP requirements definition, COP tests, WP-lead



Requirements for an interactive visualization system for GMOSS

2.3.3. Achievements

The major achievement of the "Data Integration & Visualization" work package is the close cooperation of most partners involved within the project beyond the scope of GMOSS. Especially the cooperation in the field of real time visualization as well as in the analysis of cooperative visualization technology will be continued even after GMOSS.

The progress of work during the project can be described in XXX steps.

- Definition and evaluation of the user requirements through a questionnaire
- Adaption of the COP concept available at FOI to the user requirements
- Status report of the techniques and technologies available for data integration and visualization
- Definition of benchmarking criteria for 3-D visualization
- Parallel development of a spatial search engine for the extraction of internet based information

- Identification, application and testing of the most appropriate tools within the “real world” during GNEX06 and GNEX07 exercises

Three major achievements include:

COP model for security applications

The main purpose of a common operational picture (COP) is to present information regarding relevant processes that may take place over longer or shorter periods in time. The objective is, for instance, to build an environment for coordination and monitoring of emergency situations where situational awareness should be determined, refined, compared and shared among users to enable a common operational understanding. To bring such events to their ends will requireinformation often coming from a large number of different sources.
Consequently, all data generated by these different sources have to be merged or gathered into a general overview of the situation and this has to be done in real time or at least near real time.Such requirements may be hard to fulfil. However, in many cases the users are willing to accept some delay if the information can be presented in a way that will increase the users trust in the information. This will also make it simpler for the users to make adequate and correct decisions.

The COP model aims at providing all the necessary tools to assure that the decision makers have received a correct situation awareness. In order to accomplish this, the COP-System must be able to manage the very diverse incoming information, to fuse this information, when ever necessary, and to present it in a well-organized manner to the decision makers. Furthermore, the users must also be able to share this information to maintain the overall situation awareness.

Benchmarking criteria and analysis for 3-D visualization tools

The working group has identified an extensive list of benchmarking criteria for the visualization tools used within the WP.
The criteria were applied to a range of 3D visualisation tools and therefore generated a test bed environment using data from the Kashmir test case.
As a result of the benchmarking tests, within the GNEX07 exercise several tests have been carried out. In cooperation with the commercial developers a test setup of four installations of the realtime GeoVisualization software Leica Virtual Explorer has been set up at the premises of four GMOSS WP20200 partners to evaluate the collaboration functionality of the software in real crisis situations. The outcome was presented at the GNEX07 reporting in Brussels – a video showing the interaction of the partners has been produced and has been made available to the GMOSS consortium.

Development of a spatial search engine for internet based information

Search engines are the key tool for finding relevant documents. Existing search engines support users by providing all documents which contain a set of specified words or phrases. Although such a “full text search” works well in many applications, this approach has also its weakness. In many cases search conditions cannot be defined sufficiently precise with this approach. As a consequence search engines either provide too many irrelevant documents or miss a large number of relevant documents.

The concept for the spatial search engine foresees an analyser deriving geographical point coordinates by identifying location names in documents. These geographical positions are stored together with words and phrases in a document index facilitating spatial and textual searches. Although this concept sounds simple three major challenges have to be addressed:

- Single web documents use very different formats and usually contain more than one text. The identification of distinct areas containing independent articles is a non trivial task.
- A document may contain more than one location name. Also location names are not unique (e.g. Paris in France and in Texas) and sometimes have also a different meaning (e.g. Bush).
- Methods for efficient access to a very large number of documents (index structures) via textual and spatial search do not yet exist.

Within the work package an experimental prototype to investigate these challenges in more detail has been implemented. The prototype is operated on a server to investigate its behaviour with a larger number of documents. Several students investigate methods addressing the challenges to improve the quality of search results.

2.3.4. Conclusions + recommendations + impact

Due to the partly completely different backgrounds of the partners within the working group there were some problems in understanding each others approach in the beginning. The major “misunderstanding” occurred between the partners coming from a military/defense background and the ones being mainly involved into research and development work. For example the term “Common Operational Picture” had to be understood by the research partners, as the term is not common in this community. The discussions and presentation involved in this process of “levelling” the expectations and the outcome led to a mutual understanding of the different approaches involved and also gave the team insights with aspects not considered before by the other side. In retrospect this was a sometimes difficult but helpful process for all partners. The outcome of the work package would not have been as diversified without these controversial discussions.

As 80 percent of human perception is visual, further improvement of visualization technologies for crisis management and understanding is a key prerequisite. Visual display of the situation at hand within a real world scenario using data from different sources, at different resolution and with different content is the challenge. Apart from the display of the information situation analysis and data search are additional techniques needed for this technology to proceed further.

To achieve this, the partners participating in the work package prepared a joint proposal for the first security call of the European commission. The proposal aims at building a Common Operational Picture Systems for Crisis Management enhancing the efficiency of disaster management by providing complete and reliable information and images of complex crisis situations. In contrary to existing solutions this system will also support the acquisition of data from the Internet by a spatial search engine as well data from aid workers using portable devices equipped with semi-automatic sensors. Another new feature is the support of planning and prediction tasks by this system.
According to the current feedback from the European Commission the proposal could not yet be accepted for the current call. The partners involved plan to resubmit a revised and improved version during the next security call in 2008. A funding of this proposal would ensure that key activities defined by the work package could be continued and taken forward.

2.4. Work Package 20300: Change detection

2.4.1. Executive Summary

Change detection is one of the key Earth Observation technologies in security research. Within GMOSS it is one of the three generic tools that are used to gain information from satellite image data. The main focus of the work package on change detection was to analyse and compare different methods using a variety of data (Optical and Radar) with different spatial and spectral resolution, and to test the methods depending on the applications that are studied within the application themes of GMOSS. It could be shown that several methods, developed by different partners in the work package team led to very good and reliable results if the change between data sets from different dates were analysed. There are mainly too prerequisites for this: firstly a good co-registration of the images and second a similar or better same sensor for the data acquisition of the two dates. The so called change map gives an overview of different changes which can be displayed in different colours, like new objects or missing objects. In most cases the changes found have to be interpreted by the user, since not all changes are relevant to the topic of interest. This implies that there is an automatic part and an operator dependent part in the whole process. The automatic methods though lead to faster analysis of larger areas, so that the interpreter can concentrate on the highlighted regions. The changes found in radar images were compared to those found in optical images and show a very high correlation, though resolution in radar images is generally lower. An object based methodology helps to improve the automatic analysis through aggregating the change information to certain objects. Furthermore the usage of optical stereo images, from which 3D-information can be derived, lead to improved results especially when build up areas are concerned.

2.4.2. Introduction

The work package on change detection had the challenge to provide methodologies for the application work packages of GMOSS. In the starting phase of GMOSS a change detection catalogue, which links the type of sensor with the application and the possible methods has been established and was updated throughout the project. At first an analysis on change detection methodologies has been performed in investigating the current literature. It became soon clear that not all approaches could be followed. The involved scientists from nine institutions in Europe demonstrated their expertise in the topic and decided on their involvement in mainly three subgroups of change detection methodology:

1. Object oriented change detection
2. Change detection using 3D information extracted from stereo data
3. Coherent and incoherent change detection in radar images

For the successful establishment of automatic methods a very high level of co-registration of the space borne image is an absolutely necessary prerequisite. For this reason studies concerning the necessary pre-processing steps were also carried out in the beginning of the project. One result was that for automatic change detection the geometric co-registration should be better than half the pixel size of the images. This condition is not always met by the satellite data providers so that additional work for co-registration is often necessary before starting the automatic change detection processes.

The partners involved were: CNES, DLR, FZJ, JRC, Qinetiq, RMA, TNO, TUBAF, Z_GIS

The lead of the work package was performed by Vinciane Lacroix, RMA for the first 18 months and for the second part (months 19 to 48) by Peter Reinartz, DLR.

2.4.3. Achievements

First a review and test of several classification and change detection methodologies has been performed concerning their applicability for thematic questions and applications, which arise in the context of GMOSS.

Supervised and knowledge based approaches yield good feature extraction results for most classes. In combination with filters and threshold-based decision rules nearly every surface feature can be extracted - however, the setup of such systems and the need for extensive training data stands hampers a very fast classification and extraction of objects, as it might be needed in the context of GMOSS. Within GMOSS scenarios for the application of supervised and knowledge based methods we consider all products, not demanded within near real time. This can be detailed land cover classifications, settlement extraction, water quality maps, time series analysis of vegetation, -land cover, -settlement, or geology mainly based on medium resolution data (Landsat, Aster, etc.).

Object oriented approaches combine the advantages of the combination of spectral and textural feature recognition. Segmentation and fuzzy classification allow for very high classification accuracies, especially for high spatial resolution data. However, object oriented approaches are also time consuming to implement and near real time products could not yet be generated. Furthermore, the class hierarchies and decision rules set up for one satellite data set are hardly ever transferable to other regions. Within the context of GMOSS, object oriented approaches are assumed to be applied to high resolution data (Ikonos, Quickbird, Spot, etc.) mainly. Tasks to handle, if no real time processing is desired, include the extraction of roads, railway tracks, single buildings, settlement extraction, detailed border monitoring, and vehicle detection amongst others.

For the detection of changed pixels, several statistical techniques exist, calculating e.g. the spectral or texture pixel values, estimating the change of transformed pixel values or identifying the change of class memberships of the pixels. In regard to the specific application of nuclear monitoring the most satisfactory results were carried out with the so-called Multivariate Alteration Detection (MAD) transformation. The MAD procedure is based on a classical statistical transformation referred to as canonical correlation analysis to enhance the change information in the difference images. The application and expressiveness of the proposed change detection technique for monitoring nuclear facilities depends (among other things) on the spatial resolution of the imagery. When a change signal within nuclear sites is very significant in terms of radiance changes, it can mostly be detected by the pixel-based analysis of mid-resolution multispectral image data. But when adapted to off-nadir high-resolution imagery, the results of the MAD transformation pixel-based algorithms are in general very complex and thus of limited use. Processing satellite image data in an object-based way generally extends the possibilities to detect and analyse changes between two or more dates by taking into account the changes of the mean object features (spectral colour, form, etc.), the modified relations among neighbouring, sub- and super-objects or changes regarding the object class memberships. Moreover, specific knowledge can be easily involved into the procedure. Previous studies implying a combination of pixel- and object-based techniques have already demonstrated the advantages of firstly pinpointing the significant change pixels by statistical change detection and subsequently post-classifying the changes by means of a semantic model of change-related object features. A straight-forward typology of spatial relationships among changing image objects or image objects otherwise in spatial or temporal correspondence has been developed to characterise object relationships in a spatially explicit way.

During GMOSS several radar change detection methods especially for security applications have been studied and developed. The advantage of radar, also known as SAR (Synthetic Aperture Radar), is that it can operate under cloudy skies, day and night. Because radar sensors illuminate the earth surface themselves using a microwave (generally in the range of centimetre wavelengths) transmitter, it is independent on illumination by the sun. The following methods are discussed:

1. Constant False Alarm Rate (CFAR) detection
2. Adaptive filtering
3. Multi-channel segmentation
4. Hybrid methods

All are pre-classification methods, which means that changes are detected before classification. Post-classification techniques are only reliable when the classification accuracy of the SAR images that are compared is sufficient. The first and the second method are based on the ratio image, which is obtained by dividing the after image by the before image. The third method is based on segmentation techniques. A disadvantage of pre-classification change detection is that the changes still have to be classified.

Summarising, CFAR detection is only suitable when the changes are small compared to the resolution (i.e. when changes cover a few pixels). Adaptive filtering is able to deal with distributed changes as well. A disadvantage of this method is that the shapes of changes are not always well reproduced. Multi-channel segmentation is a method that reproduces the shape of changes generally better for multi-look images, but lacks in the detection of small changes. Hybrid methods are a combination of CFAR detection, adaptive filtering and multi-channel segmentation. These methods combine the appropriate detection of distributed and small changes, even for noisy SAR images. As a result there is a preference for the last three methods, but what method can best be used is dependent on the application too.

Highlights

1) 3D models of cities can be derived with high resolution stereo data from space (e.g. IKONOS, QuickBird). Especially if the two images of the stereo pairs are taken from the same orbit (within a few minutes from different positions in the orbit), the possibilities to achieve good digital surface models (DSM) is enhanced because of the very similar illumination conditions. For a procedure of 3D change detection, based on digital surface models, at least two stereo data sets are necessary. The result of the comparison of two DSM from different dates (June 2004 and December 2005) for a region near the nuclear facility of Esfahan has been performed. Underground activities can be monitored by this method through the quantitative analysis of the dumping of material from the excavations, which results in volume changes of the DSM above ground near the excavation area (dump site). The excavation volume (probably tunnel construction) in Fig. 1c is measured to 103,000 m^3.

Figure a, b, c: Two images of different dates and combination of Orthoimage (green) and difference of two digital surface models (red). Maximum height difference is 10 m.

2) Often, the full assessment of changes requires several analytical steps, i.e. starting from broad change detection (change indication), and then – taking a closer look on indicated sites – a fine-scaled change assessment. This has been demonstrated in the Zimbabwe test case where the effects of operation Murambatsvina have been studied in Harare. Covering a 25 km² sized study area covering the capital of Harare, QuickBird data (August 2004 and June 2005), were pan-sharpened and ortho-rectified. Change analysis was done in two steps see Figure below

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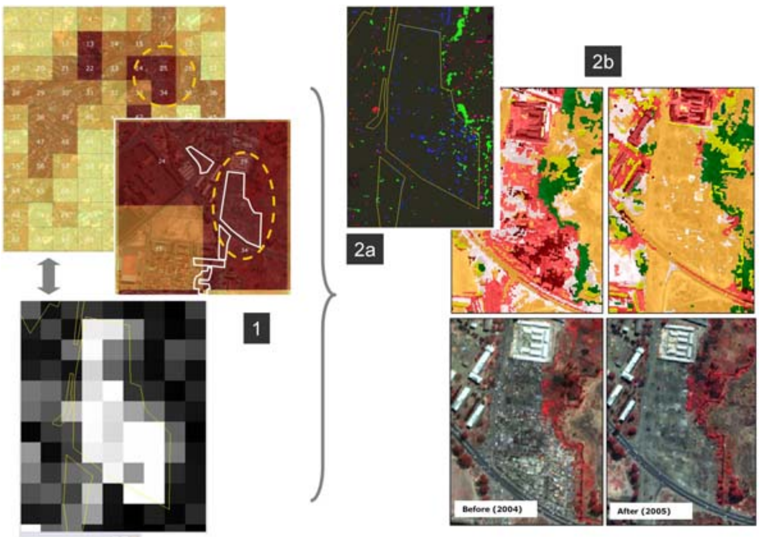
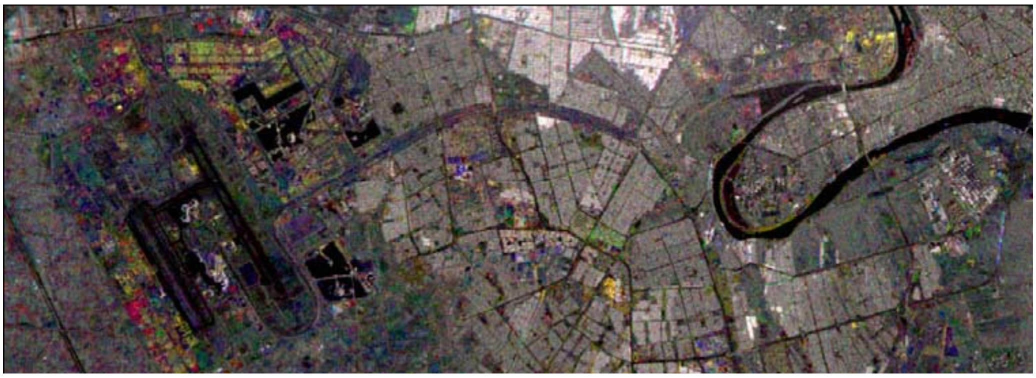


Different methods for change indication (see text)

- (1) Changes in the spectral behaviour of objects were statistically aggregated (by variances) and reported on regular grid cells (500 by 500m) or smaller. Within the detected cells, fine-scaled change assessment has been done by applying
- (2a) the MAD algorithm (see above) for detecting single features with significant changes and
- (2b) object-based image classification to gain knowledge about what exactly has changed to what, category-wise and in terms of number, shape etc.

3) Five radar images over Baghdad were analysed from 17 January 2003, 30 March 30 2003, 23 April2003, 17 July 2005, and 2 April 2007 which were collected with Radarsat in the same orbit, so that for all images the same imaging geometry is applicable. These so-called fine beam images have a resolution of 10 meter. Figure 3 shows three dates in the RGB colours channels. This method is an easy way for visual inspection in order to find changes since for no change the image is grey, while a change shows up in colour. Of course when more than three dates have to be analysed this visualisation method is inadequate.

In the figure below various colours related to changes are visible. For example blue implies that (23 April 2003) enhanced scattering occurred just after the war, while yellow indicates the presence of enhanced scattering in 2005, which remained in 2007. Red indicates recent changes indicated by enhanced radar scattering. Changes have been extracted from these data using change detection techniques, which include accurate co-registration, speckle filtering techniques and multi-temporal feature extraction.



Multi-temporal Radarsat image of the Baghdad area from 23 April 2003 (blue), 17 July 2005 (yellow) and 2 April 2007 (red)

2.4.4. Conclusions + recommendations + impact

A wide range of change detection tools was investigated and grouped into methods suitable for optical (multi spectral), radar (SAR) and 3D data. During the work on the four test cases all of the available procedures for change detection have been applied and analysed for their suitability. These test cases helped very much in the integration process of GMOSS and in this case especially in finding suitable data and applications which are prominent for operating the change detection methodologies.

Among the applications are land-cover change which is often one of the basic types of information to build analysis on, monitoring of nuclear safeguards, the distribution of populations, damage assessment and 3D analysis. What method to use for which application is not easy to say, it is for instance dependent on the size of the changes, shape, textural properties, spectral properties, and their behaviour in time. Population monitoring and land-cover analysis for example require methods that are also able to deal with larger objects over longer periods of time. What method to use is therefore also dependent on the sensor. In general, radar data is less dependent on atmospheric and illumination circumstances (cloudy skies, day and night) than optical.

On the other hand, interpretation is often more difficult due to spectral properties, so optical information (even no timely information) is necessary in most analysis. The orbit and tasking properties of different platforms play an important role here too. A trend in satellite observation is to deploy systems that consist of a number of satellites (i.e. satellite constellations) to reduce revisit times. Examples are the German optical systems RapidEye and TerraSAR-X and the French-Italian optical and radar system Pleiades-Cosmo/SkyMed. Another important parameter is the resolution of the sensor. Optical satellites with a resolution up to 0.6 m (Quickbird) are operational and accessible. In case of radar satellites the best resolution is now 1-3 m (TerraSAR X and Radarsat 2).

The challenges in change detection are to make the automatic procedures robust enough to be able to cover a wider range of applications. In general the choice of parameters for the procedures is still manual and time consuming. To arrive at a near real-time product generation there has still to be a lot of research to provide the services which are envisaged within GMES to reach the required accuracy. Also the contact to the users is always very important to understand the specific needs for each of them.

Many results and methods developed and investigated during GMOSS can also be applied in new running (FP6) and upcoming (FP7) GMES projects (e.g. LIMES, GMOSAIC). So called building blocks (BB), procedures for data analysis, can be extracted from the methods covered in GMOSS. Through the participation of GMOSS partners in these new GMES projects, the knowledge should be easily transferred to them.

As summary it can be said that change detection will surely be one of the most important method applied in operational remote sensing. Therefore it is recommended to concentrate in future research projects to improve and develop robust procedures which allow the application to the envisaged services (up- and downstream). There has still to be some research on the applicability of change detection to data of different sensors and resolutions because this hasn’t been a well investigated topic within GMOSS. But since not always the data from the same sensor are available it will be important to have methods at hand which can also cope with this setting.

2.5. Work Package 20400: Treaty monitoring

2.5.1. Executive Summary

The consortium, consisting of six institutions (BGR, FZJ, KCL, RMA, TUBAF, and TUD), continued to cooperate intensively with each other throughout the four year period of the GMOSS network on the problems of verification of, particularly, two arms control treaties – the 1972 Nuclear Nonproliferation Treaty (NPT) and the 1996 Comprehensive Test Ban Treaty (CTBT). These two treaties, together with the 1997 Chemical Weapons Convention (CWC), are perhaps the most important measures that affect the national and international security. For four years, the group focused on the development and applications of space-based remote sensing techniques to the verification of the NPT and the CTBT. Their achievements have been documented in a number of individual or joint publications. During the life of the GMOSS, members of the group coordinated their work and staff exchanges, both within the group and with other groups of the Consortium. For example, there was a very active participation in the Iran test case.

The physical characteristics or the “key”, developed for the large part of the nuclear fuel cycle, was used to train a computer to detect facilities automatically in a large area image. For this purpose, an object-based image analysis method, that attempted to emulate an image interpreter who normally uses image colour, shapes of objects, textures and association of objects of interest within their surroundings, was developed and applied to a number of Iran’s nuclear facilities. Sensitive method for the use in change detection and image classification procedures was developed, evaluated and applied to a number of nuclear sites in Iran and to the Indian, Russian and the US nuclear weapons test sites. A number of members from the Group participated and applied their techniques during the two GNEX-2006 and -2007 exercises that were relevant to the European security. Some of the members also actively participated in several training courses. In order to spread the activities of the GMOSS on arms control treaty verification, several members of the consortium participated and contributed papers in many international conferences. They also interacted with the user communities such as the IAEA.

2.5.2. Introduction

During the past four years or so, two documents that addressed the regional and international security issues were published by the European Union in December 2003 and in 2004 by a group of experts on behalf of the United Nations Secretary General.[1] Between them they identified poverty, infectious disease, terrorism, trans-national organised crime, state failure and proliferation of weapons of mass destruction (WMD) as some of the threats to national and international security. A state is secured when it is free from these threats. The European Union together with the European Space Agency initiated a project, Global Monitoring for Environment and Security (GMES), to investigate some of the above issues. In order to address the problems related specifically to security, the European Commission established a Net Work of Excellence, called the Global Monitoring for Security and Stability (GMOSS) in 2003. Under the GMOSS, several specific studies were carried out. An example of these is the verification of arms control treaties.

Composition of the Group

Two nuclear weapons related treaties, the 1972 NPT and the 1996 CTBT, were considered. The overall investigation was led by KCL (B Jasani) and FZJ (M Canty).

For the NPT, broadly the work was divided into two areas: development of a "key" for the nuclear fuel cycle (B Jasani, KCL) and the development of computer-base sophisticated image processing and analysis techniques (M Canty, FZJ; I. Niemeyer and P Marpu, TUBAF; S. Nussbaum, FZJ; A A Nielsen, TUD). The work on the CTBT war carried out using both optical and radar imageries. Both B Jasani and M Canty used optical data to study the under ground nuclear weapons tests at the Chinese, Indian, Russian and the US sites. J Schlittenhardt (BGR), A A Nielsen and H Skriver, (TUD) applied SAR and InSAR radar imageries to the problems of underground nuclear tests at the Indian, North Korean and the Nevada test sites, and assessed the use of polarimetric SAR.

"A secure Europe in a better world", **Document proposed by Javier Solan and adopted by the Heads of State and Government at the European Council in Brussels on 12 December 2003,** (The European Union Institute for Security Studies, Paris, France, 2003).

"A more secure world: Our shared responsibility", **Report of the Secretary-General's High-level Panel on Threats, Challenges and Change,** (Unite Nations, 2004).

2.5.3. Achievements

Achievements of the Group in the application of remote sensing to problems of national and international security have been thoroughly documented in a number of publications covering work completed in the four year period. A key was developed for the nuclear research and power reactors, conventional power plants, enrichment plants and reprocessing facilities. This was used to train a computer to detect facilities automatically in large area images. Object-based image analysis method using computer was developed. It was an attempt to emulate and support the image analyst's procedures. An image interpreter uses image colour, shapes of objects, textures and association of objects of interest within their surroundings. The key was then successfully tested using a number of space-based as well as aerial high-resolution images.

Computer-based, object-oriented image analysis is, to a first approximation, comparable to a person interpreting an image manually. An image interpreter, for example, recognizes, along with the colour of an image, shapes, textures and association of objects of interest within it and its surrounding. An attempt is made to achieve this in object-based image analysis, although the complexity and effectiveness of human perception are far from being achieved.

As a first step, some data pre-processing is necessary. For example, a precise geometric correction is essential for an exact pixel-by-pixel or object-by-object comparison. By means of geometric correction algorithms, image data can be registered to one another (image-to-image registration) or to a given map projection (geo-referencing). In our study a semi-automated image-to-image registration is carried out based on image correlation algorithms with sub-pixel accuracy. Moreover, radiometric correction is necessary to obtain absolute surface radiance or reflectance by removing atmospheric effects. Assuming that the relationship between the at-sensor radiances measured at two different times can be approximated by linear functions, a relative radiometric normalization seems to be sufficient. Here, a relative radiometric normalization based on the so-called no-change pixels is applied to the image data. The US Quickbird image data contain a lower-resolution multi-spectral data set (2.4m) and a high-resolution panchromatic image (0.6m). To obtain a high-resolution multi-spectral data set with 0.6m ground resolution, a panchromatic sharpening procedure is applied to all data sets. Here, a wavelet-based algorithm is used which produces well-focused looking results without significantly affecting the original multi-spectral values.

In our study, initially, multi-temporal wide-area ASTER imageries (with 15m, VNIR and 30m, SWIR spatial resolution) over some 17 nuclear-related were prepared. The results were compared with some high-resolution QUICKBIRD images acquired over limited sites. Multi-temporal ASTER images were used to detect changes in an area and also to locate activities of interest. High-resolution QUICKBIRD images and some aerial images were used to investigate in detail specific sites.

The extraction of the objects from the analyzed pre-processed images takes place at the lowest level by segmentation, at which stage the primary segments should ideally represent the real world objects. Feature recognition is carried out by the analysis tool *SEparability and THreshold* (SEaTH) providing the basis for image classification.The work also included the development of improved iteration schemes for the MAD transformation, its application to automatic radiometric normalization and the automatic selection of features for object-based classification.

New extensions to the previously published multivariate alteration detection (MAD) method for change detection in bi-temporal, multi- and hypervariate data such as remote sensing imagery were developed. Much like boosting methods often applied in data mining work, the Iteratively Re-weighted Multivariate Alteration Detection (IR-MAD) method in a series of iterations places increasing focus on “difficult” observations; here observations whose change status over time is uncertain. The MAD method is based on the established technique of canonical correlation analysis: for the multivariate data acquired at two points in time and covering the same geographical region, we calculate the canonical variates and subtract them from each other. These orthogonal differences contain maximum information on joint change in all variables (spectral bands). The change detected in this fashion is invariant to separate linear (affine) transformations in the originally measured variables at the two points in time such as 1) changes in gain and offset in the measuring device used to acquire the data; 2) data normalization or calibration schemes that are linear (affine) in the grey values of the original variables; or 3) orthogonal or other affine transformations such as principal component (PC) or maximum autocorrelation factor (MAF) transformations. The IR-MAD method first calculates ordinary canonical and original MAD variates. In iterations, different weights were applied to the observations, large weights are assigned to observations that show little change, i.e., for which the sum of squared, standardized MAD variates is small, and small weights are assigned to observations for which the sum is large. Like the original MAD method, the iterative extension is invariant to linear (affine) transformations of the original variables. To stabilize solutions to the (IR-)MAD problem some form of regularization may be needed. This is especially useful for work on hyper-spectral data.

A simple case with real Landsat Thematic Mapper (TM) data at one point in time and (partly) constructed data at the other point in time that demonstrates the superiority of the iterative scheme over the original MAD method was demonstrated. Also, examples with SPOT High Resolution Visible (HRV) data from an agricultural region in Kenya, and hyper-spectral airborne HyMap data from a small rural area in south-eastern Germany were studied. The latter case demonstrates the need for regularization.

A recently proposed method for automatic radiometric normalization of multi- and hyper-spectral imagery based on the invariance property of the MAD transformation and orthogonal linear regression was extended by using an iterative re-weighting scheme involving no-change probabilities. The procedure was first investigated with partly artificial data and then applied to multi-temporal, multi-spectral satellite imagery. Substantial improvement over the previous method was obtained for scenes which exhibit a high proportion of change.

Work has been carried out to develop a new change detection method for polarimetric SAR data combining segmentation, change detection and polarimetric decomposition. A significant improvement in the suppression of false alarms has been observed. Data from present and future satellites providing polarimetric capabilities will improve the change detection potential of SAR data for detection of man-made objects.

Apart from the above scientific achievements resulting in numerous publications in journals, reports and as chapters in books, considerable amount of intellectual cross-fertilisation occurred. During staff exchanges developments such as on neural network classifiers were realised. New versions of IR-MAD change detection software written in Matlab and are now available. Moreover, the IR-MAD was installed on the DLR XDibias system. In addition, Xiao Ying Cong and Joerg Schlittenhardt visited Joanneum Research (JR, Graz) and worked together with Karlheinz Gutjahr on InSAR data of underground nuclear explosions from India, North Korea and Nevada using JR's RSG software.

2.5.4. Conclusions + recommendations + impact

While automatic computer-based identification of nuclear facilities in high-resolution images was achieved, the real challenge is to apply the technique to images with low spatial resolution but with a wide area. If large-area images could be used, the technique could increase the efficiency of detection of known sites. It may even make it easier to detect undeclared sites. Moreover, the procedure for object-based change detection for Treaty monitoring purposes using very high resolution data still requires improvement with regard to automation and false alarms rate/accuracy.. SAR has shown potential in detection of man-made objects, and combination of segmentation, change detection and polarimetric decomposition for polarimetric SAR data has shown good results which should be pursued further

While the construction of keys for various nuclear facilities was relatively easy, the detection of uranium mines is particularly challenging. Because of the considerable similarities between mining for uranium and other minerals, difficulties are envisaged. This is because mines for other elements often look similar to those for uranium. While this could, to some extent, be overcome by using hyper-spectral sensors, the amount of uranium in nature is considerably smaller than other minerals. Thus, detection of uranium becomes difficult with hyper-spectral sensors owing to the narrow band-widths involved. In such cases, the amount of spectral signature collected by the space-based sensor is small. Thus, some innovation will be required to overcome this difficulty.

Normalization of the no-change standard deviations in the IR-MAD method is an issue that needs more attention. While the work on this carried out by some members of the Group does not solve the problem, it is a contribution to that end.

2.6. Work Package 20500: Early warnings

2.6.1. Executive Summary

The WP 20500 team has jointly worked throughout the four years of the GMOSS project with the aim of testing the ability of a number of different techniques for providing early indications of security events that might pose a risk to civilian populations, respecting substantially the initial objectives of the work package itself.

Early warnings of disasters caused by man and nature were under WP 20500 attention: in both cases, in fact, national and international security could be affected. The former is often caused by struggle for natural resources, for political power or by neighbouring failed states. Thus, armed conflicts can be predicted and observations from satellite could be a good tool for early warnings. On the other hand, early warnings or rapid alerts of some natural/man-made accidents often require frequent observations from space.

Thus, two types of imageries can be used for these two kinds of requirements: for armed conflict high spatial resolution images are needed, while natural disasters such as floods, fires or even fires caused by damaged oil pipelines due to terrorist attacks could be detected by images with very poor spatial resolution but with very high temporal resolutions. The Group explored both these applications with very considerable success. For example, for possible armed conflict, estimations of military deployments along international borders and state of armed readiness at military airfields were shown to be feasible. On the other hand, very high temporal resolution images with low spatial resolution demonstrated to be very useful early warning tools.

In addition, an amazing result was that, during the four years of GMOSS life, pre-existing algorithms, originally applied to satellite data for different purposes, turned out to be useful, as suspected, also in security field.

2.6.2. Introduction

The WP 20500 was led by KCL (B. Jasani) and UNIBAS (V. Tramutoli).

The team underwent to changes in composition during the project life: moving from the first to the second year of GMOSS, JRC and Swisspeace partners shifted their Early Warning activities (on the open source of information) to WP21300 and a new (Associated) Partner, the IMAA-CNR, joined to the WP20500 partnership. Moreover, during the third year, the high affinity of interests about satellite data processing among UNIBAS, IMAA and CRPSM led to a so strict collaboration that CRPSM required to join to Early Warnings WP: some activities, which had involved only UNIBAS, KLC and IMAA in the context of Early Warnings during the second year of GMOSS, started to employ more actively also CRPSM staff already in the first months of the GMOSS third year.

On the whole, WP 20500 members worked on Early Warning issues at two different levels:

- the use of high (CRPSM) or very high (KCL) spatial resolution imagery, but extremely low time repetition to detect troop-build-ups and/or population movements at borders as well as other signs of impending conflicts;
- the use of low spatial resolution, but high (IMAA-CNR, CRPSM) or very high (UNIBAS) temporal resolution to give an early/rapid warning and/or a real-time monitoring of events potentially dangerous for civilian population in order to give support to decisions devoted to mitigate their effects.

2.6.3. Achievements

Achievements of the Group in the application of remote sensing to problems of early-warning have been documented in a number of publications covering the joint work completed in the four year period.

Work with high spatial resolution data

Detection of armed forces getting in a state of readiness and even the knowledge of an adversary's military strength is an important aspect of early-warnings. Some of these were examined during GMOSS project. The idea was to determine if observations from satellites with high spatial-resolution can be used effectively. Following issues were investigated:

Inter-border conflict

- Identification of potential conflict areas using open sources;
- Determination of the military potentials of States under examination;
- Determine deployment mode of military hardware
- Using change detection methods, estimate if there are any troop movements;
- Determine concentrations of military hardware along international borders;
- Various types of targets were studied using commercial satellite imageries;
- The work on developing possible typical signatures for such targets has been initiated for application to monitoring arms control and peace treaties;
- These could then be applied to EW activities.

Work with high temporal resolution data

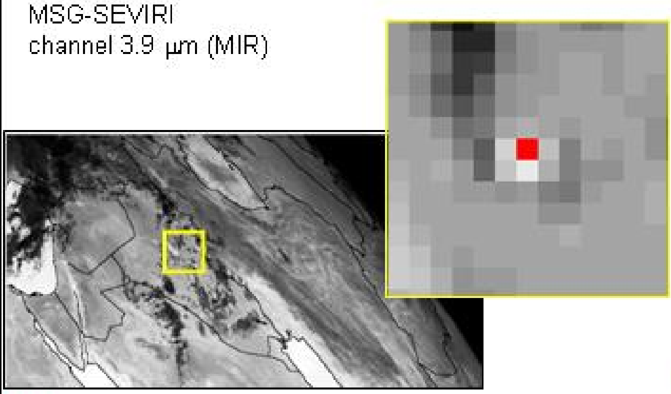
The usefulness of high temporal but low spatial resolution satellite sensors in security field is probably one of the most important result within GMOSS. Before the project, satellite data acquired by such instruments were usually employed in meteorological applications, but inputs induced by integration among GMOSS partners led to test that some events related to the citizen security may be rapidly detected only by using sensors with a high repetition time in spite of their rough spatial resolution. The rapidity in detection, in fact, may play a crucial role in some circumstances because it may assure a rapid response and more effective rescue operations.

At the same time, pre-existing algorithms, originally applied to satellite data for different purposes, have been skilfully readapted to security-related applications with successful results.

In the ambit of the work with high temporal resolution data, the main investigated issues were connected to the following kinds of events:

EXPLOSIONS of oil/gas pipelines

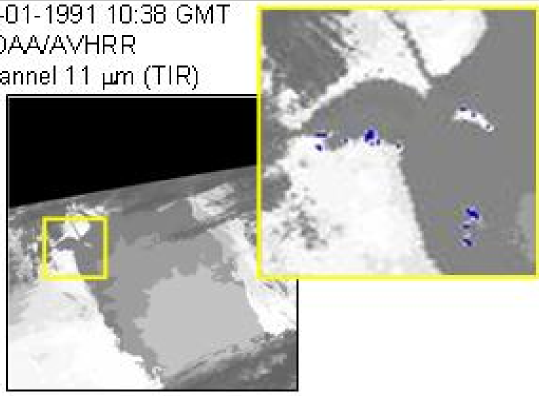
18-10-2005 20:00 GMT
MSG-SEVIRI
channel 3.9 μm (MIR)



Timely detection of an explosion along an oil pipeline in Iraq due to terrorist actions.

OIL SPILLS due to sabotages of oil pipeline

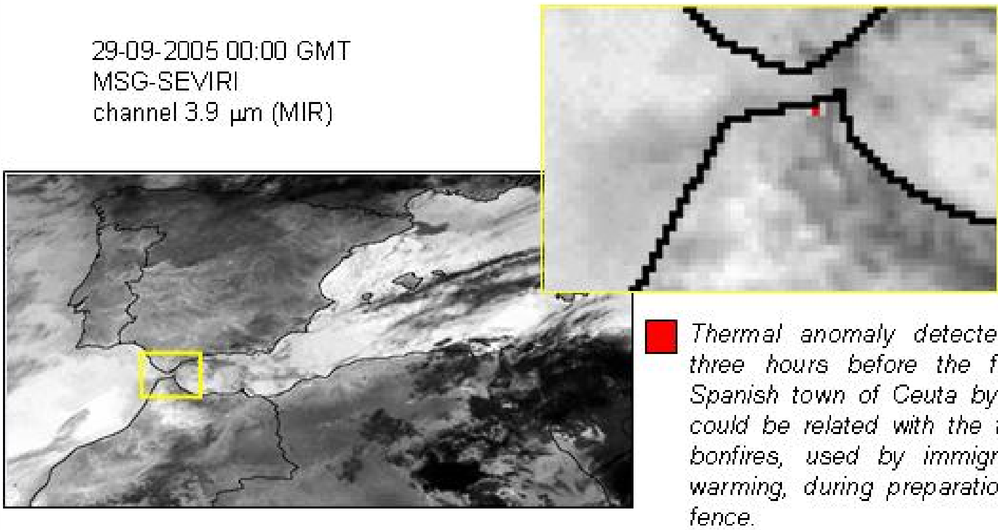
24-01-1991 10:38 GMT
NOAA/AVHRR
channel 11 μm (TIR)



Oil spill along Kuwait coasts during the Gulf War, as consequence of the military action of Iraqi forces that opened valves at the Sea Island oil terminal near Kuwait City and released large quantities of crude oil into the Gulf.

Pipeline sabotages, both in the case of explosions which affect pipeline networks and in the case of oil spills deriving from terrorist breaking of land/submarine pipelines;

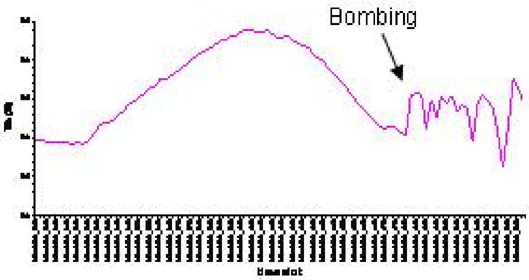
29-09-2005 00:00 GMT
MSG-SEVIRI
channel 3.9 μm (MIR)



Thermal anomaly detected on SEVIRI images three hours before the fence crossing of the Spanish town of Ceuta by African immigrants. It could be related with the temporary presence of bonfires, used by immigrants for cooking and warming, during preparation of the attack to the fence.

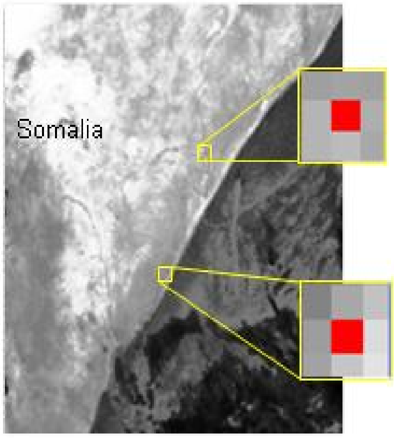
Immigrant bonfires ;

BOMBING over civil airports and villages due to terrorist attacks



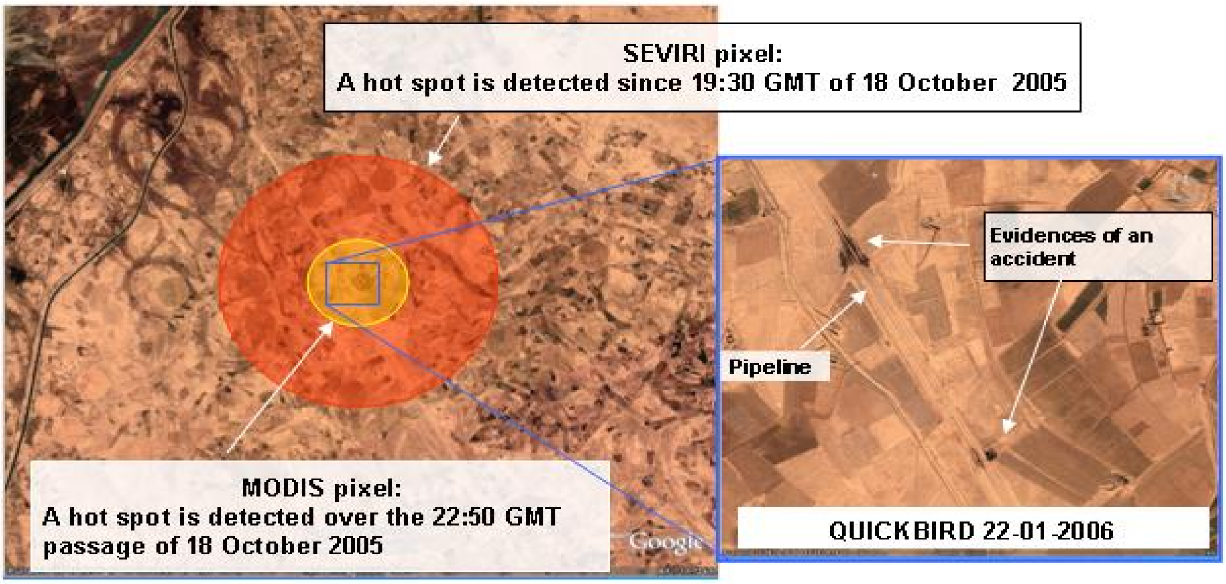
SEVIRI MIR brightness temperature evolution during all the day (13 July 2006) at the Beirut airport: the rapid increase of the brightness temperature is in correspondence of the bombing.

07-01-2007 10:45 GMT
MSG-SEVIRI
channel 3.9 µm (MIR)



Between 10:30 and 10:45 GMT of 7 January 2007, two strong thermal anomalies are detected over Somalia. They should be related to an aerial raid over some villages in the south of Country.

In each application, the integration of different sensors and/or collateral information is fundamental for a complete description of the event itself, but generally it is not possible



Red circle identifies the SEVIRI pixel which turns to be affected by blast on the basis of RST technique. Yellow circle represents a MODIS pixel where a hot spot is detected by MOD-14 technique (see http://rapidfire.sci.gsfc.nasa.gov/). On the right, a zoom of a QUICKBIRD image allows us to recognize ground evidences of an accident along a pipeline network.

to have enough information from space and/or ground. When available, the analysis of different sensor data clearly helped us to identify with precision, for instance, both time and place of an event as showed in the case above.:

Finally, it should be highlighted that in reality many security related events require a rapid response of decision makers so that they have to be able to delineate the scenario of the event and take the better decision starting from partial information.

2.6.4. Conclusions + recommendations + impact

During the GMOSS project, an exchange of expertise and constructive comparisons were computed not only in security field but also on natural and environmental hazards such as forest fires, earthquake & tsunami, oil spills,…, which are, among other things, in a direct connection with many GMES topics. In addition, in the course of the project, services probably useful even in the context of GMES were inspired. They will be tested in the framework of new FP7 projects (e.g. G-MOSAIC) and exploited by new SMEs (like GeoSpazio Italia, spin-off of Unibas) even in the wide market of satellite-based applications for security and Civil Protection.

As a matter of fact, solid bases for a future cooperation among different Institutes were built up during GMOSS project and the great number of joint proposals within the FP 7 may be seen as an indicator. The aim is, in fact, to continue the collaboration started within GMOSS exploiting EC calls on security, but also on other topics which are always under EC attention such as natural risk monitoring and mitigation, environmental & technological hazards monitoring and mitigation. Moreover, GMOSS represented also the occasion for starting new collaborations in training field between partners (e.g. Unibas and Linkoping, Unibas and EUSC) in the framework of common Erasmus program.

A part from more concrete outputs, the impact of WP 20500 work on research is quite clear considering the successful results obtained both using high spatial and high temporal resolution data for early warning purposes. In particular, it was successfully tested that the use of high repetition time satellite sensors, usually employed for meteorological purposes, may be determining in the case of security events which may require a rapid response. At the same time, pre-existing methods (like RST approach), originally applied to satellite data only for natural/environment risk monitoring, were used for the first time within GMOSS for detecting thermal anomalies related to security related events, obtaining amazing results.

2.7. Work Package 20600: Populations and borders

2.7.1. Executive Summary

The overall objectives of the work-packages monitoring population and borders were common in extracting information from satellite imagery and geo-spatial information layers in order to derive population characteristics and activity (i) at regional level in population density estimation and border permeability index and (ii) and at local level in refugee camps population estimation and population behaviour patterns.

Regional population density estimations developed for Zimbabwe (Schneiderbauer and Ehrlich 2006) have been refined (based on land cover classification of satellite images and GIS analysis) (Schneiderbauer and Ehrlich 2007). A border permeability concept (Stephenne and Pesaresi 2006) has been applied in two respective regions with different scales in East Europe (Stephenne and Zeug 2007), compared in Central Africa by CRPSM (Stephenne et al. forthcoming). A method to automatically identify and count refugee tents using EO data in Lukole (Tanzania) (Giada et al. 2003) has been tested by the WP partners on various tests areas, using various sensors. CRPSM, Z_GIS (Lang et al., 2006a, b) and EUSC have explored additional morphological approaches to solve the problem of automatically counting tents in two sites: the Goz Amer and Mille refugee camps located in western Chad using Ikonos and Quickbird very high resolution images. Based on two satellite images of the refugee camp “Mille” in the Chad, Kraus et al. (2007) have developed a new system for automatic detection and counting of tents that has to be enhanced further to be useful for the desired purpose. Z_GIS has established a workflow of using VHSR image data for rapid information delivery that relies on transformation of raw image data into ready-to-use information (Lang et al., 2006a). Automated analysis of image data is coupled with GIS-based visualization techniques (Analytical 3D views, Tiede & Lang, 2007). Extracted dwellings and habitation structures are used as proxies for an estimation of camp inhabitants

For the benchmarking objective, the WP provided different assessments of population datasets, classification methods, nigh time images, new algorithms and new sensors. The provision of a geo-referenced, pseudo-realistic 3D-scenario of the Goz Amer refugee camp (Z_GIS) has been evaluated in terms of its usefulness for improved humanitarian aid delivery. The use of night-time satellite images in the visible (DMSP/OLS sensor) to detect lights or bone-fires revealing human settlements, further images and different sensors (SAC-C/HSRC) have been analysed

2.7.2. Introduction

- History of the work package

Population monitoring work package was proposed in GMOSS to address the shortcoming of population data for security studies. The work package started by taking stock of scientific work carried out to date on the use of Earth Observation for improving population data. The work package has strived to identify the new requirements for population information from the security community and come up with solution. The work package has largely explored the requirements from humanitarian and crisis management community. New procedures have been tested to assess population data in conflict situation in Iraq, in Lebanon, and on Refugee camps in Darfur as well as Zimbabwe. A number of sensors have been tested from the traditional optical medium resolution imagery such as Landsat, spot, to the VHR imagery Quickbird and Ikonos to Night lights (OLS) and new sensors recording in the thermal part of the spectrum.

- Team composition, lead, members

JRC: Daniele Ehrlich, Nathalie Stephenne, Raphaele Magoni (WP lead)
CRPSM : Giovanni Laneve (responsible scientist), Munzer Jahjah, Giancarlo Santilli, Diego De Rosa, Giuseppe Russo, M. Castronuovo.
EUSC : Antonio De la Cruz (responsible scientist), Marcin Mielewczyk, Daniele Cerra, Maria Jose Garcia Quijano, Gracia Joyanes.

Z-GIS : S. Lang (responsible scientist), D. Tiede, E. Schöpfer, S. Kienberger, A. Uttenthaler (MSc student)
DLR : T. Krauss

2.7.3. Achievements

GMOSS 20600 work package has used a number of different sensors and applied a large range of image anlaysis tools for population related studies. All partners widened their scope of EO-based techniques for population and border monitoring. Particular focus has been set on integrative, trans-workspackage (e.g. WP 20200, 20300) and trans-institutional activities, as been framed by the test cases (in particularly Zimbabwe – led by Z_GIS) and the GMOSS benchmarking exercise on dwelling extraction (led by Z_GIS)

The applications are grouped in this summary into the following broad categories

1. Alerting for disasters – Lebanon, Kashmir - (EUSC/CRPSM)
2. Refugee enumeration, Lukole, Goz Amer (All)
3. Benchmarking of population estimation, Zimbabwe test case (Z_GIS; all)
4. Border permeability studies – Europe, Africa (JRC, CRPSM)
5. Vulnerability studies Europe, Iraq (Z_GIS, JRC)
6. Population density Iraq (JRC)
7. Population Dynamics – Europe (Z_Gis)
8. GNEX exercise (All)
9. New sensors and algorithms

1. Alerting for disaster

EUSC and CRPSM studied the use of night time imagery such as that available from OLS DMSP and newly available sensor such as SEVIRI for alerting in case of disaster. This is based on the assumption that there is a constant and known emission of lights from the earth surface that corresponds to populated centers. Changes in the illumination –that can be monitored from satellite imagery – can then be related to changes in societal activity due to – for example –a disaster unfolding. The work is very promising and new research will identify the sensitivity of sensors to energy emissions on the EARTH surface.

Changes in night time illumination during the Kashmir earthquake in 2005 and the Lebanon crisis were correlated through open source analysis of people movement and re-settlements. Energy analysis of SEVIRI images was also used to identify pipeline explosions in Iraq. A pipeline network over Iraq was made available to the network. Comparison to open source shown that pipeline explosions can also be detected with this kind of sensors,

2. Refugee enumeration

The enumeration of refugee received most attention from the work package. The work focused on testing the usefulness and shortcomings of satellite imagery in mapping refugee camps. Comparative studies on automated dwelling extraction algorithms was conducted in different refugee camps starting from Lukole (Tanzania) by JRC to refinement of the methodology with mathematical morphology and E-cognition in the refugee camps of Darfur. JRC provided dataset of Lukole to the partners who achieved comparative studies using mathematical morphology, e-cognition and traditional pattern recognition techniques. CRPSM has provided interesting insights in the use of mathematical morphology for locating and mapping dwelling as well as other infrastructures. They have tested the algorithms on the Lukole refugee as well as the Goz Amer Camp. EUSC, Z_GIS and CRPSM have studied several test areas in Darfur, Zimbabwe and Chad to (1) to identify huts, small shacks or any other dwelling damaged or destroyed during humanitarian crises in these areas and (2) to gain population estimates in refugee camps and shanty towns. The potential and limits of automated dwelling extraction were tested against visual / manual delineation. To this end, QuickBird (Sudan, Chad, Zimbabwe) and Ikonos (Tanzania, Zimbabwe) scenes analyzed by algorithms of Mathematical morphology (using Matlab) and class modeling (using Definiens).

Textural analysis algorithms have been applied to medium resolution images (Aster, SAS-C/HSTC) in order to automatically detect man-made infrastructures (airports, roads, military installation, ..) on large mosaics of satellite images around national borders (Darfur, Zimababwe, Libya/Chad, Kenya/Somalia and Kashmir border). Results have been submitted to international conferences (De La Cruz et al. 2007, Laneve et al. 2007). Application of these image processing techniques to medium resolution and very high resolution (Quickbird) on the area of Esfahan has been used to complement the treaty monitoring analysis.

Z_Gis provided a workflow to extract quantify and visualize ephemeral settlements structures with case study on Goz Amer in Chad. The workflow foresees an automatic transformation of images and complex content into products, ready to use and relevant for decision makers. It includes techniques like image pre-processing (geo-referencing and object-based segmentation), feature extraction, classification, spatial analysis and pseudo-realistic 3D visualization, referenced on using global viewers (for example Google Earth, in the case of the GNEX07). Improvement of this work focused on transferability and robustness with respect to changing sensors, study area, types of extracted dwellings (Lang et al. 2006, Tiede and Lang 2007) A master thesis on the camp provided support on the socio-geographical and socio-political background as well as comparison of population figures (Lang et al. 2006a). The validity of algorithms and workflows strongly depends on the usability of the results for policy makers in crisis management, emergency response and contingency planning. Through the network staff exchange facility, EUSC image analyst visited (J. Ebeltjes). CRPSM and Z_GIS to compare the rapid counting algorithms developed by these institutions to the visual and manual counting of destroyed or damaged village huts in Darfur.

Spatial explicit approaches of dwelling extraction have paved the way for locally disaggregated, fine-scale estimates of vulnerable population in refugee camps and shanty towns, including spatial descriptors of size and arrangements of dwellings.

3. Population estimation in Zimbabwe test case

Within the GMOSS test case Zimbabwe, Z_GIS carried out research on the operations of demolitions and resettlements (operations Murambatsvina and Garikayi) taking place in Zimbabwe during 2005/06. Data and basic information have been provided by JRC (Schneiderbauer and Ehrlich, 2006). Main objectives of Z_GIS study were to pre-assess the possibilities of automatically vs. visually detecting indications of demolitions as well as the number / type of deconstructed structures; d. to derive estimates the number of people affected by the respective action taken place; as well as to spatially quantify and assess the living conditions (sizes of dwellings, inter-dwelling distances, and the like) (Lang et al., 2007). Change detection methods have been applied in order to identify the demolished structures automatically. To this end, we adapted the workflow for information delivery, towards (1) a transferable algorithm for indication of changes in urban areas based on before and after images, and (2) spatial aggregation of the results for comparative change detection and analysis (Schöpfer et al., 2007). Throughout the network, this approach was compared with change detection methods used by TUBAF and FJ, respectively. These results were also compared with change detection analysis carried out by TNO using ASAR radar data. Work on the test case Zimbabwe was supported by a Master thesis of Andreas Uttenthaler at Z_GIS (supervised by Prof. T. Blaschke and co-supervised by Dr. S. Lang). Feedback and input was received Mr Dominik Kwecha from the Zimbabwean Forest Commission, who joined the GMOSS Summer School 2006.

4. Border permeability

Border permeability studies used satellite imagery to calculate a friction associated to a potential illegal migration along the border. The geographical friction was derived from different type of land covers, topography, population density data and from transport network. The analysis was carried out on the entire land border of the EU from Sweden to Greece. A detailed analysis was conducted using VHR imagery over an area on the Slovak and Hungarian order that combined also information on legal and illegal transits over that section of the border as an example of a full model that can support border security. The analysis was carried out by the JRC and benefitted from cooperation with border security institutions.

The concept has been applied by San Marco in a simplified way to assess border permeability in Africa and specifically n the Kenya Somalia border. This index can be seen as an indicator of the place where VHR and medium resolution satellite images can be analyzed.

5. Vulnerability studies in Europe

Z_GIS has used advanced spatial modeling technique to derive standardized vulnerability maps at sub-catchment level (Salzach river basin). This work addresses susceptibility, adaptive capacity and resilience according to different hazards (e.g. floods, droughts). Using an object-based classification approach, the multi-criteria have been weighted through expert knowledge. .

JRC analyzed the vulnerability of communities in northern Iraq and their susceptibility to suffer from conflict. The work was supported by a land use land cover analysis, from socio-economic data available over a decade for Northern Iraq.

6. Population density estimation at regional scale

Applying the methodology set up in Zimbabwe by Schneiderbauer and Ehrlich (2006), JRC has conducted population density estimates over Northern Iraq. The work takes advantage of medium resolution satellite imagery to derive land cover, SRTM data in the form to derive likelihood of finding villages. The work produced a population density map that was the validated from a village survey conducted in Iraq in 2003 (Mubareka, et al. 2007). The work has been the basis for a more in depth analysis of the likelihood to suffer damage from conflict.

7. Population dynamics

Z_GIS has conducted spatial-temporal GIS models of population behavior patterns. This is an extension of the population density assessment and attempts to provide also the dynamics over the day, week and month. Recent increasing of spatial detail of EO data can be utilized to identify clues for human presence, and temporal dynamics and behavior of population. Especially in urban areas, from a security point of view, it may be a great difference looking on a public square at midnight or noontime. The work focused on Urban areas (test case in the city of Salzburg) and aimed at (1) representing the municipal area as a contiguous set of human activities grouped into homogeneous human activity unit, (2) characterizing the spatial temporal dimension of human activity by establishing specific patterns of occupancy, (3) integrating the information into a GIS that provides a spatially and temporally disaggregated mapping of human activities.

8. GNEX exercises

The GNEX'07 exercise provided the opportunity to highlight the topics and achievements of the population work package. This exercise focused of a human security study on refugee camp and epidemic situation. The work showed the potential of imagery but illustrated that images is not sufficient to address crises if no information on population is provided. Different techniques of population assessment were applied and distributed to the other partners in the exercise. JRC calculated an automatic built-up mask using morphological image processing and derived a population density dataset. Z_GIS applied dasymetic mapping and visual 3D modeling in Google Earth in both GNEX'06 at the municipality level and GNEX'07 using population figures on the refugee camp and land cover classification derived from SPOT 5 data (2.5m GSD). The resulting population density was provided at 100 x 100 m.

The exercise has been successful in showing the potential and limitation of dissemination platforms like Google Earth. On one side the absolutely fantastic possibility to drape over any type of geo-spatial product and on the other side the awareness that in time of crisis the internet connection may be the first infrastructure that fails as was clearly shown during the exercise.

9. New sensors and algorithms

CPRSM has provided an in depth analysis of the possibility to analysis changes of the surface of the earth for sensor analysis continuously the surface of the Earth at different time of day and thus – with different illumination and viewing angles. San Marco has also tested algorithms to automatically extract roads from SPOT satellite imagery. San Marco has also tested the concept for UAV to be used in the field.

2.7.4. Conclusions + recommendations + impact

The work conducted in GMOSS has shown that satellite imagery has been and will continue to be used to improve population information. Information from a range of satellite, from the coarse resolution Night Lights / OLS to the VHR optical, have been used to address population.. Huge potential lies in the very high resolution SAR sensor data that are starting to become available. The EO derived information is used indirectly to extract the information. Namely to the feature extracted from satellite some population weights is associated.

The integration with other work packages of GMOSS is critical. Feature extraction from satellite imagery and testing of new algorithms and image data should be conducted by the more specialized work packages while the population work package should rather emphasize on the relations between image features and population presence. The work is in big demand given the shortcoming of population data in many part of the world especially in conflict countries.

The research should also focus on new features that can be detected from the imagery that can be related to population presence as well as characteristics of population. A new research avenue is also the temporal spatial analysis of the population within built up areas as well as at regional level. Finally EO just start to address security issues and future security challenges will require new information sources of which EO may be an important one.

The GMES community is certainly an important user of population information especially within security component. For example, human security is a theme where population totals (numbers) and characteristics are the variables that needs to be estimated. The current GMES services that focus on human security includes the

Emergency Response GMES service addressing crisis management. Within the crisis management cycle population information are required at different accuracy and at different spatio-temporal intervals depending on whether the information relate to the emergency relief, the assessment of the damage and/or the rehabilitation. The requests are far from being met. The security GMES service that starts to take shape requires population. When the requirement for such a service will be available the appropriate procedures will be developed to bring the information to the right user.

The challenges related to the timeliness for which population information can be derived. Also, the accuracy and precision of their geographical and temporal distribution and their relevance to the application is an issue. Especially for a global coverage that is the geographical scope of the GMES. Global population, even within a fully fledged GMES service, can not be made available in an updated way. The pattern of global population distribution and dynamics just can not be captured with a precision used for all security applications, no matter what effort is put in the process. In fact, even population total, let alone population characteristics, can not be made available without very important assumptions. For the community addressing security issues, the main challenge is to be able to get a snapshot of temporal spatial distribution of population for that given area in a given moment in time that is the time when a security event unfolds. That flexibility will be obtained when up to date baseline datasets – such as global coverage of VHR imagery, will be available, knowledge of the population characteristics of the area as well as population figures at the finest scale recorded. Then modeling – providing the best educated guess of where people are - will be possible. The second biggest challenge is to be able to get tools that can monitor, for a given area, the movement of people in short amount of time. Earth Observation will be able to help if it will be able to provide very fine resolution coverage, with coverage at day and night. Such systems may not be provided by satellite imagery. Tools and data sources other than Earth Observation may be developed in that case.

The recommendations are for the Earth Observation Community and the social scientists.
EO community should maintain a close watch on the newly availability of optical and SAR sensors that are made available. These may provide some of the characteristics that allow to rapidly assess situation that are required for population estimation. However, non satellite flying equipment and sensors should also be followed carefully. Unmanned vehicles seem to offer the biggest opportunity at the moment of writing. The Image processing community should produce global datasets of built-up areas – that remain the best indicator of human presence – and continue to improve the information extraction techniques for optical and SAR imagery. The social scientists – the demographic community – that supports the GMES service – a global service – should maintain a database of global administrative units at the finest level in cooperation with UN institutions. The population figures attached to those units should continuously be updated as done by the UN Population Division and the US International Census bureau and probably other players.
Finally, the most important recommendation that social scientists – the demographers – and the more technical community – Earth Observation community, GIS community- should continue to work together to allow to social scientists to benefit from the newest technologies and techniques, and the technologist to learn in order to target with more precision the development of algorithms and techniques of analysis to the benefit of the user community.

2.8. Work Package 20700: Damage assessment / Monitoring infrastructures

2.8.1. Executive Summary

WP 20700 on critical infrastructure monitoring and damage assessment started in 2004 as two separate work packages, one on infrastructure monitoring, and one on damage assessment and rapid mapping. In 2006 both were merged because of the overlap in topics, interests, and partners.

Within WP 20700 12 partners from 8 countries have worked together on different case studies: Bam earthquake (Iran 2003), South-east Asia tsunami (2004), evaluation of pipeline infrastructure monitoring project PRESENSE (FP5), the GMOSS-wide test cases (Iran, Iraq, Kashmir, and Zimbabwe), and the near real-time exercises (GNEX 06, GNEX 07). Among the deliverables are a critical infrastructure monitoring catalogue, a proposed standard for damage assessment and reporting, and 19 papers and reports.

Mapping the results against the initial objectives we can say that we succeeded in bringing together the European expertise in infrastructure monitoring and damage assessment, and demonstrated the use of satellite earth observation for these and other security applications with different tools and methods.

Requirements and standards were identified (critical infrastructures) and established (damage assessment). The use of techniques as synthetic aperture radar (SAR) and interferometry (InSAR), and information from other sources was assessed (optical imagery, collateral data, open source intelligence). Tools and methods were (further) developed with knowledge from the network and partners. GMOSS also resulted in further co-operation between partners in new FP initiatives.

2.8.2. Introduction

WP 20700 on critical infrastructure monitoring and damage assessment started in March 2004 as two separate work packages: WP 20700 on infrastructure monitoring and WP 20900 on damage assessment and rapid mapping. The first was managed by Joanneum Research (first by Lado Kenyi, later by Karlheinz Gutjahr) and the second by TNO (first by Philippe Steeghs, later by Bert van den Broek). During the meeting in Belgirate in March 2006 was decided to merge both work packages because of the overlap (topics, interests, partners) and the workload of Joanneum Research and TNO. In December 2005 it was decided that the activities of all WPs were partly combined into the study of four test cases, of which Joanneum Research and TNO were both coordinating one case study. The new WP 20700 was managed by TNO (Rob Dekker).

The initial WP 20700 started with the following partners: Definiens (Germany), EUSC (Spain), DLR (Germany), Joanneum Research (Austria), and TNO (The Netherlands). WP 20900 started with CEA (France), DLR, Joanneum Research, JRC (Italy), QinetiQ (UK), RMA (Belgium), and TNO. After the merge in March 2006 Definiens became associated partner. In the same year RMA left, and University Pontificia de Salamanca (Spain), University of Pavia (Italy), and SERTIT (France) joined WP 20700 as associated partners.

Date	20700 Infrastructure Monitoring	20900 Damage Assessment and Rapid mapping	20700 Critical Infrastructure Monitoring and Damage Assessment
March 2004 (kick-off)	Brussels	Brussels	
July 2004	Graz		
December 2004		The Hague	
May 2005	Madrid		
November 2005		Brussels	
December 2005	Graz		
March 2006	Belgirate	Belgirate	
November 2006			Farnborough
April 2007			The Hague
December 2007 (final)			

Table . History of WP 20700 meetings

2.8.3. Achievements

WP 20700 partners have worked together on the following case studies:

- Earthquake damage assessment of Bam (Iran) after the earthquake in December 2003. The interest was twofold: (1) the investigation of the value of SAR interferometry, and (2) the investigation and comparison of methods using high-resolution optical imagery. The first made use of an Envisat ASAR interferometric data set provided to the scientific community for free by ESA (http://envisat.esa.int/applications/la/bam_seism.html). Result was that interferometry can be used for damage assessment, but that resolution and temporal decorrelation due to vegetation have to be taken into account. The work on optical imagery focussed on automatic correlation (Spot 5) and visual interpretation (Ikonos and Quickbird). Practice showed that visual interpretation is still a fast and reliable method. The urgency of information is dependent on the application (search and rescue, emergency response, economical damage assessment and reconstruction). Standardisation is an important issue.
- Evaluation of the PRESENSE FP5 pipeline infrastructure monitoring project (http://www.presense.net/) which ran from in 2002-2004. The main interest in this project was to study the effectiveness of radar and optical sensors to detect activities around infrastructural works. The focus of PRESENSE was on the European gas transport network, but there are many similarities with other types of infrastructural networks (drinking water, power lines, road networks, and even borders). Result of this evaluation was that for both sensors, high-resolution imagery is preferred (≤ 1 m). Evaluation was based on airborne imagery, but today high-resolution radar (since 2007) and optical satellites are operational.

- Flood damage assessment of the countries around the Indian Ocean due to the South-east Asia tsunami on December 2004. As a result of the International Charter Space and Major Disasters (http://www.disasterscharter.org/) many images of the stricken areas were made available for free and analysed by GMOSS partners. Results of the analysis were processed into flood maps and damage maps (including coastal erosion and damage to vegetation, agricultural, and urban areas), and were based on optical and radar images (Spot, Quickbird, Envisat, Radarsat 1)
- GMOSS wide test cases (http://gmoss.jrc.it/):

    - Monitoring of nuclear technology infrastructure in Iran. Most work focused on the Esfahan Nuclear Technology Centre (ENTC). Result of this case study was that it is not easy to detect specific nuclear technology automatically. Visual interpretation is still the most important method. High resolution radar images can be used for automatic (change) detection of activities, but for classification high-resolution optical imagery is preferred.
    - Pipeline monitoring and (urban) damage assessment in Iraq. The work focused on (1) monitoring the pipeline network in the north, and (2) monitoring the capital Baghdad. For the first topic pipeline data was combined with low-resolution high-temporal thermal images (OLS, Seviri) to determine the time and location of pipeline attacks. In the second radar data (Radarsat 1) and high-resolution optical images (Quickbird) were used for conflict damage assessment during the second Gulf War and its aftermath, and for monitoring of rehabilitation and development activities. In the analysis non-geospatial open source intelligence was used.
    - Earthquake damage assessment of Kashmir after the earthquake of October 2005. The work is similar to that connected with the Bam earthquake in December 2003, except that 3D change detection was also studied from an optical stereo 3D model perspective. Additionally, nightlight imagery (OLS) was investigated to monitor the fall-out of electricity in stricken areas and migration.
    - Urban damage assessment in Zimbabwe. Most work focused on the capital Harare. In this study was investigated if demolitions of dwellings can be detected from satellite imagery. The same techniques were used as with earthquake damage assessment of Bam (December 2003). Again visual interpretation of high-resolution optical images (Ikonos, Quickbird) showed to be the most effective method. Envisat ASAR was studied too, but showed no evidence of demolitions. This was partly due to the resolution of Envisat ASAR, and partly due to fact that most demolitions took place before the image acquisitions.

- Near real-time exercises GNEX 06 and GNEX 07 (http://www.zki.dlr.de/). The first exercise covered WP activities as a result of an invented nuclear accident, the second one as a result of an internal conflict. Real data was used (optical: Spot 5, Ikonos, Quickbird; radar: Envisat, TerraSAR X). Most important outcome was that it is possible to provide useful information on a short term, but that standardisation is necessary for interpretation.

Other results include a critical infrastructure monitoring catalogue. The idea of this catalogue is to identify elements of critical infrastructures, threats, and methods to monitor these elements and threats (algorithms, sensors, collateral data). Critical infrastructures were defined by the Commission of European Communities (CEC) as infrastructures that are important for the health, safety, security and economic well-being of citizens and government in member states (CEC COM 2004-207):

- Energy installations and networks (electrical power, oil and gas production, storage facilities and refineries, transmission and distribution system).
- Communications and Information Technology (telecommunications, broadcasting systems, software, hardware and networks including the Internet)
- Finance (banking, securities and investment)
- Health Care (hospitals, health care and blood supply facilities, laboratories and pharmaceuticals, search and rescue, emergency services)
- Food (safety, production means, wholesale distribution and food industry)
- Water (dams, storage, treatment and networks)
- Transport (airports, ports, intermodal facilities, railway and mass transit networks, traffic control systems)
- Production, storage and transport of dangerous goods (chemical, biological, radiological and nuclear materials)
- Government (critical services, facilities, information networks, assets and key national sites and monuments)

The critical infrastructure monitoring catalogue is available as MS Excel workbook and MS Access database (http://gmoss.jrc.it/).

A standard for damage assessment and reporting was proposed, based on a grid-system and the European Macroseismic Scale by Gruenthal (1998).

2.8.4. Conclusions + recommendations + impact

Within WP 20700 12 partners from 8 countries have worked together on different case studies. Among the deliverables are a critical infrastructure monitoring catalogue, a proposed standard for damage assessment and reporting, and 19 papers and reports. Mapping the results against the initial objectives, we can say that we succeeded in bringing the European expertise in infrastructure monitoring and damage assessment together. We successfully demonstrated the use of satellite earth observation for these and other security applications with different tools and methods, that we (further) developed with knowledge from the network and partners. GMOSS also resulted in further co-operation between partners in new FP initiatives (TANGO, LIMES, and G-MOSAIC).

An interesting development is the operationalisation of high-resolution (1-3 m) radar satellites TerraSAR-X, COSMO-SkyMed, and Radarsat-2, in 2007. Because this was at the end of GMOSS these could not be fully exploited. Application of these sensors is recommended because radar can acquire images of objects obscured by cloud-cover, and has better control of illumination conditions. Furthermore it is advisable to improve the temporal coverage of EO platforms (satellite, airborne), and to use information from different sensors (radar, optical, infrared) and ancillary databases, including non-geospatial information (information fusion). Combined analysis will generally result in a better understanding and awareness. Final recommendation is to further operationalise tools and methods that support image and information analysts (software development).

2.9. Work Package 21100: Scenario analysis

2.9.1. Executive Summary

The emphasis in the GMOSS NoE has been on science and technology for monitoring through remote sensing/EO satellites. Most of the work packages have been dealing with such problem areas. The WP 211 has (like e.g. WP 213) been of a more supporting character, supporting with respect to the contexts of EO information. Dimensions of the contributions to the contexts were:

- Furnishing analytical tools which could be of use for GMOSS activities; primarily scenario techniques and gaming.
- Decision support aspects of EO information. Criteria for a constructive dialogue between decision-makers and scientists/analysts.
- Possible contributions from EO and their character during different phases of a course of events (prevention, protection, crisis management, consequence management/reconstitution)
- Contributions to the knowledge of substance in certain areas.

The term scenario is here loosely defined as possible development(s) from today into the future for an area of interest or a description of a possible future without any reference to the path from today. Gaming is a two-sided activity where there is a natural interaction between the two sides. The two sides could be opposing parties or one party could by nature.

The main advantages of the scenario and gaming tools are problem orientation and incentives to cooperation between WPs. For a science and technology orientated NoE both aspects of the tools are of great importance. The way of thinking has had an impact on the test cases and GNEX.

2.9.2. Introduction

- Report provided by WP-Lead: Jan Foghelin, FOI
- Work package team: OD, Z_GIS, BICC

The WP 211 has, from the beginning of GMOSS had a supporting function. The overarching goal has been to give contexts to the scientific – technical activities of GMOSS. With the introduction of the test cases, GNEX and summer school exercise cases this task was facilitated.

- In the 1st year WP 211 was labelled “Reducing threats” (Lead Wilhelm Unge from FOI) and we had an additional work package 105 Games and Scenarios (Lead Ola Dahlman)
- For the 2nd year we decided to combine these 2 WPs and the resulting WP 211 was now entitled “Scenario Analysis” (Lead Bengt Andersson from FOI) with the focus on collaboration with the freshly defined WP 213 Issues and priorities…
- From year 3rd onwards the main task of WP 211 was the collaboration with the test cases teams.
- Year 4th the composition of the team was the following FOI (Lead Jan Foghelin from FOI), OD, Z-GIS, BICC (Associated Partner).

2.9.3. Achievements

Scenarios could be used at least for the following two applications:

- As a starting point for (input to) a gaming activity. The role of the scenario is to give a backdrop to analysis of a problem where EO could be of possible use. The scenario focuses the discussion on a specific problem and the highlighten the restrictions concerning resolution, time constraints etc. which belong to the problem.
- As possible future developments of a problematic situation. The different scenarios (some wanted others we wish to avoid) give ideas of actions and information needed (EO or by other sources) for different decisions which have to be made.

The main advantages of the scenario and gaming tools are problem orientation and incentives to cooperation between WPs. For a science and technology orientated NoE both aspects of the tools are of great importance. The way of thinking has had an impact on the test cases and GNEX.

Documentation: *Games and Scenarios in the context of GMOSS*, book chapter by Adrijana Car, Ola Dahlman, Bengt Andersson, Peter Zeil.

A NoE is an organization for mutual exchange of tools, knowledge and skills. Analysts can learn from the science and technology side:

- Possibilities and limitations of remote sensing for different information needs (resolution, time constraints…)
- An awareness of mindsets among S&T-personnel.

As there sometimes could be a tendency to oversell technical quick-fixes analysts can serve as honest brokers; analysts commnading a decent knowledge of substance without being part of the S&T-establishment.

Test Cases. Satellite (EO) information as decision support

General

Sooner or later the satellite information should be used in support of decisions, which will be taken in different areas and on different levels. The test cases are mainly orientated towards the EU level. In most cases satellites are not the only source of information. Using the language of the intelligence community 'Humint' (human intelligence) and 'Signet' (signal intelligence) could be complementary. Sometimes there may be constructive synergies between different sources.

As always the quality of the decision support is of great importance. The quality can be assessed at several dimensions as:

- Relevance for the decision makers (information of the "need to know" type instead of "good to have" from the decision maker's point of view)
- "Technical quality" (resolution, interpretation…)
- Quality of fusion data from different sources.
- Timing (information coming too late, then even good quality is of little use)
- Presentation (the ability to present answers to questions in a pragmatic way).

The different sources of information are dissimilar in character. The satellite information is probably considered to be objective, especially in comparison to Humint which for natural reasons is more subjective. The satellite is more rigid as a sensor in relation to the more adaptive human being. Depending on the decision situation there could be possible advantages for different sources.

In general terms clusters of situations can occur, where satellites could be of special importance:

- Objects which are difficult to come close to due to a hostile environment (human hostilities, natural obstacles like fires…)
- Difficulties to "get to" the area of crisis rapidly with other mean (e.g. an area of earthquake or a tsunami).
- Observation of long-term changes e.g. the spread of deserts or the melting of glaciers.

The information could be used for different purposes by the decision-maker in the loop of a general crisis:

- Prevention i.e. how to avoid problems by using early warning information.
- Protection i.e. how to reduce the impact of possible events.
- The proper crisis management i.e. how to handle an ongoing crisis in an efficient way.
- Consequence management/reconstitution i.e. to return to normal conditions as smoothly as possible.

Test case: Iran

The decision problem is the following: Does Iran produces fissile materiel with the aim of producing nuclear bombs? If the answer is yes (with high probability) different preventive actions could be taken by EU and/or other actors.

Satellite information is important in this case because of the simple fact that it is difficult to use other sources for these types of clandestine activities (e.g. underground) different means of deception makes the interpretation of images difficult. Interpretations should be worked out in close collaboration between image analysts and reactor physicists.

Time is not a critical factor because it takes years to produce enough of fissile material. Quality of decision support in other dimensions is however very important. The political costs of making the wrong decisions on faulty analysis and information could be considerable.

Test case: Kashmir

Decision problem: after an earthquake in Kashmir, the EU wants an early estimate of the situation (possible number of casualties, damages to infrastructure in different area) in order to decide on supporting activities during crisis management and consequence management phases.

In the early phase it is better to get a rough assessment rapidly than a more precise later on. Satellites have an advantage in an area which is not easily accessible. Other sources could also be used as air reconnaissance and people on the ground.

Test case: Zimbabwe

Decision problem: Zimbabwe is a failing state. To be able to consider measures to stabilize and improve the situation in the country it is necessary to have a good knowledge of the situation and the causes of the problems.

As it is not possible to get reliable information from the government in the country other sources have to be used. Satellites could be one of them.

Examples of indicators:

- Land use changes as an indicator of socio-economic problems (e.g. decreasing food production).
- Number, location and time frame of demolished houses in urban areas (as an indicator for a politically motivated conflict).

In this case time is not a critical factor. The most important things to know are a correct overall assessment of the situation in the country and the root causes of the problems. Clearly satellites cannot provide all information needed. Together with information from other sources the information can be used e.g. by starting a dialogue with the government of Zimbabwe.

Test case: Iraq

Decision problem: Oil export is the most important factor to improve the Iraqi economy. A prerequisite is functioning pipelines. The ability to protect and rapidly repair the pipelines is therefore very important.

Measures to maintain the pipelines could be a part of EU economic support of Iraq. The question is however, if this can be accomplished.

Possible use of satellites could be to provideindications of imminent attacks towards pipelines. Information from satellites could be used to allocate protective forces to proper places and/or allocate repairing resources.

It is not an easy task to identify attackers in an early phase. Information from satellites must be complemented with other sources (local population, air reconnaissance, coalition troops, and human intelligence). To be useful for prevention you must be able to keep the time from observation to countermeasures very short. In many cases it might be more realistic to be able to make a rapid repair of an attacked pipeline.

Summer school exercises (example)

Exercise case: Evacuation of Salzburg.

Decision problem: A scenario of a "dirty" bomb (nuclear material) placed in the Opera house. How to handle the situation and what tools to use?

Summer School 2005: Sourcing expert knowledge on handling a nuclear device used during a fictitious terrorist attack (scenario)

The study was done by using satellite information to look at the road net and try to simulate different strategies for the evacuation from the Opera House. Using maps and satellite pictures were the instrument to come up with a plan for evacuation.

Taxonomy

Taxonomy in the form of a matrix has been constructed to generalize possible contributions from EO satellites. One axis of the matrix is the phases mentioned above (Prevention/Early Warning…) and the other are potential problematic areas. The main areas are environment, transportation, safety, security and defence. These areas could still be subdivided.

2.9.4. Conclusions + recommendations + impact

Test cases, GNEX and summer school exercise have all had an impact on problem orientation and networking between WPs scenarios, and gaming is considered as being a useful tool.

That said more can be done. The test cases and GNEX have more or less ended with a presentation of what can be seen from EO satellite and what type of information could be extracted after an analysis. It has been a one-step-game without any real feed-back from decision-makers, such as: these are the decisions which are going to be taken - these are the critical pieces of information). Further studies should include the following parts:

- A multi-step process in which decisions are taken and the critical information (time, resolution…) is assessed.
- If "real decision-makers" are difficult to engage (often the case in all organizations) pseudo-decisions-makers consisting of a group of analysts could be used.
- Areas where improvements, from the user's point of view, are most important should be identified. Areas of possible improvements could span from sensors to rapid interpretation.
- For most of the applications in the test cases EU-information is not the sole source. To include other sources in exercises has at least two advantages,
  - You learn about data-fusion and how different sources could be complementary.
  - You learn about situations where EU is very important and where other sources could be as good.

When giving policy advice in a crisis situation trust is of utmost importance. Trust between decision-makers and scientists/analysts on a personal level but also a trust from the decision-maker concerning the situations where the tools could be used. In a crisis situation you normally do not want to use new methods or involve persons which you have never met before. It is for this reason important to have an exercise with the real crisis-managers. Probably the best way to succeed is to have an exercise in an area which for the moment is of real importance.

It is important to convey to decision-makers an assessment of the quality/uncertainty of the information given. These assessments should normally not be on a technical level (resolution etc.) but on an aggregated level (validation). How sure are we about these important inputs to policy recommendations?

2.10. Work Package 21200: Responding to crisis

2.10.1. Executive Summary

The main focus of the work package 21200 "Responding to Crisis" was to study and review the application of Earth Observation derived information for civilian crisis response by the European Union. First, the WP organized a number of workshops to review relevant crisis types, key actors, response mechanisms and main policy drivers. Second, crisis response patterns related to Earth Observation derived information, which were relevant for the network, were identified with the help of a questionnaire survey within the network. The results of this survey showed that many work areas of the network partners still focused primarily on issues of natural disasters. These findings were used as driving force to steer the attention of the partners more to the technical and conceptual issues of security and stability related analyses. Third, to support this process, two real-time functional exercises were prepared and executed.

The goals of these exercises were to
(1) test and evaluate technology available in the context of realistic crisis scenarios,
(2) to provide the network partners with a common working platform, and
(3) identify new research areas, which require attention of the network.

The exercises proved to be very successful. Besides the two exercises, a scenario guide was developed for the network partners in order to support them in preparation of own micro-exercises/simulations.

2.10.2. Introduction

One major driver for GMES is the setting up of improved civilian monitoring capacities on global security issues in and for Europe. Major project activities, including the GMOSS network of excellence, target this application domain and support the development of this sector. As the GMOSS network had a strong technical and methodological focus, it was felt in the very beginning of the development of the work plan that there should be components in the network that bring the technical development into the context of the practical application and user domain of GMES. At the time of writing of the initial proposal, mechanisms such as the ‘International Charter Space and Major Disasters’ and the definition of the security aspects of GMES were still in its early stages. Furthermore, the roadmap for implementation of operational security and emergency response capacities were just shaping up. In its early phase, the responding to crisis WP carefully reviewed these developments and established a common understanding of the security and stability questions relevant for the work in GMOSS.

Building on these findings on key crisis response patterns, the work of the WP team continued towards the aim of bringing the GMOSS work closer to the operational requirements of crisis response actors in Europe. In this context, a conceptual guideline on how to best select suitable working and exercise scenarios for the research activities of the network was developed. Furthermore the idea of the network wide near real time exercises involving large parts of the consortium and relevant users, possibly at European level, was developed. Two GMOSS near real time exercises -GNEX- were conceptually developed, planned and implemented by the work package 21200 during the last two and half years of the project.

The core work package study team consisted of one to four scientists from each: the German Aerospace Center (DLR, lead of WP), University of Linkoping, Sweden (LiU), the French Space Agency (CNES) and, during parts of the project, of one scientist from each: Qinetiq, UK, the French Centre Maurice Janowitz (associated partner) and the Belgian Royal Military Academy (RMA).

2.10.3. Achievements

While the work was initially planned to be more general and of theoretical character with respect to the analysis of crisis response patterns and capacities in Europe, the progress and developments within the network showed that there a was demand for the design and implementation of network wide GMOSS near real time exercises. Exercises were initially not an integral part of the WP in particular, however, during the course of the work it turned out that this tool was well in the scope of the topic of the WP and that the network was ready to join this collaborative undertaking. While the first GNEX’06 exercise was considered to be a first test of such a tool to be used in the network, the very positive feedback and results made the team more optimistic and confident that a second exercise could even me more challenging and stimulating to the network. Summarizing this work the following main achievements of these actvities were:

- Increased understanding of crisis response in the European context by the network partners (through workshops).

- Increased understanding of crisis response concerning the Earth Observation (EO) derived information as well as its analysis by the networked partners (through real-time exercises, survey, interviews, workshops).
- Increased awareness of available and near future Earth Observation technology capacities for crisis response by the end-users and actors in the domain (through real-time exercises, workshops)

GMOSS relevant crisis response patterns

Analysing the key elements of crisis response patterns, which were relevant for the network's focus and tasks, it was important identify main categories, which drive a crisis response and for which Earth Observation derived information may be of high relevance. The following categories were established to structure the crisis response analysis:

- **Key crisis types** relevant and to be considered: Humanitarian disasters, terrorism, natural disasters and general conflicts
- **Key Actors:** decision makers at European, national and provincial level, security and relief officials, policy makers and the public
- **Key elements to facility a possible crisis response** and mitigation: Technical systems, response strategies, organisational and hierarchical structures, information and response resources as well as analysis and interpretation systems and schemes.
- **Key policy drives** to influence the work were identified as: A Common European Security and Defence Policy, Internal security and Humanitarian Interventions

The questionnaire survey and interviews within the network revealed the types of crisis covered by the work of GMOSS and the products developed. It showed clearly that only very few links to potential users of the products were established. It further revealed that GMOSS was focussing on important crisis types, relevant to key EU and even UN users, however, the GMOSS work had only minor relevance for NATO, national and NGO user groups. Finally the study revealed that the type of events GMOSS was focussing on, were mainly (natural) disaster events with a very strong impact on countries with a low coping capacity, while only little work was focused towards disasters of high impact affecting societies with high coping capacity. It was suggested to the network to refine the activities where possible to the area of stability and security monitoring. In order to support this, a guide for selecting relevant working scenarios was developed.

Conceptual design of a near real time exercise

During the course of the network it was observed that the more political and conceptual work packages remained detached from the technical and methodological work packages. Even among the different technical parts of the consortium some times the interaction and exchange was felt to be limited. One important element to overcome this problem was of course the setting up of the different jointly studied test cases within the GMOSS network.

In order to even improve the practical interaction and coordination among the researchers and to provide the team with a common experience, linking the different technical and methodological capacities in the consortium the concept of the so called GNEX exercises was developed. The exercises were set up such, that the teams were confronted with challenging, rapid response (matter of hours and days) analysis task on a predefined scenario, which no single network partner could handle alone or manage directly.

Prime objectivel of this type of exercise was to strengthen integration and coordination among the partners and associated organizations, by being forced to split a complex analysis task into subtasks, distribute and share the processing and interpretation work and finally join the individual results into a common answer to the scenario questions. Furthermore, the exercise aimed at helping to assess and demonstrate the state-of-the-art of satellite imagery analysis and handling by the GMOSS NoE partners and teams. In addition, the exercises should help to involve users and decision makers in the domain of civil crisis response into the work of GMOSS and to demonstrate to them the added value of EO based information in civilian crisis response using GMOSS methods. In doing so, the exercise supported the political process for paving the way for the operationalization of these new developments.

In order to reach these goals the following approach was used for setting up the exercises: The scenarios defining the analysis tasks and information request were jointly developed with a selected group of relevant user organisations and field experts, ensuring the relevance and realistic character of the undertaking. In order to provide a certain work pressure, without overloading the teams, the duration of the exercises was set to the order of a few days. Thus, a certain time constraint could be put to the team and the focus could be kept on the GNEX activities. The necessary data sets, including satellite imagery and basic GIS layers, were acquired well before the exercise and even partially pre-processed by the exercise organisation team.

The data was only made available to the participants after the start of the exercise. In order to keep most parts of the consortium interested in the GNEX activity, the work and analysis tasks were composed such, that as many as possible techniques and study fields could be addressed. Last but not least the teaming of groups was carefully elaborated, either for the selection of competing subgroups (during GNEX'06) or for the joint work on subtasks (during GNEX'07).

It is important to note that the GNEX exercise concept was always to provide a close to reality experience to a relatively large group of scientists (50-100 people, from 20-30 organisations all over Europe). The GNEX exercises were not designed as exercises for real operational service providers and crisis analysis operators. Thus, the products generated during the exercise have to be considered provisional and are not ready for scientific bench marking etc.

Planning, execution and analysis of the GNEX'06 and 07

GNEX'06 was the first near real time exercise with three sub teams of scientists spread out over Europe working in parallel to answer a fictitious information request by the European Commission on a nuclear leakage scenario within Europe. The scenario addressed a confined nuclear fall out situation in Europe requiring up to date information for local decontamination and evacuation measures. The sub teams were provided with satellite imagery and additional geo-information related to the hypothetical event. The teams were mandated to extract and provide up to date information on infrastructure, urban areas and land cover. The information was generated in form of maps, reports and statistics for the end users.

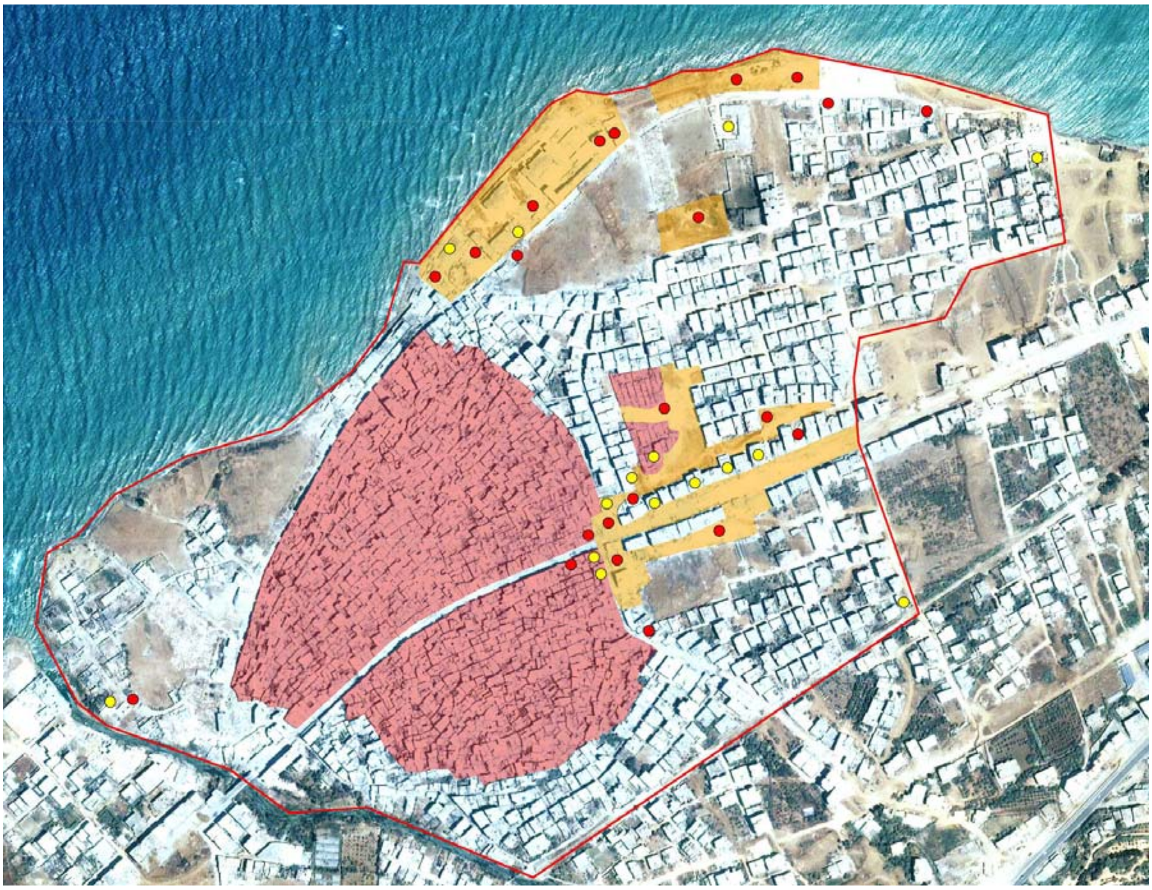
The review of the exercise operation and review of the observations reports showed that the overall perception of such an exercise among the participants, users and observers was very positive. As expected, also various problems occurred during course of the work. For example the data handling and sharing proved to be difficult and even redundant among this group of science teams. Communication within and between the different groups was seen as some times problematic. Furthermore technical issues when applying preoperational methods and algorithms had to be solved. Beyond this, a great team working spirit could generally be developed among the groups. In some cases observers noticed a bit of competition between organisations even in those situations when the groups should work jointly towards one single result. In many cases creative solutions were found for unforeseen problems and a good interaction between working teams was developed. Generally even more information products were provided than asked for and the scenario laying the basis for the exercise was considered suitable. It was observed that the rapid response mapping caused new challenges for decision making, task organisation and prioritisation to the teams usually working in more scientific contexts. A general issue turned out to be the quality management of the rapid production of information products. Due to the time constraint important quality control measures were often disregarded.

The GNEX'07 exercise was the second near real time exercise within GMOSS. The fictitious scenario was developed in close cooperation with European Commission (DG RELEX, DG Environment/MIC and DG Enterprise). In this fictitious scenario a refugee camp in the country 'Albenon' had been severely damaged in the course of an armed conflict and refugees escaped to a neighbouring camp. When the refugees returned they were confronted with destroyed housing and sanitation facilities, including broken water and sewage networks, what lead to first cases of watery diarrhoea and cholera. On top of this a severe influenza epidemic was affecting the camp and started spreading into the country. In this exercise, the government of 'Albenon' asked the European Commission for relief support and the Commission tasked the GMOSS team to provide satellite based crisis information to support the decision making in the following areas:

- disease control (quarantine/treatment/sanitation) with deployment of mobile field hospitals and water sanitation units for microbiological analysis capacity,
- evacuation of European Citizens; and
- recovery and reconstruction of the camp.

The GNEX'07 exercise involved about 18 European research institutes and at least 60 scientists were working to produce the requested information.

The results of the different teams were integrated into reports, dossiers and maps which were presented during a user briefing to representatives of the European Commission. Right after the exercise, half a day was used for a first network-internal debriefing at the GNEX'07 meeting location in Brussels. Of course, also during the operation of GNEX’07 several issues arose for the teams: communication turned out to be difficult, since either too much (e-mails, phone, and chat) or too little (people felt left aside), central coordination of the teams was considered difficult with too many hierarchical levels, resulting in a certain redundancy of work. Although new for many of the participants the exercise was considered an interesting experience for the researchers. With respect to the user community the exercise provided an interesting window for the DG RELEX and DG ENV/MIC to interact with the GMES community.



Damage assessement map of a refugee camp, produced in the GNEX'07 exercise

2.10.4. Conclusions + recommendations + impact

As the civilian European crisis response mechanisms using Earth Observation information are only in their beginnings, the work package started its activity by reviewing relevant response patterns and their relevance for the network. Building on these results the WP team developed the real-time exercise called, GNEX, involving the Network partners, user groups and interested communities. The GNEX exercises had a significant positive impact on the cooperation and integration in the network as well as on the "visibility" of the GMOSS network within GMES. The exercise provided an important platform for testing and evaluation of methods and tools in realistic settings.

It can be concluded that exercise activities can be very helpful tools for groups of scientists to jointly test and prove their methodological developments in such simulated near real time scenarios. It is important to note, that those exercises, of course, neither serve as scientific validation or benchmarking activity, nor do they provide fully developed service provision examples for the user community. They are a methodological tool to stimulate better cooperation for researchers, provide new ideas for future research work and give involved users an insight into what research is currently working on. As a final recommendation it can be stated that the concept of near real-time functional exercises for a larger group of researches in the domain or security and stability monitoring proved to be very fruitful and stimulating. Thus, this methodology should further be used, developed and exploited in future major R&D projects to test and demonstrate their integrative and collaborative capabilities.

2.11. Work Package 21300: Issues & priorities

2.11.1. Executive Summary

The principal objective of WP21300 has been to facilitate collaborative relations between the customers and suppliers of earth observation product by helping to bridge the different backgrounds, training and perspectives of the two communities.

In summary, we have set about achieving this goal by:

- Producing two substantial papers for the guidance of GMOSS participants on EU security policy and the potential role to be played by earth observation
- Contributing a chapter on EU security policy and the part played by earth observation to the GMOSS book
- Contributing five chapters to the JRC's compendium of work conducted on integrated scientific and technological research supporting security aspects of the EU
- Providing advice on potential topics to be addresses by the Test Case studies
- Providing background information on the economic, political and security circumstances of the Test Cases countries
- Conducting research into a number of areas in which earth observation could provide practical support for EU security policy
- Participating in a range of integration workshops, the GMOSS Summer School and the annual crisis management exercise GNEX.
- Attending relevant seminars and conferences held by outside bodies.

2.11.2. Introduction

History of WP21300

Following initial uncertainties about its role and functions, WP21300 in its current form started work some 18 months after the inauguration of GMOSS. At a preliminary meeting held at KCL on 22 September 2005, members defined the WP's initial work programme against the background of its overall objective of encouraging closer links between suppliers and customers of EO product. They also agreed to monitor progress by conducting regular biannual workshops at KCL. As a first step, it set about defining the risks facing the EU by drawing on and analysing key policy documents. This work was completed early in 2006.

Follow-on work was then pursued from mid-2006 until February 2008. This consisted principally of:

- analysing further the contribution which EO can make to information gathering and decision-taking for security policy purposes;
- research work conducted within and between individual academic institutions on topics designed to assist decision-takers;
- support to the integration activities of other WPs, particularly on Test Cases, the GNEX exercises and education and training aimed at enhancing understanding of the requirements of decision-takers;
- outreach, comprising links with other academic and security institutions and contributions to GMOSS publications.

Responsibility for overall supervision of the programme rested with the plenary meetings of WP21300. Day to day management was handled by the chairmanship.

Team Composition

WP21300 was led by King's College, London (UK). Other members included: the EU Joint Research Centre (JRC); the EU Satellite Centre (EUSC); the Royal Military Academy (RMA) (Belgium); Swisspeace (Switzerland); the Centre for Geoinformatics (Z_GIS), Salzburg University (Austria); and the Netherlands Organisation for Applied Scientific Research (TNO). TAAS, Salzburg University (Austria) is an Associate Partner.

2.11.3. Achievements

Progress of work

a. Security analysis

Work in this field was intended to broaden the understanding of security policy issues in the GMOSS community. It built on an initial analysis of basic EU policy documents on the Union's security strategy and preliminary conclusions regarding:

- the potential contribution to be made by earth observation to the conduct of EU security policy;
- the scope for ranking potential areas of risk to European security.

The outcome of WP21300's initial review was set out in two papers:

- Priority Issues for Earth Observation in European Security Policy
- European Security Policy – Proposed Guidelines for Country Prioritisation

The first of these papers was intended to provide an understanding of the principles of EU security policy by analysing the principal official documents setting out its overall approach, including the EU Security Strategy and policies on counter-terrorism and the response to the proliferation of weapons of mass destruction. Against this background, it identified fields in which earth observation might be able to play a particular part in achieving an integrated information picture to help guide policy makers in decision-taking and crisis management.

The second paper supported the scientific, technical and training activities of GMOSS by providing an evaluation of the current geographical priorities of EU security policy. It approached this task by drawing on the general guidance provided by the EU Security Strategy and identifying the principal fields in which the EU is active in the security sector, including preventive engagement, strategic partnerships and relations with third countries. The resulting proposals for geographical prioritisation were intended to help guide the scientific and technical work of GMOSS, including the selection of test cases and crisis management exercises.

The conclusions of these papers were presented in summary form to participants in the integration workshop held at Belgirate on 6-7 March 2006. The debate was pursued during the plenary workshop in Salzburg (April 2006) which identified the general policy framework within which EO contributes to decision making. It also reviewed the full range of technical means of information gathering besides EO, including the collection of electronic, communications and signals data, which contribute to the production of policy assessments for decision-makers. A further presentation was made at Farnborough in November 2006. Against the background of the key elements of EU security strategy and the contribution to be made by EO and other technical capabilities to information gathering, the Farnborough workshop confirmed WP21300's initial ranking of the principal areas to which EO had the potential to make a significant contribution to decision-taking.

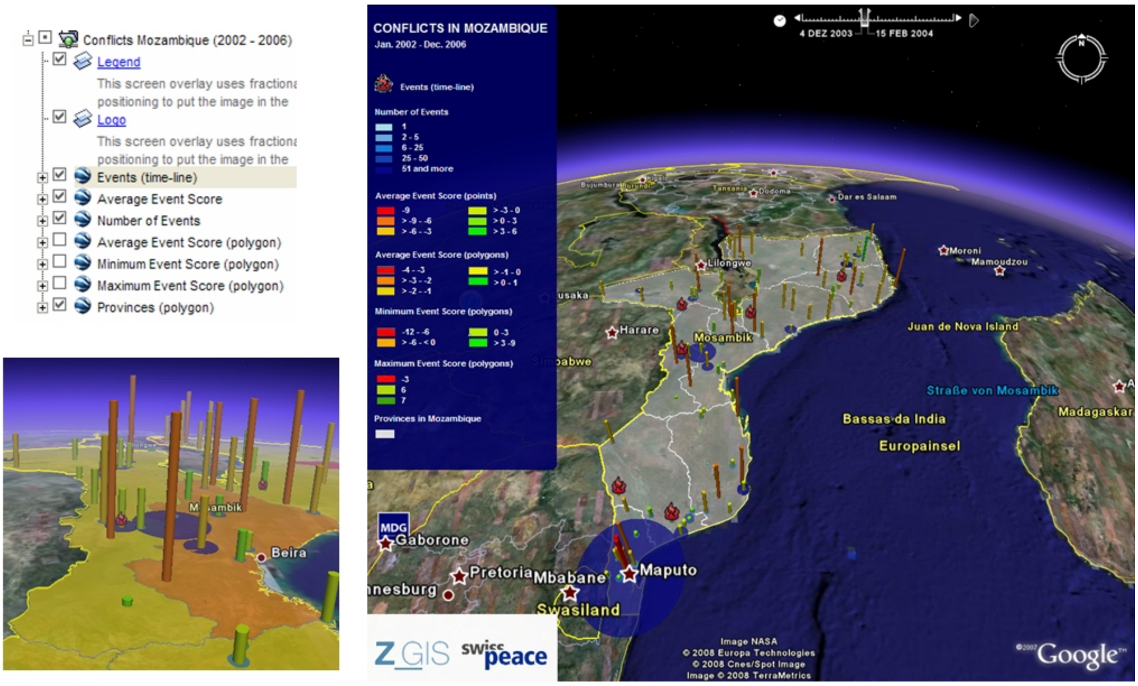
b. Research Programme

WP21300's research programme has concentrated on exploring the scope for identifying early warning of potential crises and defining possible criteria for assessing the likely contribution of EO to crisis management. Both are intended to be an aid to decision-takers. A number of successful results have been achieved and further work is continuing. The main elements of the research programme include:

Utility of earth observation. A study by TNO of the scope for producing a compendium of possible objective criteria against which policy makers can assess the value of the contribution which earth observation can make to the formulation and conduct of policy in response to individual emerging or actual crises. The overall objective was to assist policy makers in understanding the capabilities and limitations of earth observation and scientific and technical staff in understanding the requirements of policy makers for earth observation support in the management of individual crises. The results were published in December 2007 as a contribution to the JRC compendium of work by GMOSS

Structural indicators of risk of conflict. Based on a regression analysis of about 20 indicators of major conflict factors, including the economy, demography, human capital, regime type, experience of conflict, resources and geography etc, JRC conducted a project aimed at defining a basic set of indicators – as far as possible obtained from open sources – for the purpose of assessing the risk of armed conflict or instability. The initial results were presented at a seminar conducted under the auspices of the Bonn International Centre for Conversion (BICC) in November 2007 and a summary account submitted for inclusion in a BICC brief. An overview was also included in the JRC's compendium of work by GMOSS, published in December 2007. A full report was published early in 2008

Mapping of conflict. Research by JRC and SWISSPEACE on the scope for presenting regularly updated data on violence in Kosovo during 2005/06 on an interactive map. This was completed in 2007 and the results presented in summary form in the JRC compendium. They are currently considering a possible extension to Armenia and Azerbaijan (with particular reference to Nagorno-Karabakh). The aim is to map and regularly update information on violent events both geographically (by municipality of other appropriate administrative unit) and thematically (violent occurrences and selected non-violent event such as demonstrations, threats, sanctions etc) on the basis of the SWISSPEACE Event Coding System. An interactive visualization of SWISSPEACE event data on GoogleEarth has been provided by Z_GIS. Work is well in hand and results are expected to be published later in 2008.



Visualisation of conflict data of Mozambique in a virtual globe environment (Google Earth). Columns indicate the severity of the conflict based on a score developed by SwissPeace. Blue circles indicate the number of events (Stefan Kienberger, Michael Hagenlocher, Z_GIS, 2008).

*Events-based early warning of conflict***.** Identification by SWISSPEACE of the tools and programs required in order to apply the technique of sequence alignment logarithms to the analysis of political data. A paper is due to be published in the journal ‘Political Methodologist’.

GMES services derived from GMOSS: The integration of crisis indicators such as hotspots and nightlights to determine the scope for providing GMES services derived from the work of a number of GMOSS partners. Efforts have been made – and will continue post-GMOSS – to integrate these results with those obtained by SWISSPEACE, BICC and JRC for the further investigation of crisis indicators.

*Assessment of information bias***.** A study by SWISSPEACE based on over 150,000 political events in more than 20 countries of the extent to which locally generated information is also available in English on the internet. This has the potential to reveal the extent to which there may be systematic information bias in Western media. A paper is due to be considered at the 5th International Symposium on Risk Management to be held in Orlando, USA on 29 June – 6 July 2008.

A summary of some of the major elements of WP21300’s work on security analysis and its research programme is to be found in the GMOSS publication ‘GMOSS - Integrated Scientific and Technological Research Supporting Security Aspects of the EU’.

c. Integration activities

A key element of WP21300’s work has been to integrate the skills of the socio-economic and political experts in GMOSS into the work of its scientific and technical community in order to provide an operational understanding of the priorities and requirements of EU decision-makers. To this end, we have:

- provided advice on the key social, economic and political circumstances of the countries selected to be Test Cases for assessing the technical capability of EO to contribute to decision making in a real life context;
- participated in two GMOSS Summer Schools with the aim of fostering understanding of the requirements of security policy makers;
- provided management support for two GMOSS crisis management exercises;
- contributed a chapter on security policy and priorities to the forthcoming GMOSS book;
- attended a range of conferences and seminars on security policy conducted by other academic bodies and security institutions in order both to share expertise and to foster an understanding of GMOSS's work.

Results - Highlights

Among the main achievements of WP21300 have been:

- the successful dissemination among the wider GMOSS community of the main principles of EU security policy;
- the wider recognition in the GMOSS community of the requirement to tailor the provision of EO product to the demands of the decision-maker;
- active support for efforts to integrate the work of the scientific and political-economic communities in GMOSS by means of test cases, exercises and educational activities;
- the initiation of a number of research projects designed to assist decision-takers in the field of security policy.

Further information about the work of WP21300 can be found on the GMOSS website.

2.11.4. Conclusions + recommendations + impact

Critical review of work

There is a relatively small corpus of authoritative unclassified guidance on EU security policy. It also tends to be highly generic in approach. It would, of course, have been open to us to interpret or extrapolate extant policy statements but the results would not have been authoritative and would not have provided a robust framework for the conduct of scientific and technical work. This limited the ability of WP21300 to provide detailed concrete guidance on security policy to EO practitioners. Overall, however, the contribution made by WP21300 to work on the Test Cases, the GNEX exercises and the Summer Schools has made a substantial contribution towards the goal of integrating an understanding of the priorities of EU security policy and crisis management modalities into the technology and applications work of GMOSS.

Impact on Research

WP21300's research programme is of potential value to decision-takers but it is not yet fully mature and some of it remains to be completed. This is inevitable, however, and it is to be hoped that individual institutions will pursue it and that any follow-up work to GMOSS will take it into account. Likewise, we hope that mechanisms will be found post-GMOSS to pursue the important task of fostering the recognition that the requirements of the consumer should guide EO research activity.

Challenges

The main challenge facing GMOSS as a whole and its individual components is to find a means of ensuring that the positive results achieved by the network are not dissipated or lost. We believe this to be particularly true of the need to continue encouraging dialogue between the EO scientific and technical community and social science practitioners with the aim of facilitating collaborative work. Further work should be pursued on policy analysis to help target scientific effort on EO. Research should also continue on issues designed to assist decision-taking on EU security policy.

Recommendations

We recommend that the challenges identified above should be pursued in any post-GMOSS work in the context of FP7 and that all participants should be made fully aware of the principles of EU security strategy and of the priority to be given to the requirements of policy makers.

3. Training and Communication

3.1. Work Package 30000: Training and Communication

3.1.1. Executive Summary

GMOSS put in a variety of efforts to reach out to other GMES projects, experts outside of the European research area and end users. GMOSS considers other GMES projects in implementation as scientific end users, which need to be exposed to the results and concepts developed by the network through scientific exchange and outreach.

The GMOSS Gender Working Group managed to address gender issues in the network both thematically and institutionally by organising on the one hand a conference on gender-specific issues of security and on the other hand by highlighting the importance of work-life balance in research environments resulting in an arts exhibition.

3.1.2. Introduction

The objective of the horizontal action was to provide the dissemination and exchange interface of GMOSS for all who want to interact with the Network and to reach out to end users and stakeholders. To achieve this effectively involved several steps:

Internal integration: Shortly after the inception of GMOSS, there was the felt need to organize specific meetings which facilitate the integration between working groups and disciplines. Moderation and visualization together with elements such as information markets were used to design integration meetings once a year.

Training measures: The two aspects guiding the planning of activities were (a) to move from information exchange between consortium partners to sharing of knowledge, skills and methodologies, and (b) to expose research results to young scientists from diverse disciplines and sectors through joint analysis and problem solving. Both activities required interactive methodologies and the giving-and-taking of feedback to explore achievements and challenges in a new and complex field of research and to ascertain ideas for future research efforts.

Outreach: All dissemination activities towards various target communities such as public, press, science, end users, GMES-projects, decision makers and the GMOSS team itself needed to be integrated. The approach encompassed a website with public and restricted areas, a document management system to facilitate the reporting process and the publication of books, brochures and promotion material.

Gender: Struggling for a common understanding of gender in the context of the network's activities, the consortium developed a gender action plan which was managed by a gender working group:

Nathalie Stephenne, Clementina Burnley (both from JRC),
Irmgard Niemeyer – TUBAF,
Vinciane Lacroix, Karin Mertens, Michal Shimoni (all from RMA),
Susan Giegerich, Daniele Hoya, Claudia Künzer, Thomas Kemper (all from DLR),
Iris Lingenfelder – DEFINIENS

Gracia Joyanes - EUSC
Peter Zeil –Z_GIS.

Moving from gender reporting (as an obligation) to gender action, GMOSS started an analysis of the work-life balance of its community and looked into gender dimensions related to security issues.
The horizontal action was coordinated by Peter Zeil (Z_GIS), Stefan Schneiderbauer (former JRC, now EURAC), Gunter Zeug (JRC) and Thomas Kemper (former DLR/now JRC).

3.1.3. Achievements

The network intended to engage partners of respective consortia in training measures as a way to stimulate the exchange of expertise. Users from the communities-of-practice had been involved in training events (such as GNEX, summer schools and seminars) to increase the awareness about the benefits of using spatial information for decision making in security situations. The activities of the training program cater not only for outreach, but also strongly facilitate the integration within the partnership. The year 2007 may serve as an example: following the presentation of the test cases in an integrated analysis framework during the Review Meeting in The Hague (April), the third Summer School on 'Early Warning and Monitoring of Agreements' in Madrid (September), and a Seminar on 'Environment and Conflict' in Bonn (October) provided platforms for exchange between different communities. It is by these 'interfaces' that the network attracted a substantial number of institutions from sectors such as policy analysis, science and technology and service providers to apply for associated partnership. The implementation of the near-real time exercise (GNEX'07) is a clear indicator for the progressing integration within GMOSS. In the end, the concept of gaming under realistic scenarios as a tool for problem analysis and validation was broadly accepted by the participants, from GMOSS and outside.

The outreach activities of GMOSS contribute to the awareness building in regard to security applications in GMES. The main effort is facilitating dialogue between the communities-of-practice and the communities-of-service-providers. GMOSS provides a platform for this interaction by maintaining the GMOSS website, disseminating GMOSS knowledge through books and journal articles, but also by organizing or contributing to special events. An example for this is the contribution to the GMES-Africa conference, held in Lisbon in Dec. 2007 at the occasion of the AU-EU Summit. Another opportunity was the joined meeting of partners from RESPOND, GMOSS and LIMES about new technologies and developments for crisis response, and the dissemination of GNEX experience to PREVIEW. Of particular value to the GMOSS consortium was the meeting organized together with the project officer in October 2007 to engage with different units of DG RELEX; the feedback demonstrated the impact of GMOSS made over the past years as the service samples provided were mostly relevant for the users, and the users recognized the need to appropriately formulate their information requirements. The network consortium offered a synthesis of the GMOSS-process to an audience from science and policy during the final event in Brussels in December.

A very specific achievement of GMOSS is the Gender working group that managed to address gender issues in the network both thematically and institutionally by organising on the one hand a conference on gender-specific issues of security and on the other hand by highlighting the importance of work-life balance also in research environments resulting in an arts exhibition. A GMOSS Gender and

Security Workshop, organised by JRC together with the Women and Science Unit, DG Research and the Equal Opportunities Unit, DG Administration, convened GMOSS scientists with researchers and experts in the analysis of gender issues in the domain of Security. The workshop focused on the perspective of women in conflict, post conflict reconstruction and peace building. The proceedings of this exchange and the main impacts on a future research agenda were published in an excellent workshop report. The ‘Gender Lives’ exhibition was the highlight during the Final Event in Brussels (December 2007): an artistic exhibition composed of photographic portraits, artworks and response to a questionnaire, illustrated how some GMOSS scientists both men and women conciliate a rich private life beside their professional work. Conceptualized, produced and implemented by Vinciane Lacroix of RMA, the exhibition exquisitely visualized the various gender dimensions in the lives of selected scientists of GMOSS.

3.1.4. Conclusions + recommendations + impact

The outreach concept of GMOSS will be carried on after the end of GMOSS, thanks to the support of JRC by organising a yearly conference for exchange on security research and by maintaining the website as an established platform for networking and sharing of expertise. The developed training methodology, and here in particular the summer school approach, continues to be implemented under the GEOSS Capacity Building Task of GEO. In 2008, a new proposal for a research training network for security research will be submitted under the PEOPLE Programme in FP7. Recommendations from the many exchanges – interdisciplinary, intersectorial and international – are:

- the gender dimension has to be incorporated in concepts for a future network of excellence on security research. For this purpose, connections with other NoEs were established to explore and evaluate potential gender action concepts.

- the link between environment (status, changes) and security needs to be addressed; following wide-spread speculative statements about the impact of climate change on stability and security, a NoE seems to be the most prospective context to ascertain scientific evidence.

3.2. Work Package 30100: Training measures

3.2.1. Executive Summary

Training is understood as sharing of knowledge and joint problem solving. In the context of GMOSS, the two aspects – initiating integration within the network and engaging with experts outside of GMOSS – had to be addressed simultaneously. The activities of the training program cater not only for outreach, but also strongly facilitate the integration within the partnership.

The network intended to engage partners of respective consortia (e.g. other GMES projects) in training measures as a way to stimulate the exchange of expertise. Users from the communities-of-practice had been involved in training events (such as GNEX, summer schools and seminars) to increase the awareness about the benefits of using spatial information for decision making in security situations. The year 2007 may serve as an example: following the presentation of the test cases in an integrated analysis framework during the Review Meeting in The Hague (April), the third Summer School on 'Early Warning and Monitoring of Agreements' in Madrid (September), and a Seminar on 'Environment and Conflict' in Bonn (October) provided platforms for exchange between different communities. It is by these 'interfaces' that the network attracted a substantial number of institutions from sectors such as policy analysis, science and technology and service providers to apply for associated partnership.

3.2.2. Introduction

Responding to the overall objectives of GMOSS

- to evaluate the capability of remote sensing for human security applications, and
- to identify existing gaps that have to be addressed and bridged by future research programmes of the European Union, as well as
- to integrate European research on the usability of remotely sensed data for civil security application,

the capacity building concept had to address the dissemination of research results, strengthening the internal integration of research efforts, and to facilitate the exchange with actors outside of the Network. With the aim to increase European competitiveness, to benefit from synergy effects and to build a critical mass of expertise, a newly developed research training agenda encompassed, in addition to remote sensing technologies, social and political science research, the exchange of information between stakeholders, and the evaluation of existing or recommendations for new organizational structures. The concept was implemented in the form of summer schools (duration: eight days) by exploring the broad expertise of the GMOSS partnership and inviting experts from outside contributing specific aspects not covered by the network partners.

The core sessions of the schools covering technical aspects regarding the processing of EO data for effective monitoring were framed by explorations of the socio-political context. The structure of the schools had to provide for technical presentations, practical exercises, as well as group work and feedback sessions with policy actors. To create an enabling environment for sharing experience and problem awareness in a relatively short period, games based on theme-specific scenarios were selected as appropriate methodology (see chapter on scenario analysis).

As a matter of fact, integration within the Network did not just happen by itself. The initial attempt to use gaming (understood as a near-real time exercise under a given scenario) as a mean to develop a common understanding of problems at an early stage of GMOSS faced criticism and reluctance. In order to establish a 'culture for integration' the consortium had to follow subsequent steps to facilitate the exchange at specific levels:

- inter-working groups (integration meetings, information markets, test-cases)
- inter-institutions (staff exchange, training seminars)
- inter-sectoral (summer schools, GNEX – near-real time exercises)

- science-policy (user meetings, panel discussions, summer schools, seminars, GNEX, test-cases)
- inside-outside of GMOSS (meeting with other GMES project consortia, summer schools, test-cases)
- EU-global (summer schools, test-cases)

All these steps comprise training measures which aim at internal integration (training seminars (3 days), integration meetings (2-3 days), near-real time exercises (3-4 days), test cases (continuous)) and elements which offer access to other communities outside of GMOSS (information markets (1 day), summer schools).

The training activities were coordinated by the Center for Geoinformatics Salzburg (Z_GIS) supported by a core team consisting experts from of the German Aerospace Center (DLR), the European Satellite Center (EUSC) and the associated partners Bonn International Center for Conversion (BICC) and, later on, the Universidad Pontificia de Salamanca (UPSAM). While all consortium partners contributed to training events, specific input was provided by Joanneum Research (JR), Kings College London (KCL), Centro di Ricerca Progetto San Marco (CRPSM), OD Science Application AB (OD), Università degli studi della Basilicata (UNIBAS), Royal Miltary Academy of Belgium (RMA) and University of Pavia (TLCLAB)

3.2.3. Achievements

After several successfully completed training events, the concept developed for the Network of Excellence GMOSS still offers opportunities for improvement. The participants using questionnaires and group feedback evaluated each of the three summer schools and several training seminars. In addition, the review team of GMOSS has continuously assessed the impact. In pursuing its set objectives and implementing the developed concept, the training team of GMOSS managed to ascertain the optimal dissemination of the GMOSS expertise under the selected theme and, by this, strengthened the integration among the consortium members.

Already during the first Summer School, invited experts immediately applied for associated membership to GMOSS at the end of the training event, a persisting trend which helped to constantly increase the GMOSS partnership. Capacity building has to be understood as an important outreach activity. The announcement of GMOSS Summer Schools has attracted between 60 – 70 applications every year; due to financial and infrastructural constraints however, only 25 participants could be accepted, whereby two-third of the attendees where from EU with the remainder coming from Asia, Africa and Latin America. The gender balance has been maintained at an above 40% participation of female experts. Capacities were built and partnerships facilitated. As one example among many: during extreme floods in Somalia in the early months of 2007, one participant from Africa contacted one of the lecturers at the 2006 Summer School for assistance with satellite data; the request led within a day to a call to the International Charter Space and Major Disasters which provided the required raw data.

During the summer schools, ideas for joint projects are tabled and – in some cases – were pursued as submitted proposals. As a crucial element, games facilitated the building of consensus on threats and policy intervention options, as well as served as the integration mechanism between different nationalities, sectors and disciplines. To foster the alliance with the alumni of the schools, an e-Learning platform has been developed by the Center for Geoinformatics Salzburg. Presentations and material used during the event are prepared on the platform as a continuous accessible source of information.

Summer Schools:

Salzburg, 11.- 18. September 2005
'Rapid information generation for security applications and decision support'
Objectives:

- To explore the global aspects of security threats and to compare/contrast different perspectives, approaches and issues concerned, in particular the ways and means of how security can be addressed in planning and decision making will be explored.
- To allow young interdisciplinary scientists from around the world to make contact with established scholars and decision makers to reflect critically on current issues in the security network.
- To enable young scientists to develop and discuss their own thinking in the context of other approaches and perspectives.
- In the context of rapid-mapping: understand and analyse satellite imagery data, learn about different methods for image interpretation, acquire basic competence in process modelling, develop skills for the visualisation of relevant information

Scenario used for exercise: terrorist attack on Salzburg Festival House using a nuclear device (dirty bomb); Prevention and evacuation.
Participants: 23 (female: 11, male 12); GMOSS partners (6); Europe (16), Serbia & Montenegro (2), Rumania (1), Kyrgyzstan (1), Laos (1), Japan (1), Nigeria (1)

Acting in the gaming exercise

Final panel with experts from NATO, UN, EU and Austrian Government

Summer School 2005

Salzburg, 1 - 8 October 2006
'Monitoring for Human Security. People - Homes – Infrastructure'
Objectives: Explore GMOSS work-flows for

- Monitoring population
- Human settlements (incl. refugee camps) detection
- Landuse monitoring – food supply, natural resources

- Monitoring critical infrastructure – roads, railways, harbors, energy, water supply

in the context of socio-political questions and issues:

- when do internal conflicts become an international affair and vice versa?
- Intervention options
- Crisis management – the first steps
- Prevention, forecast, early warning
- Information support for Rapid Reaction Unit

Scenarios based on test cases – Zimbabwe, Kashmir and Iraq
(near real-time mapping exercise at DLR)
Participants: 22 (female: 8, male 14)**,** Countries 11

Near real-time exercise: rapid damage assessment Kashmir Earthquake at DLR

Final panel with experts from UN, BICC and NATO

Summer School 2006

<u>Madrid/Salamanca, 2 - 9 September 2007</u>
'Early Warning and Monitoring of Agreements'
Objectives: Explore GMOSS work-flows for:

- early warning
- treaty monitoring
- population monitoring
- indicator development

Presenting results on scenario analysis

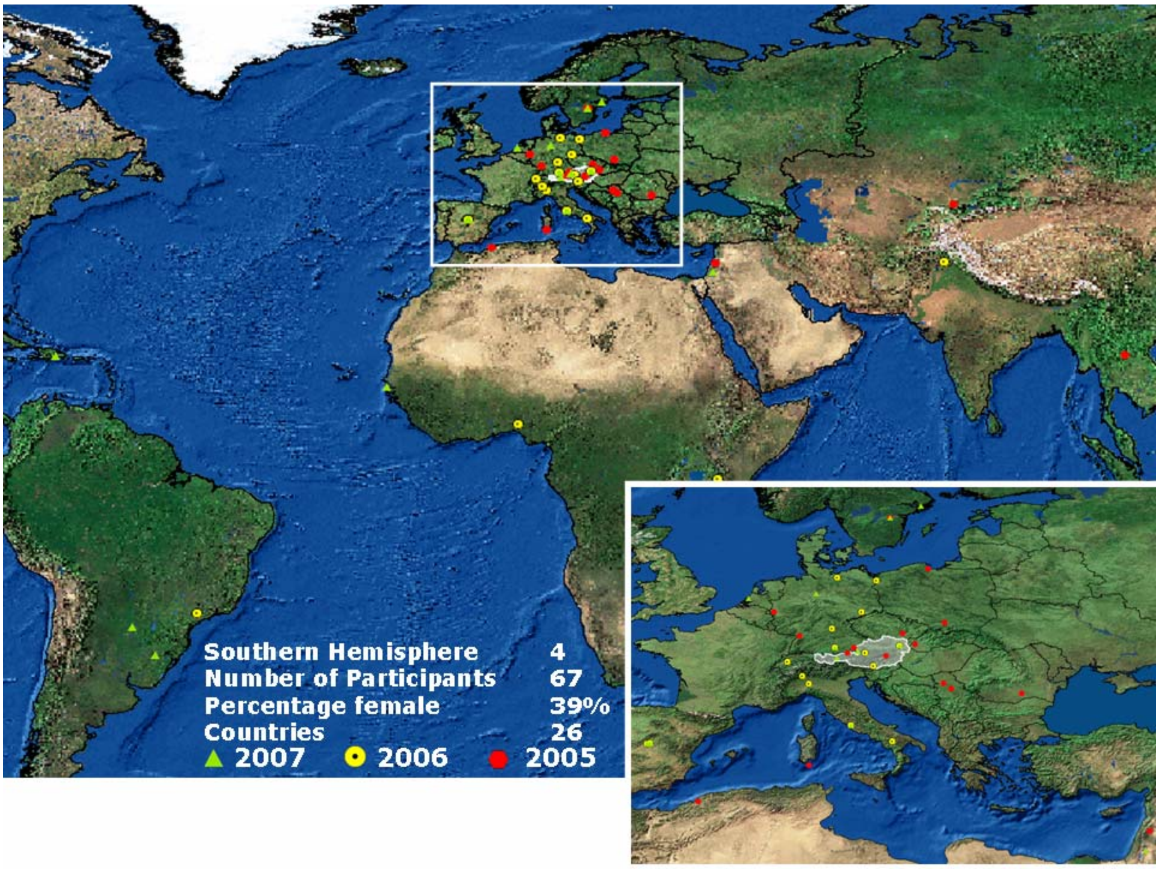
Final panel with experts from Spanish Civil Protection, political sciences and United Nation University.

Summer School 2007

in the context of socio-political questions and issues:

- what are the indicators for early warning? Regional conflicts, humanitarian crisis
- who needs what to act?
- agreements: ceasefires, peace settlements, human rights,….

Scenarios based on test cases – Zimbabwe, Kashmir, Iraq, Iran
(Treaty verification (Russian nuclear warfare) and damage assessment (Libanon) at EUSC).



Participants of GMOSS Summer Schools 2005-2007: places of origin

3.2.4. Conclusions + recommendations + impact

GMOSS produced evidence that a NoE is a perfect platform for medium-career staff to present the results of their research to a European auditorium. The wealth of new ideas – pre-operational as well as service-improving in nature – can be tapped better by the facilitation the network provides. In this respect, the training concept developed by GMOSS (e.g. summer schools and near-real time exercises) can and should be extended as an integrated component of all GMES services and development projects.

3.3. Work Package 30200: Public outreach

3.3.1. Executive Summary

The spreading of excellence (also beyond the boundaries of the NoE's partnership) was a primary goal of GMOSS. The progress of GMOSS work and the results were continuously disseminated to the international research community, decision makers, the public and the press. GMOSS has contributed to other projects of the European Union's Global Monitoring for Environment and Security initiative (GMES).

The dissemination of expertise was accomplished through publishing media, tools and by organising outreach events. A GMOSS website was implemented at the launch of the Network and developed as a modern integration platform which enabled the GMOSS members to share their knowledge, discuss relevant issues in the forum section and to access the pool of data sets. The public part of the website offered general background information about GMOSS activities and results. A news section provided information about latest activities and announcements. The GMOSS partnership has published two books collecting the full spectrum of results from their joint research. These publications will stimulate researchers and decision makers in the field of security to perform and support more in-depth work and analysis to face the new challenges in this domain. A scientific conference about the integration of GMOSS results and experiences in GMES finalized the Network.

3.3.2. Introduction

The initial integration section of the GMOSS work programme included the work package "Information Exchange", focusing on the aspects of disseminating existing expertise across the partnership, and on the establishment of a public website. Apart from this approach training activities were conceived in a separate work package domain. After one year of work the necessity for an overall outreach concept was raised by the reviewers, integrating all dissemination activities towards various target communities such as public, press, science, end users, GMES-projects, decision makers and the GMOSS team.This request was put into practise in the updated working structure of GMOSS, where new work packages on "Training Measures" and "Public Outreach" were subsummized in the "Training and Communication" domain. The lead of "WP 30200 Public Outreach" was assigned to the JRC , the other team members were Z_GIS and DLR.

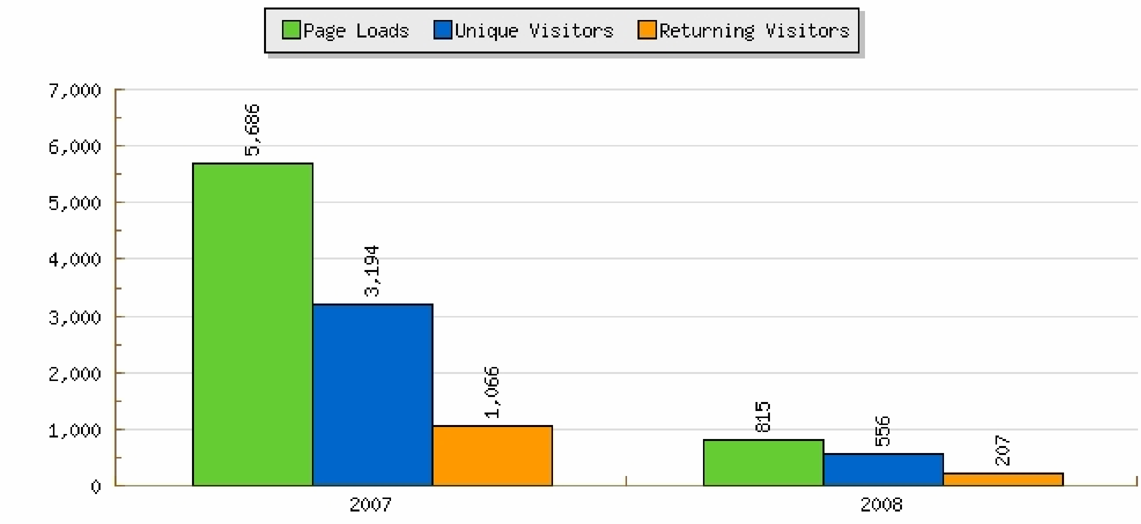
It was decided to redesign and to relaunch the GMOSS web-site, separating the public part from the access-controlled internal working platform, which was later also used for online-reporting. The scientific community was addressed by book publications and conference contributions, whereas GMES projects, other end-users and decision makers were directly contacted in order to establish the exchange of information and the participation at workshops organised at either side. Due to the sensitive character of GMOSS security research the press publications of GMOSS have been reduced to overview articles in selected magazines.

3.3.3. Achievements

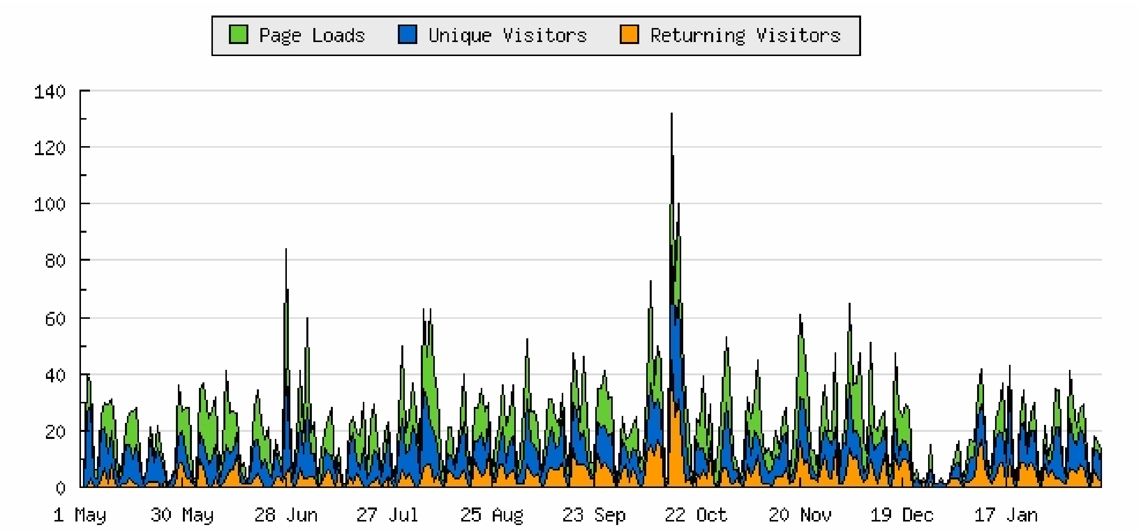
GMOSS Website

The GMOSS website can be seen as main information hub of the network. The website was set up to disseminate the GMOSS story to the interested public. Its development as integration platform facilitated the exchange of knowledge for the network members. Besides it served as data and document repository. For the public information about the project, its work packages, project news, activities, and results were published. In a restricted area the GMOSS partners were able to share project related material, documents and data. The project tracking and archive software was customised for the consortium allowing each partner to up- and download documents. Even after the project end JRC will further host the website.

The success of the website can be demonstrated in traffic rates. Since May 2007 (the launch of the new website) 3750 visitors searched the sites which mean an average of 12 visitors per day. A peak in October 2007 can be explained with the GNEX'07 exercise that used the GMOSS platform also for communication. More than 20% of all visitors stayed longer than one hour on the site. Around 50% of all visitors stayed longer than five minutes.



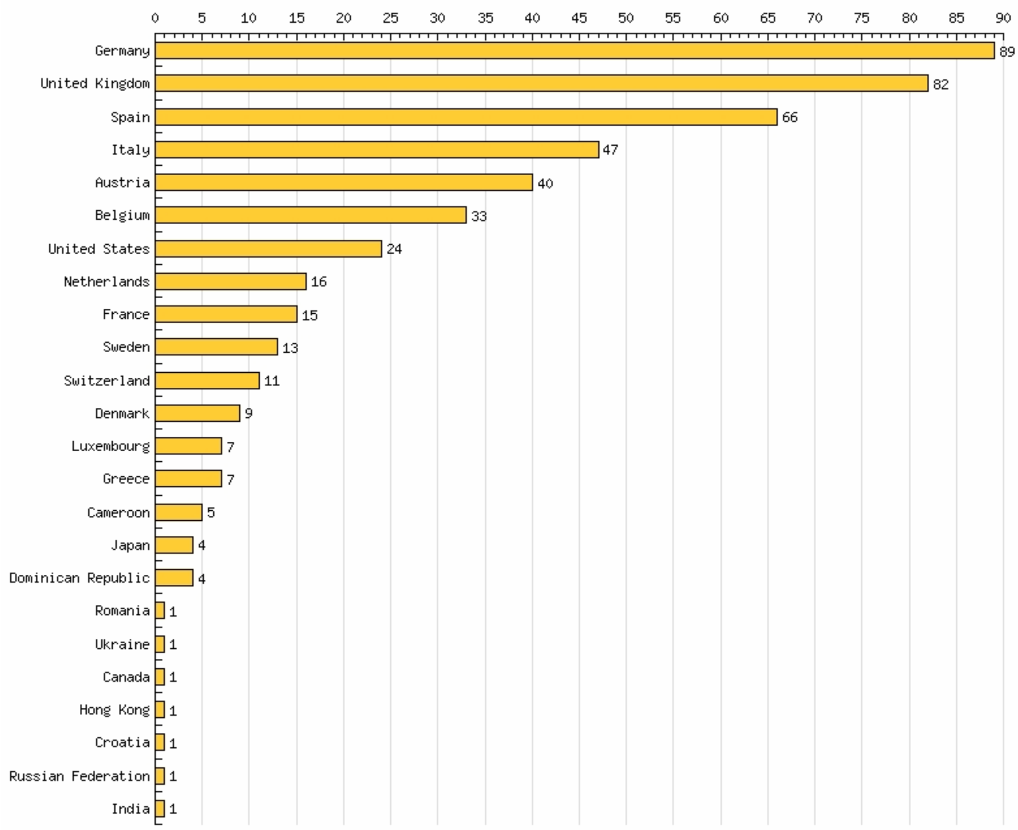
GMOSS webtraffic since May 2007



GMOSS visitors per day (the peak in October can be explained with the GNEX'07 exercise)

A visitor map from February 13, 2008 gives a good example that the website was not only visited by European users but worldwide. Logins were registered from Africa, the Americas and the Caribbean, as well as Asia and Australia.

GMOSS website visitor map of Feb. 13, 2008



GMOSS website country statistics for Feb. 13, 2008

Publications

Two project flyers were created during the project lifetime with updated information. These flyers were disseminated during events, workshops, conferences and meetings by all GMOSS partners to spread the information and success of GMOSS to the public and to colleagues working in the same field of research.

Two books were/ are published in GMOSS. The first one in 2007 was edited by JRC as JRC Scientific and Technical Report. Its title is: *Global Monitoring for Security and Stability. Integrated Scientific and Technological Research Supporting Security Aspects of the European Union (EUR 23033 EN, ISBN 978-92-79-07584-1, ISSN 1018-5593).* This 400 pages report contains 33 contributions from several GMOSS members. Following the WP structure of GMOSS it was organized into different chapters about *concepts & integration, applications,* and *tools.*

A second book will be published in 2008 by Springer Netherlands. It holds the tentative title: *Remote Sensing from Space - Supporting International Peace and Security*. The editors collected several contributions from GMOSS members covering security concepts as well as the development of tools. All contributions passed an anonymous review procedure.

Dissemination of project reports

Despite the fact that the internet has developed to become the primary source of information on recent research activities, there is still a request and justification for printed information. Comprehensive reports on the work of GMOSS were produced on a 6 month time scale.

GMOSS Publications in public media and at events

The two lists of GMOSS publications in public media as well as at events provided on the GMOSS website (http://gmoss.jrc.it/final_reporting/home?op=33, http://gmoss.jrc.it/final_reporting/home?op=43) is a further example how GMOSS members supported the aim of disseminating the successful GMOSS story to colleagues and the public.
Overviews on the Network of Excellence GMOSS were also published in "The Parliament Magazine" Issue 252 in Sept. 2007 and in a recent compendium of the European Commission on results from FP6 projects (to be published 2008).

GMOSS workshop: "Remote sensing for international stability and security: integrating GMOSS achievements in GMES"

In February 2008 the JRC hosted a scientific two day workshop to disseminate the tecnical achievements of GMOSS to scientific and technical staff of ongoing and future GMES projects such as RESPOND, LIMES, RISK-EOS, PREVIEW, BOSS4GMES, SAFER, GMOSAIC and others. Selected oral presentations and poster sessions of tools and methods developed in GMOSS set the framework for discussions on integration of these tools in other projects with space for an exchange of ideas. The objectives of this workshop were in detail:

- Bring together technical people from the GMOSS NoE and from thematically related GMES projects.
- Discuss and compare alternative technical solutions (e.g. final experimental understanding from GMOSS, operational procedures applied in projects such

as RESPOND, pre-operational application procedures foreseen from LIMES, etc.)

- Draft a list of technical/scientific challenges relevant in the next future.
- Open the GMOSS (and the other projects) to a wider forum in the JRC

The workshop was attended by more than 35 participants from Europe.

3.3.4. Conclusions + recommendations + impact

The dissemination of research results is usually done by publishing the outcomes in scientific journals. The GMOSS members frequently used this way which is impressively shown with the publication list of the GMOSS website (http://gmoss.jrc.it/web/guest/results/publications).

Nevertheless it is the responsibility of publicly funded projects to disseminate information about ongoing activities and results to the funding organization as well as the public. In addition due to the nature of a Network of Excellence, GMOSS sees itself as a think tank for related projects and consequently aims to disseminate its knowledge also to the Global Monitoring for Environment and Security (GMES) community.

GMOSS achieved this aim successfully by using different channels for dissemination. The website was used by the interested public as well as other scientists for getting a general overview about the project. The analysis of the website traffic underlines this success.

Using the traditional way of publishing, GMOSS was able to bring two books on its way, reporting about latest scientific achievements in the field of security.

A general problem for dissemination activities was the sensitivity of the subject 'security'. This led to the fact that dissemination channels had to be selected very carefully and well known forms as press releases or publications in newspapers or magazines had to be avoided.

As general result we are convinced that the work package for Outreach was able to put GMOSS in perspective. By keeping the modern website online and by publishing two books we are sure that the GMOSS success story will be kept in memory and will be remembered as a very successful example of Network of Excellences within FP6.

4. Contractual management of the Consortium

4.1. Work Package 40000: Consortium Co-Ordination

4.1.1. Executive Summary

Thanks to the annual relaunch of the planning process, the coordination of the NoE GMOSS required a more sophisticated management concept than straightforward project planning. The GMOSS consortium management has mastered this challenge, and supported by the reviewers' recommendations achieved the objectives of integrating partners from different research domains within a joint programme of activities, which has attracted both new collaborations and end users. The financial set-up of GMOSS has been flexibly adapted to the appropriate demands of the tasks at issue and the partnership. The GMOSS consortium has used the Commissions grant not only for the internal work but also for offering their expertise and education/training services to end users.

The key issue for the success of GMOSS has been however the good team spirit of the partners and their willingness for open cooperation.

4.1.2. Introduction

The management structure of GMOSS categorized various layers of control and steering, where the overall management is in the responsibility of the Consortium Coordinator (DLR), being in charge of:

- the internal management of the consortium, and preparation of decisions from the Governing Board and the Executive Committee;
- the overall financial controlling;
- the reporting and planning process towards the European Commission
- the management of the contract with respect to changes and amendments
- the organisation of meetings with representatives from the Commission and the reviewers.

He was supported by the research coordinator (JRC), the training coordinator (SBG) and the integration coordinator (RMA). Decisions with relevance to the contract were in the sole responsibility of the Governing Board, composed of one representative from each contractor, voting on the base of a 2/3 majority. In everyday management however, decisions were taken by the Executive Committee, a body of 8 members, which was also in charge of the preparation of the annual planning of the joint work programme and the distribution of the budget.

Independent control was executed on a regular base by the group of 3 external reviewers, being nominated by the European Commission. Additional advice was provided by the User Focus Group of external end users.

Fluctuation of staff turned out to be a problem not only in the management team, but also in the recruiting of user focus group members.

4.1.3. Achievements

Networks of Excellence can be regarded as self-focusing organisms. They start with an initial membership configuration a preliminary work programme and financial set-up, being evaluated and refocused by annual reviews. In the ideal case this iterative process ends up with an optimal configuration providing a clear concept with respect to the best collaboration role model and the issues of collaboration to be pursued.

Contract management

- Nine amendments to the contract were prepared by the coordinator and forwarded to the Commission; eight of them were accepted and put into action.
- Regular management meetings of the management boards have been prepared, organized and documented. Due to the increasing number of appointments of the representatives, the annual meetings of the Gov Board (22 contractors) and semi-annual meeting of the ExeCom (8 representatives) have been coupled to integration workshops. In addition fax decision procedures were introduces and applied.
- Two contractors left the consortium, one (AFES-Press) by decision of the Governing Board, the other (DEFINIENS AG) by their own decision to avoid the high administrative load, they rejoined GMOSS as an Associated Partner.
- Activity reports were delivered on semi-annual schedule, where the input was compiled from the work-package reports and edited by the Coordinators of GMOSS. By month 36 reporting was done online supported by the GMOSS web-platform at http://gmoss.jrc.it/
- The annual planning for the next 18 months followed a bottom-up approach, covering more than 3 month of time. The work-package teams submitted their planning to the Coordinator, who prepared a first draft of the Joint Programme of Activities and the financial set-up, which was forwarded to the Executive Committee members. In an iterative process this draft was refined and finally discussed and completed in a meeting of the ExeCom. The resulting draft planning document was then submitted to the Governing Board for approval. Final corrections were discussed and applied during the annual meeting of the Governing board.
- Fluctuation of staff made high demands on the management of the consortium with respect to keep up the continuity of work. The research coordinator and the integration coordinator were replaced after year 1, and the person being responsible for the financial controlling was even exchanges five times in four years.
- The reviewers' comments and recommendations were analysed and a majority of them was integrated in the future planning successfully put into practice.

Financial set-up and control

Modification of the funding scheme proposed by the European Commission, where a contractor's budget is determined by fixed grants per researcher and students. Instead in order to achieve more flexibility:

- Introduction of a non-allocated budget for tasks of common interest, training courses, staff exchange, gender actions, big events
- Supplementary grants for work-package leaders

This approach emerged to be a flexible and powerful instrument; however it also complicated the task of controlling and financial reporting.

Audit certificates had to be provided by each contractor for the annual declaration of costs. Experience showed that many commercial auditors were not familiar with the procedure and that the resulting documents did not provide the detailed information that was required for the filling of the reporting tables of the Commission (cost-budget follow-up table, person-month status table).

In the initial phase a number of contractors were confused by the complicated and fuzzy financial regulations of the EC, in particular with respect to the AC cost model. This resulted in an involuntary under-spending of their budget, which had to be compensated by later adjustments.

Impact and networking

Even without dedicated public relation activities GMOSS has attracted 13 organisations to apply for associated partnership on a contractual base although these partners did not receive funding from the Commission. However their travel expenses for the participation at GMOSS workshops were reimbursed These partners have substantially increased the expertise and the competence of the GMOSS community and widened the scope of the work programme and the partnership.

On the contrary, it turned out to be a difficult task to establish the User Focus Group, which was conceived to act as steering committee of external experts and end users in order to give feedback on, and to focus the work programme of GMOSS. Although a multitude of experts and representatives from various institutions were contacted, the UFG never formed as a body with constant members, instead the structure developed towards floating membership.

Being embedded in the GMES programme, GMOSS has sought cooperation with other projects in GMES. Agreements were arranged about mutual participation of meetings and tangible collaboration with LIMES, RESPOND and TANGO.

4.1.4. Conclusions + recommendations + impact

The Network of Excellence GMOSS has proved to be a role model for initiating fruitful cooperation across complex communities. GMOSS has been successful with respect to the integration of remote sensing researchers with socio-political/economical scientists. The key element for trustful cooperation in GMOSS has been the open working spirit of the partners.

Recommendations

Some recommendations emerging from the GMOSS experience have already been implemented in the FP7 rules, such as the cancellation of obligatory audit provision for contractors with small budgets. But still most suggestions for improvement relate to the reduction on of administrative overload:

- Activity reporting documents should be reduced to annual scale, intermediate control can as well be carried out by review workshops. Additionally reporting should be supported by web-based systems.

- As the number of consortia members has substantial impact on the effectiveness and the reactivity of management and reporting procedures, the number of contractors should be kept to a minimum of core actors. Supplementary collaborators should be attracted and recruited as Associated Partners, allowing for flexible adaptation of the team to master changes in the work programme. In this context the options for reimbursement of Associated partners for their contributions has to be thought over.
- Cumbersome decision procedures because of big consortium (max 12 better)
- Because of the increased effort for the coordination of a Network of Excellence, the provisions for NoE should define an explicit budget for this task; in fact it implies more than just acting as “postman and banker”.

Impact

One of the unique selling propositions of GMOSS is the collaboration of remote sensing experts and researchers from the socio-political-economical domain. This challenge was not mastered without misunderstandings and frictions. However, it has been synergistic productive and resulted in a proposal to launch a network on Environmental Processes and their impact on Human Security.

The recommendations emerging from the GMES and Africa workshop in Lisbon (Dec. 2007) cite GMOSS explicitly as a role model for starting extended cooperation of GMES with African institutions.

Concepts developed and put into action in GMOSS, such as Near-Real-time Exercises, summer schools, training seminars and benchmarking models are considered to be utilized for the GMES fast track services and FP7 projects.

Documentation and References

The full documentation of the Network of Excellence GMOSS is kept on the GMOSS website at http://gmoss.jrc.it/ , which will be maintained by the JRC even after the lifetime of the network.