Executive summary:

The G-MOSAIC project has responded effectively to the needs expressed by EU Member States and international organisations. Users such as these have provided positive feedback on the services delivered during the course of the project. The consortium received official letters of appreciation from the United Nations Department for Field Support and the United Nations Operation in Cote d'Ivoire (UNOCI), expressing their gratitude for the support provided to their respective operations.

During the course of the project, crisis management and assessment services were provided on the basis of round-the-clock availability (24 hours a day, 7 days a week). Service production was organised through cooperative 'service chains', altogether 16, in which service providers worked closely with the European Union Satellite Centre to build the services up to the required level. The involvement and contribution of the users, as well as the contributions from research and institutional partners in the G-MOSAIC consortium have been highly valuable, with regard to both the detailed technical requirements and the assessment and operational validation of the final products.

G-MOSAIC has shown that GMES can deliver tangible support to the EU External Actions . A number of EU missions and operations have taken advantage of the G-MOSAIC products and services, and subsequently reported favourably on their effectiveness and usability. Two notable examples are the European responses to the civil unrest in North Africa in early 2011 and the Haitian earthquake in 2010 .

G-MOSAIC has also demonstrated the capability to provide products and services across a very wide range of areas ('security domains') related to intelligence and early warning and crisis management.

Project Context and Objectives:

During the three years of the G-MOSAIC project, a set of pilot GMES services for Security applications have progressively evolved from research and development activities into pilot and / or pre-operational services. Five Security domains have been addressed by the services developed:

a)Natural resources and conflicts;

b)Migration and border monitoring;

c)Non-proliferation and treaty monitoring;

d)Critical assets, and

e)Crisis management and assessment.

These security domains fall into two categories: 'Intelligence and Early Warning' (a-d), and 'Crisis Management and Operations' (e).

The European Commission (GMES unit), in consultation with key European Union stakeholders, has further defined the scope of the Security dimension of GMES and - through interaction with users - has investigated service perimeters and a possible 'modus operandi' for the three principal Security domains indicated in the EU Regulation on GMES and its initial operations (2011-2013), namely: border surveillance, maritime surveillance and support to the EU External Actions .

Governance and Data Security policy are pre-requisites for the operational phase of GMES services in the Security field. To this end, a GMES Security Board was established, in order to take into account the recommendations on GMES Data Security policy adopted by the Council Security Committee (CSC) on the 26th of January, 2010.

Industrial partners, who have been involved primarily as service providers in GMES projects for Security, have progressively developed pilot and / or pre-operational services some of which have proven to be both sufficiently advanced and technically mature. In G-MOSAIC, this is particularly the case for the crisis management and assessment products and services.

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G-MOSAIC has also demonstrated the capability to provide products and services across a very wide range of areas related to Intelligence and Early Warning. These services are considered to be less mature than the Crisis Management and Assessment activities and therefore further research and development work is necessary in order to bring them up to an equivalent level of maturity.

The G-MOSAIC project has enabled substantial progress to be made in building up pilot and / or pre-operational services within the Security Dimension of GMES, notably through the mobilisation and involvement of users. In the area of crisis management and assessment, the project contributed towards supporting real-world operations in rush mode. Taking into account the progress made within G-MOSAIC in developing these services, the work of the GMES Bureau in defining requirements and modus operandi within the Security Dimension of GMES (in close coordination with the European External Action Service (EEAS) and relevant stakeholders), the involvement of the EUSC related to the technical coordination of users and services and the efforts made towards defining a strong Data Security policy, many aspects are likely to converge in future in order to make possible future services in the Security dimension of GMES.

During the third and final year of the project, services in support to crisis management, in particular reached operational maturity. The G-MOSAIC project raised also several important points that should be taken into account in the further evolution of services in support to EU External Actions:

-The continuity of the service provision. GMES services in the Security field have established a strong and active base of users, who regularly utilise the services in support of their activities. Any discontinuity in the provision of services is likely to impact adversely both on user and stakeholder confidence in the GMES services for Security applications.

-Data Security policy. In the Security field, some of the data and information handled by, and exchanged between GMES service providers and users could be deemed sensitive, for political or strategic reasons. The need for a consensually-defined and properly implemented Data Security policy is therefore a necessary condition to be met by the services, in order to avoid the potentially detrimental use of sensitive data or products.

-Cooperative workflow production. Thanks to a common view and coordinated approach, the specialized knowledge of each partner converts often to a common Product Design that allows a true synergy of different fields of expertise. This was a very significant characteristic of the service development process within the G-MOSAIC project. The benefit of this type of service organisation is maximising the collective potential of the specific expertise of the consortium partners. The consortium supports the view that similar organisation of work practices should therefore be implemented in future GMES initiatives.

-Flexible product design, tailored to user needs. One of the major lessons learned through working with the GMES user) community in the Security field is that each crisis or event is unique, deferring in terms of both observation and information requirements. Consequently, each product calls for specialised customisation. For instance, with the Rapid Geospatial Reporting (RGR) service the main lesson learned is that the information created during a crisis has a contextual value for that crisis. The accent of the value was on the service itself, on the availability to react in short time providing the appropriate information to support decision-making. Further to this, the quality of the tailored products to user needs is enhanced as a function of the intensity of collaboration between service providers and users. This involves the definition of the areas of interest and of the observation modes.

The evolution towards operational services relies on the effectiveness of two parallel assessment processes, external and internal to the production:

1)The assessment of the service by the final user, who assesses the products received against the initial requirements and expectations, and evaluates the usefulness of the information and its potential for integration into the user's operational workflow.

2)The assessment of the service by the consortium partners, which occurs through a number of internal processes. These include the product quality assurance process developed within the different service chains, and the independent validation carried out by partners who are not directly involved in the product generation process.

-The cost-benefit analysis. As well as the technical assessment, service enhancement and improvement must also be evaluated in terms of cost. Thus, a rigorous analysis of costs and benefits should accompany decisions taken on the evaluation of the service portfolio. The stakeholders should be able to develop an accurate understanding of the total service costs.

-User involvement. The engagement of users for the Security dimension of the GMES was a very challenging - and ultimately successful - activity within the G-MOSAIC project, despite the fact that only three SLAs were eventually signed. The strategy for the involvement of users should consist principally of stimulating and maintaining the dialogue among user communities and project partners, including service providers. This can be achieved through a variety of methods, including direct meetings and common events. As a recommendation to future projects, and as a follow-up to the User Workshops organised during G-MOSAIC, more technical and dedicated workshops and training sessions should be organised in order to elicit feedback and encourage open discussions. Such user engagement activities will assist in identifying areas of improvement in the products and services, thus preparing for the operational implementation of GMES Services for Security applications.

-Synergies between GMES services in the Security and other GMES services, in particular Emergency . The need for the exploitation of synergies between the recently operational Emergency Management Service (powered by the SAFER project) and the community of Security users was identified in the early stages of the G-MOSAIC project. A protocol for synergetic work between the two services was designed and implemented. Synergies with parallel and past GMES projects and initiatives should be ensured in order to optimise resources, capitalise on past experience and ensure that proper continuity in the relationship with the User community is sustained.

-An external validation service: Within G-MOSAIC, validation was performed on a best-effort basis by consortium partners, internal to the production workflow. As a recommendation from G-MOSAIC to on-going and follow-up Security-related projects, a system of independent validation (at least external to the production) should be set upto provide production support as well as controlling quality. Ideally, the validation should be undertaken by an external agent and integrated into the production chain. In order for such an external validation system to have a genuine impact on the quality of the products, validation should be carried out before the delivery of the product to the user. There is a risk, however, that such an arrangement may delay the final delivery of products - especially in the case of rapid mapping activities.

-Governance. One of the main concerns emerging as an outcome of the G-MOSAIC project is the lack of a governance model for GMES Security-related services. The need to design and implement a sustainable governance structure has been expressed both in recommendations from the user community and by several key actors involved in setting up operational services for GMES Security applications. The BRIDGES project, started in January 2012, coordinated by the EUSC is contributing to this process by proposing potential governance models, implementation options, stakeholder positions and cost-benefit analyses. BRIDGES is building on the preliminary assessment work carried out within G-MOSAIC.

-Coordination of the user-related activities between FP7 projects in the framework of Support to EU External Actions should be ensured, in order to provide the user community with a general and complete view of the GMES Security capabilities and to ensure a coordinated approach to user engagement. This may, for example, lead to shared events (workshops and co-located meetings) and communication and dissemination strategies.

-Integrated and centralised imagery analysis. The development of an integrated and centralised architecture for imagery analysis is a recommendation from G-MOSAIC. This architecture should allow secure access for retrieving, viewing and analysing all available (spatial and non-spatial) information for a given site. The information provided should include satellite imagery, Geographic Information System (GIS) information, external databases and collateral information. Symbology and map legends should be customisable by the service providers. A centralised model will maximise the return on the costs and resources committed in respect of fully operational activities, minimise the points of failure and improve usability, both for users and for service providers.

-The high reliance on non-European data providers should be evaluated. Many of the products and services developed within G-MOSAIC remain dependent on such data, and clearly this needs to be addressed before the operational phase.

Finally, progress in the areas of governance and Data Security policy is a key factor for a successful transition from pre-operational to operational services. In particular, it will be necessary, to set up mechanisms for the operational and technical coordination of both user requests and service delivery. Such mechanisms should build on the experience gained through the initial operations of the Emergency Management Service (GIO-EMS), whilst further developing the synergetic interactions between the Emergency and Security applications.

For the initial operations of services for Security applications, emphasis should be placed on the most mature pilot services which respond to the largest user base, within the scope of the policies addressed by the Security dimension of GMES. Such services will have to be developed in coordination with the respective Security working groups (e.g SEA WG).

The G-MOSAIC consortium considers that research and development is a key factor for the development of future services in those service areas that are less mature. Enhancing and maintaining continuous user involvement during the transition from pre-operational services into operations is necessary, in order to sustain user confidence and garner support for future operational funding in this area. G-MOSAIC users have expressed concerns about the continuity of the services, and it is therefore of paramount importance that user engagement and consultation activities are sustained.

The consortium recognises that GMES implements a phased approach bringing progressively pre-operational services to operational status. This phased approach is reflected in the recent SPACE call for proposals (i.e. 2012), through which services should be prepared for operations in 2014.

The G-MOSAIC and SAFER users, including the Monitoring and Information Centre (MIC) of the Directorate General for Humanitarian Aid and Civil Protection (DG ECHO), the United Nations, Member States' Civil Protection Agencies, and other stakeholders have benefited from the coordinated approach to the provision of Security and Emergency services. The G-MOSAIC consortium therefore believes that the current synergies between SAFER and G-MOSAIC should be further developed in the context of the follow-on projects as well as in the Initial Operations of GMES.

G-MOSAIC partners look forward to capitalising on the experience gained through the project, and will participate in future projects aimed at further developing the Security dimension of GMES, taking into account the lessons learned and the challenges to be overcome.

Project Results:

The design of the G-MOSAIC project was based on a review of available technologies and service elements in order to build up a pre-operational service portfolio aimed at supporting different thematic domains. The Service Portfolio was based on successful outcomes in the following activities: scenario definition, user needs collection, service operation and validation. The definition of scenarios led to the combination of specific technological applications into pilot services.

At the end of the validation and appraisal activities, performed by the service providers in cooperation with the Users, the G-MOSAIC Service Portfolio, in terms of services provision and observation modes, was consolidated.

Furthermore, the pre-operational deployment of services included a Service Level Agreement/Service Level Specification exercise, aimed at outlining the applicable legal models for service distribution.

The G-MOSAIC service portfolio is composed of the following sixteen services ('service chains'); reflecting five European areas of interest and related priorities ('security domains'):

-Natural Resources and Conflicts

Exploitation of Natural Resources

Population Pressure

Land Degradation

Illegal Mining

Illegal Timber Logging

Illicit Crops

-Migration and Border Monitoring

Border Area Monitoring

Monitoring Migration Routes and Settlements

-Nuclear and Treaties Monitoring

Monitoring of Nuclear Decommissioning Sites

Continuous Surveillance of Nuclear Facilities

-Critical Assets

Critical Assets Monitoring

Critical Assets Event Assessment

-Crisis Management and Assessment

Contingency Plan Preparation

Rapid Geospatial Reporting (RGR)

Damage Assessment for Post- Conflict Situations

Support Reconstruction Missions After Conflicts

Reference cartography (baseline maps) was applicable to all the Security service domain servicesand represented the basic layer onto which thematic layers were overlaid and to which change detection methodologies were applied. Different levels of detail were made available based on the final scope of the services (against multiple parameters, such as legend, accuracy and scale). The reference cartography was based on the adaptation and fusion of existing databases (Vmap0, Open Streetmap, etc.) as well as feature extraction from Earth Observation data sourced from the Multinational Geospatial Co-production Program (MGCP).The MGCP-based reference cartography required close cooperation with users for the definition of the data model, and regarding the constraints on delivery time.

G-MOSAIC services were based on change detection techniques, specifically aimed at producing the following service types:

-Periodic updates of cartography: applicable to services focusing on the seasonal observation of phenomena (for example, in the case of agricultural targets) or analysis of historical data (e.g. population distribution).

-On-demand surveillance: applicable to services triggered by users on demand, which can be further sub-divided into:

- Off-line mapping: one-off observations for which the information delivery is not subject to tight temporal constraints;

- Monitoring: Recurring observations, for which the time window, update frequency, and timeliness of service delivery are pre-defined;

- Rush mapping: one-off observations, for which the products are delivered with tight temporal constraints in relation to the time of activation (ranging from 12 to 48 hours). The service allows for a degree of flexibility regarding the customization of products.

Data and geospatial information within the G-MOSAIC project have been distributed to users and to the consortium with different levels of security, according to a project-specific classification system based on the sensitivity of the information:

-Public: Available to the project and to the general public for subscription and download.

-G-MOSAIC restricted - Level 1: This level refers to a dataset not included in the European Space Agency (ESA) catalogue but available to other projects for subscription. Such datasets may only be re-used in case other projects make a request for satellite data over the same area. Transparency is maintained with the project which originally requested it (ESA will keep the information reserved). The products are either adapted for the purpose of wider dissemination, or the publication is delayed until the information is “declassified”.

-G-MOSAIC restricted - Level 2: The dataset is not included in the ESA catalogue. Information about the area of interest can be disseminated, but the distribution of products is non-public and subject to the restrictions specified by the user.

G-MOSAIC SECURITY DOMAINS

The series of the five security domains within G-MOSAIC were developed with the cooperation of users, who participated by providing requirements, contextual data and information and by assessing and evaluating the services. The domains bring together different services within the context of specific geographic or thematic boundaries. What follows is a short description of the G-MOSAIC Security domains, with some examples of the products delivered.

Natural Resources and Conflicts

This domain is focused on exploring the concept of early warning crisis indicators of regional conflicts. The exploitation of natural resources (such as timber and minerals), increases in population and the degradation of land are amongst the phenomena which have been examined in relation to occurrences of regional conflicts. The core information used in this service is land use and land cover change, which is combined with socio-economic data and local conflict information.

Environment and natural resources can play a role in the onset, duration, and termination of conflicts. Conflicts are not caused by environmental factors only. However, they can play a key role in the dynamics of conflicts. This role is complex and has an impact only in combination with other socio-economic factors. Generally speaking, it is often the lack of vital goods (such as food, but also access to land, work or housing) or the availability of valuable goods (such as diamonds, gold, etc.) coupled with poor economic conditions (poverty) and weak constraints (weak government, corruption, strong foreign influence, etc.) that could contribute to (violent) conflicts. Earth observation (EO) data could help to measure both environmental and certain socio economic factors. This could ultimately lead to the development of crisis indicators.

The indicator development in this domain tried to follow a modular top-down approach with three levels from global to sub-national. The indicators are developed for 'hot-spot' countries that are characterized by a high risk of armed conflict as defined in previous work based on structural indicators. Then three different service chains (exploitation of natural resources, population pressure and land degradation) aimed at providing conflict related information for these countries at sub-national level. The information is derived 1) from multi-temporal analysis of EO data aiming at identifying possible flash points for crisis within a country, and 2) through situation monitoring using information about conflictive events, population, socio-economic data, where available, and other relevant datasets.

The following three indicators were developed:

1.Exploitation of natural resources

2.Population Pressure

3.Land Degradation

The service of 'Exploitation of Natural Resources' was developed for the North- and South-Kivu provinces in the eastern Democratic Republic of Congo (DRC). The Democratic Republic of Congo is still suffering the impacts of extended, intensely violent conflict. The wars of 1996-1997 and 1998-2003 were characterised by a series of complex, shifting alliances between foreign and indigenous armed groups, national government, and foreign governments. Despite recent combined military operations by Uganda, Rwanda and the DRC, supported by United Nations forces, rebel violence continues in the Kivus and neighbouring provinces.

Against this background the service aimed at establishing a spatial link between the conflict intensity and changes in the land use/land cover. These changes were observed by medium resolution satellites (Landsat and DMC) with the ultimate goal to identify hot spot areas of the conflict based on land use/land cover changes. A particular focus was put on the exploitation of mineral resources in the area. To this end, conflict information was collected from the Armed Conflict Location and Events Dataset (ACLED) as well as from the FAST Local Information Network, which operated exclusively for G-MOSAIC in the Kivus, and the NARECO conflict data set prepared by the JRC. Additional data sets included for example population densities and infrastructure.

Land use/land cover information was derived from multispectral Landsat and DMC satellite time series.

The approach was based on an adapted FAO Africover classification scheme in order to allow cross comparison and to assure continuity for other purposes. The biggest challenge for the service chain was the lack of appropriate satellite data. Despite search in GMES and other global archives, it was not possible to set-up a regularly spaced time series of satellite data. The achievable time series includes time slices from 2003, 2008/2009 and 2010 for the north Kivu province. Full coverage of both Kivus was achieved only with the data of 2010. This led to the production of land use/land cover maps and their changes over time. The recent land use/land cover maps were validated in the field by local experts, which were trained during a validation workshop in Goma organised by the project.

The combination of land use/land cover change and conflict information did not reveal any links. Moreover, the analysis did not show any link between conflict locations and the mining positions nor the population density. The reasons for this are manifold, but the most important is probably the insufficient EO data coverage to make a regional assessment, where land use/land cover changes in a period of 5 years are compared with more or less continuous conflict information. However the absence of a demonstrated link between conflict locations and the variables examined (land cover changes, mining positions, population density) does not mean that it does not exist; with more and better quality data the situation might well be different. Although the objectives were not fully achieved, the products were highly appreciated by local and international NGO's working in the area.

Worldwide, more people currently live in cities than in rural areas. The appeal of the city remains strong in particular in Africa, where currently the highest growth rates are observed. But the growth is mostly unbalanced and the gap between the rich and the poor continues to grow. In the long term these inequalities may pose threats to social and political stability ultimately leading to violent conflict. Earth observation (EO) data can help to measure the growth of a city over time and to map the urban inequalities. The service 'Population Pressure' aimed at providing refined geographical and thematic information related to changes in the city structure for the identification of potential conflict hot spots in larger urban zones.

The service was developed for Harare, the capital of Zimbabwe and it is connected with the 'Land Degradation' Service Chain. Zimbabwe has a recent history of violent, sometimes racially-motivated conflict over land tenure and for control of its government. These issues are shared with several other countries in the Southern African region. Despite the establishment of a coalition government, the political situation remains tense. The international community has consistently condemned political violence carried out by the ruling government, especially after an urban slum demolition initiative in 2005 called 'Murambatsvina', which left an estimated 700,000 people without jobs and/or homes. The humanitarian consequences of the operation were enormous.

Satellite imagery is an alternative source of independent information for monitoring processes such as Murambatsvina. In this spirit, the service provided built-up maps (2004, 2006, 2009) based on SPOT 2 and 4 as well as RapidEye satellites. Such detailed mapping of built-up areas is key information needed in any crisis at any phase, because it is a direct proxy for population. The built-up area of a city can be automatically extracted from satellite data. In analogy to the well-known compact and robust NDVI, a general index related to the presence of built-up based on image texture was used.

Subsequently, the built-up index was used to derive built-up change maps for 2004-2006 and 2004-2009. Multi-temporal built-up area mapping allows the mapping of changes over time to illustrate the urban development. In the case of Harare, Zimbabwe, some noticeable areas occur in the urban fringes. The changes can be interpreted using the base imagery. EO based change detection allows synoptic analysis of large areas for the identification of change hot-spots for further analysis.

Besides mapping the extent of built-up areas, the service provided products, which characterised an urban area based on its spatial variations according to building types, size, height and material, as well as social differences and usages (residential, industrial, commercial).

Characterising the built-up area based on its physical characteristics allows the inference of links to population occupancy and economic status (e.g. poor slums, middle class residential). Possible application areas are in urban planning and monitoring of urban development. Furthermore, by providing refined geo-spatial information, it can support the preparation of censuses. The information provided was derived from very high spatial resolution GeoEye-1 satellite data.

The combination of the settlement information with conflict data (ACLED) did not reveal any specific link.

The reported conflicts are mostly linked to the general unstable political situation and do not specify specific locations within the city. Nevertheless, when combined with other socio-economic information it is possible to identify future conflict potential.

The 'Land Degradation' service uses, similar to the 'Exploitation of Natural Resources' service described above, land use/ land cover information derived from EO data in combination with conflict and other socio-economic data to derive information about hot spots of politically influenced land degradation as a potential source of conflict in the future. The service was developed for two areas of interest. First, an area in central Zimbabwe south of the capital Harare, and as such linked to the area of interest for the population pressure service, and second the trans-boundary watershed of the Umbeluzi river between Swaziland and Mozambique.

The service chains included in the 'Crisis indicators' activities were able to produce relevant background information for conflict prevention, even if it was not possible to develop crisis indicators based on land use changes. This is owed to the complexity of the interactions between land use/land cover and conflict. It was aggravated by the often scarce data coverage (in particular for Kivu/DRC). Nevertheless, maps combining conflict and land use information provide an added value for decision makers at different levels. In addition, the activity demonstrated the feasibility of validation on the ground even in crisis situations. This was possible thanks to links established with local/regional entities, both governmental and NGO's.

The security domain Natural Resources and Conflicts addresses also the identification and characterisation of potential illegal activities (Illicit Mining, Timber Logging and Crops), in relation to their role in the development of conflict.

Illegal Mining. Exploitation of natural resources in most cases impacts the environment, often even spoiling natural habitats and affecting people's livelihoods. In special cases, the exploitation and trade of minerals can even fuel armed conflicts, as is the case in the East of the Democratic Republic of the Congo (DRC). The country is said to be one of the richest in the world in terms of mineral resources. Economically, however, it is one of the poorest. The lack of precise geographic information is a critical issue in the prevention of, and response to, on-going crisis situations relating to natural resource exploitation. Mining areas in the eastern DRC are often very difficult to access because they are widely dispersed, far away from road infrastructure, or regarded as unsafe. Field studies are fraught with difficulty and danger, as extremely bad road conditions hamper access and researchers studying the area run the risk of violence from rebel groups and militias. In this context, where armed conflicts and the militarisation of the mining sector have made traditional field assessments almost impossible, the use of remote sensing techniques has proven beneficial for the detection of widespread mining sites. Satellite monitoring thus provides a tool to complement field-based monitoring studies.

The pilot service for the monitoring of 'Illegal Mining' developed within G-MOSAIC provides conflict researchers with relevant information about mining areas and their surroundings, in order to contribute to focused reactions during conflicts, and to support the rapid identification of meaningful geospatial context information.

In the beginning of the project different areas of interest were defined together with the users (BICC, EEAS, Global Witness, IPIS and Resource Consulting Services). For an analysis at regional scale three large areas (spatial coverage: 2500 km^2) were identified to get an overview of the situation on the ground and to detect hot spots of mining activities, which are subsequently analysed at local scale (spatial coverage: 100 km^2). The study sites differed in landscape and topographic characteristics, in order to allow the development and testing of robust and transferable analysis approaches.

For the pilot service different product types were developed:

(1) Geographic Reference Maps, providing basic geo-information such as road and river networks and settlements,

(2) Potential Mining Maps including change detection, highlighting those areas where mining activities might be taking place and

(3) Information Dossiers providing detailed information on product generation and major results.

Within the service chain evolution several intermediate products were developed such as the phenological analysis, i.e. the use of medium resolution Earth Observation data (specifically MERIS) to detect anomalous decreases in vegetation vigour as indicators of mining activities.

For the extraction of potential mining sites a combination of semi-automatic object-based image analysis (OBIA) and further geospatial refinement was applied. The workflow was organised in two stages:

(1) a transferable feature extraction scheme for the detection of bare soil areas, indicating potential mining sites, by using very high spatial resolution satellite imagery, and

(2) further refinement after the initial classification by using relevant ancillary information (e.g. vector data such as roads, rivers and settlements) to reduce the number of false alarms.

A special focus was set on defining a classification rule set based on stable image characteristics, to ensure transferability to other natural environments and to different sensor systems.

In summary, the activities of the pilot service 'Illegal Mining' demonstrated the applicability and usability of Earth Observation techniques for supporting the monitoring and documentation of mining activities in the DRC. New developments should place an increased emphasis on in-cooperating users' feedback and further specified needs such as the provision of detailed information on the mining activities, e.g. estimation of extracted volume.

Illegal Timber Logging. The Democratic Republic of Congo (DRC) comprises the greatest extent of tropical rainforests in Africa, covering over 100 million hectares. The country has been exposed to industrial logging since the 1920s, which gradually developed until the majority of DRCs forests were under large-scale logging concessions. By the 1990s, the main cause of deforestation was industrial activity, including the extractive industries, large-scale cattle ranching, and extensive agriculture. Illegal logging is a major driver of deforestation, and the cause of severe social, economic and environmental damage. From 1990 to 2005, forest cover in the DRC decreased by nearly 3%. The United Nations estimate that at the present rate of exploitation, more than two thirds of the Congo Basin forest could be lost by 2040.

The overall scope of the pilot service 'Illegal Timber Logging' developed within G-MOSAIC is to provide information support for the surveillance and situation awareness in the field of natural resource exploitation. Emphasis was set on the evaluation of nature and extent of logging in order to support intelligence and early warning. Together with the users (BICC, EEAS, Global Witness, IPIS and Resource Consulting Services) different study areas in the provinces Bandundu, Équateur and Orientale were selected, covering industrial-scale logging in a concession and clearings for small-scale swift farming.

For the pilot service different product types were defined:

(1) Geographic Reference Maps, providing basic geo-information such as road and river networks and settlements,

(2) Timber Logging Maps, highlighting those areas where logging activities are taking place and

(3) Information Dossiers, providing detailed information on product generation and major results.

Within the service chain generation several intermediate products were developed such as the phenological analysis, i.e. the use of medium resolution Earth Observation data (specifically MERIS) to detect anomalous decreases in vegetation vigour as indicators of logging activities.

The overall methodology used for the identification of logged areas and related changes is based on both, optical and radar satellite data. Since optical radiation does not penetrate through clouds, a special emphasis was placed on the combination of optical and radar data. Radar-based analysis provides information about logged areas in a region irrespective of cloud coverage, whereas detailed information about land cover changes is obtainable using optical satellite data. Change detection based on SAR images covered pre-processing, speckle filtering and additional false alarm reduction. The detected changes flow in an information management system that is able to query changes, view changes over longer periods of time, combine changes with other geospatial information, and to help interpretation. The information extracted by using optical data was derived by means of multispectral land-cover classification and image differencing analysis. In this respect, the use of vegetation indices derived from satellite data (such as the Normalized Difference Vegetation Index, NDVI) proved to be useful in identifying vegetated and non-vegetated areas. Five types of transformation were described and mapped accordingly, i.e. seasonal variation in natural vegetation, deforestation, clearances due to the agricultural cycle, regrowth after 'slash-and-burn', and the growth of secondary forests.

To summarize, the products developed within the 'Illegal Timber Logging' pilot service, demonstrate the combination of different sensor systems and algorithms which can fulfil the requirements for the localisation and identification of logging areas. Nevertheless for a more detailed and in depth analysis, further research should include the analysis of very high resolution satellite imagery. Furthermore advanced validation in the field will support method development and evaluation.

Illicit Crops. Many countries around the world are affected by the devastating consequences of drug abuse and illicit trafficking: adverse effects on health; an upsurge in crime, violence and corruption; the draining of human, natural and financial resources that might otherwise be used for social and economic development; the destruction of individuals, families and communities; and the undermining of political, cultural, social and economic structures, as expressed in the United Nations Declaration on the Guiding Principles of Drug Demand Reduction.

The production of the poppy or opium plant was introduced in Peru some years ago. Currently, there are poppy plantations in the departments of San Martin, Amazonas, Huanuco and Cajamarca (Cortegana, one of the study areas within this service).

Colombia is the location of approximately 43% of the world's coca cultivation, although this percentage is decreasing mainly due to eradication. The majority of the cultivated area (79%) is distributed across 8 departments, one of them corresponds to a study area within this Service, Nariño. This department has the highest amount of land under coca cultivation with 24% of the total coca cultivation in the country. In contrast, the department of Antioquia represents 7% of the 2009 total coca cultivation in Colombia.

The core products developed during the G-MOSAIC project are:

-Potential areas of coca cultivation maps (Colombia) using optical or radar data, which provides indicative locations of potential coca plantations.

-Potential areas of poppy cultivation maps (Peru) using optical data, which provides indicative locations of potential poppy plantations.

-Mature Coca Index (MCI) using optical data is an index expressing the extent of mature coca plants on the ground.

-Phenological analysis, detecting anomalous decreases in vegetation vigour as an indicator of illegal activities.

The potential areas of coca cultivation maps are produced using Very High Resolution (VHR) optical data, for Antioquia, and High Resolution (HR) data for Surbol and Nariño East/West.

The figure below corresponds to an area of Surbol (Colombia), and it shows the potential areas of coca cultivation (in yellow colour) projected on a SPOT-4 image dated on 24th July 2010. These potential areas were extracted through a semiautomatic approach (over the SPOT-4 pansharpened image): by visual extraction of potential coca signatures; by supervised classification using the previous training signatures over the whole AOI; using photointerpretation of potential areas of coca cultivation, with the support of field data from the UNODC (user).

The potential areas of coca cultivation are produced also using radar data, as the acquisition of the optical data is strongly influenced by the high cloud coverage over the Colombian study areas, so the optical data is complemented with VHR radar data (TerraSAR-X). The changes are detected using the Multitemporal Coherence images (MTC).

The potential areas of poppy cultivation maps are produced using VHR optical data covering a surface of 198 km2. Preliminary results for the identification of potential areas of poppy cultivation have been obtained.

These potential areas were extracted through a semiautomatic approach (over a KOMPSAT-2 multispectral image):

1. Automatic object oriented segmentation of multispectral imagery;

2. Automatic removal of non-suitable segments based on spectral and textural signatures;

3. Improvement of remaining segments by interpretation with support of field data from the user.

The Mature Coca Index using optical data is based on the calculation of texture measures derived from the Grey-Level Co-occurrence Matrix (GLCM). It is calculated automatically, without need for field information, on panchromatic satellite images taking advantage of the textural differences between coca fields and forest areas.

Finally, the phenological analysis was intended to be performed over Colombian and Peruvian sites, but the production system for time series of Level 3 vegetation maps at 300m spatial resolution and processing is restricted to the areas where systematic MERIS data acquisition is available. This is principally Europe and Africa. A query was carried out using the South American AOIs but there were no MERIS data input products. A future analysis will be entirely dependent on ESA acquiring the data and loading it on to the production system.

Migration and Border Monitoring

The Security domain 'Migration and Border Monitoring' objectives could be synthesized as follows:

-identification and monitoring of main migration routes, along terrestrial border and around coastal areas of the uncontrolled flow of migrants through a monitoring of migratory routes extending from unstable countries to third countries borders

-identification of migration origin and destination country, migration routes

-develop an early-warning system in order to anticipate and monitor destabilizing mass population movements.

In particular the service chain Border Area Monitoring puts a focus on the monitoring of border regions and the observation of border crossings and related infrastructure along the borders.

All products offered by the Border Area Monitoring service aim at providing monitoring and surveillance services and to support situation awareness in border areas and in areas and/or along routes subject to migration and temporary settlement/urban extensions. The products provide a significant intelligence and decision support in order to help stakeholders involved in issues related to border control, migration and (temporary) settlements.

The service chain Monitoring Migration Routes and Settlements puts a focus on the monitoring of migration routes, settlements and population movements. This includes the observation of long range migration routes and of settlements along the routes.

All products offered by the Migration and Border Monitoring service aim at improving (partially already) existing monitoring and surveillance services and to support situation awareness in border areas and in areas and/or along routes subject to migration and temporary settlement/urban extensions. The products provide a significant intelligence and decision support in order to help stakeholders involved in issues related to border control, migration and (temporary) settlements.

For both the service chains included in the Migration and Border Monitoring security domain, the services can be offered worldwide; within GMOSAIC the focus was on Eastern Europe and Central Africa.

Users come from various domains, but mainly public, civil security and military stakeholders are addressed.

The main Science and Technology (S&T) results and foreground of the activities developed within this Security domain are as follows:

-Continuous adjustment and improvement of the services' workflows with special focus on the implementation of the appraisal's period user feedback

-Contributing to the project's use on Eastern Europe and Central Africa with selected elements of the core service chains

-Validation of products by the users and advancing the services into operations

With reference to the individual products generated some specific technical achievements are summarised hereafter:

'Border Permeability Map' (BPM) and 'extended Border Permeability Map'

The BPM provides a description of the ease with which a border can be crossed, taking into account the topography and the land cover along the border as well as the surveillance measures on site (Border guards, check points etc.)

In the extended version of the BPM additional information about the trafficability is taken into account. By using high-precision data and additional parameters such as snow cover or slope direction a more precise modelling is enabled than using only the BPM.

The BPM is produced on the basis of three different criteria / indices: 'Walk', 'Hide' and 'Secure'. These three indices characterize a site and / or a region in terms of its suitability to be passed by foot (walk), for a hiding place (hide) or for being crossed discreetly (secure). For example the BPMHide product displays the possibilities available for a migrant to hide along his way towards the border. By experience there will be more suited locations for a migrant to hide further away from inhabited and in sparsely and / or inaccessible areas. For determining the indices and finally drawing the map the following information layers are analyzed: Land cover, DEM and slope, night-lights, and population density.

Finally, the 'extended BPM' consists of a BPM plus a so-called 'Trafficability Map'. The latter is based on a trafficability analysis which aims at combining and modelling parameters that influence the ability of vehicles getting moved / driven ('speed factor' dependent on terrain conditions). The parameters considered for the trafficability analysis are terrain slope, soil type, forest density and land cover type.

'Reference map (Basic) ' and extensions 'Population density map' and 'Road network map'

These product types correspond basically to a topographic map featuring the main features on the earth's surface. Modifications have been specified with special focus on population and network: For the first the information is derived from the grid world population database and a recent land cover map. For the latter ancillary data is used to better locate roads and to better assess their accessibility. The main results of the mapping process, for example applied to the border area DR Congo /Burundi, are represented by a digital geo-database containing topographic features extracted by visual interpretation of SAR imagery and physiographic features extracted by semi-automated contour line and spot height derivation using elevation data (here SRTM DEM was used). Eventually, four maps at the scale of 1:50.000 in DIN A1 page format were created. An overview map with a scale of 1:100.00 in DIN A1 format was produced as well. Each map layout is available in two versions: One version displays the extracted features only. A second version displays the extracted features on top of the imagery used as main data source (here TerraSAR-X imagery was used). The results achieved this way are based on standard feature extraction rules (here: FACC for a scale of 1:50.000).

Change detection map (Optional plus update): the change detection product provides geospatial information about areas where changes occurred and / or about regions with ongoing activities on site. An update of the situation may be required after a certain period of time. For example, for the border area Poland/Ukraine, the change detection product is composed of a base map derived from satellite ortho-images and additional geo-spatial information in support of emergency planning for evacuation and for intervention in critical institutions. The change analysis is performed on satellite imagery acquired before and after - and ideally also during - the respective situation or event of interest. The analysis helps to identify areas where changes occurred and to provide information about on-going activities on-site (e.g. construction site progress, air- and seaport movements, vehicle movements along / close to the border etc.). The change detection has been applied to several test sites. EO data used were from optical (EROS B) and radar sensors (TerraSAR-X).

Users took a very active part in the enhancement of the Migration and Border Monitoring service chains, ideated during the LIMES project. They provided datasets, in field measurement, requirements and several inputs. At the end of the project, the Users agreed on the flexibility of the products (in particular referring to the use of border permeability and trafficability maps) and on the good level of repeatability and very high location accuracy of the reference maps provided them during the G-MOSAIC project activities.

Users highlighted the methodological shortcoming in regards to the changes in weather condition.

They made several recommendations and suggestions in order to improve the products (to use an additional annual/monthly weather condition information: the precipitation forecast, the soil moisture, etc). Finally , Users were highly interested in the analysis and they encouraged to extend the analysis with aid of additional dataset, making them more suitable to the changeable climate conditions over the whole Europe.

Nuclear and Non Proliferation Monitoring

The Nuclear and Treaties Monitoring security domain , comprises the monitoring of known Nuclear areas of the world where treaties have been established for the control of the state's nuclear activity, the dismantling of the area, etc.

Thus, the 'restricted' GMOSAIC security services dedicated to nuclear activities have been included in this topic.

This domain supports efforts for preventing and combating the proliferation of Weapons of Mass Destruction and verifying compliance with the relevant treaties. There are two services in this domain:

-Monitoring of Nuclear Decommissioning Sites, with the objective of monitoring the decommissioning of nuclear sites in order to verify compliance with nuclear non-proliferation treaties.

-Continuous Surveillance of Nuclear Facilities, with the objective of verifying that nuclear material and facilities in the selected sites are used for civil purposes, and the assessment of whether the initial declaration of material and facilities was complete and correct.

The pre-operational products developed within this security domain were based on Multitemporal Coherence Maps , interferometric analysis and change detection maps. The maturity of these products should be further improved in on-going of future GMES Security initiatives.

The two service chains has contributed to demonstrate the feasibility of SAR products from VHR SAR data to the recognition of targets when VHR optical data is not available or a more frequent monitoring is needed. New products as the MTC images are now required by image analyst to monitor nuclear areas.

More advanced SAR products and tools to improve the identification of targets in their study areas are required. Further to this, advanced tools to perform an adequate Non Proliferation analysis are needed. Although satellite imagery is an essential component, there is also other, equally important information, including collateral information obtained from Open Sources, declarations provided by member states and data acquired during on-site inspections. Therefore, it is fundamental that satellite imagery forms part of an integrated information system.

The adoption of new sensors to complement the information collected from VHR optical data should be considered. Satellite data from shortwave infrared, thermal infrared, hyperspectral contains a considerable amount of relevant information for analyzing activities on and around nuclear sites, which may not be available in optical data.

Critical Assets

The activities performed in the 'Critical Assets' Security domain are in alignment with the provisions of the European Security Strategy (ESS). Thepolicy frames accounted for service definition have been: EPCIP [COM (2006) 786, 787], EU civil protection: COM 2008/73/EC, Council Decision 2007/779/EC, and CSDP Common Security and Defence Policy (SEA).

The Strategy identifies five principal threats to European Security: international terrorism, the proliferation of weapons of mass destruction, regional conflicts, state failure and organised crime.

Specifically, in the European context, critical infrastructures are intended as the physical technology facilities, networks, services and assets that, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of citizens or the effective functioning of governments in the Member States.

Critical assets comprise a wide variety of elements, either manmade structures or natural.

Natural Critical Assets not only to extreme natural hazards leading to natural and humanitarian chaos in need of reconstruction, but also to singular geomorphological elements that, under certain circumstances can become 'critical': wells in the dry Sahel season, gullies sheltering illegal route passages, family farmlands irrigation ponds, cliffs or shallow water tables disrupting access, etc.

The catalogue of natural critical assets has been carried out by GMOSAIC team with the purpose of using those features as background reference. In other words, no environmental monitoring of natural assets or phenomena is intended when extracting natural assets features.

An example may clarify; a flood plain is considered critical and recorded as such in so far as, during the rainy season it may affect the local road network. Hence, the flood plain is thus depicted as a natural critical feature into the geodatabase. The analysis of specific flooding events or rhythms falls beyond the objectives of the service.

Man-made critical assets are widely acknowledged as objects associated with property and economic activities, generally coincident with civil engineering critical infrastructures.

Close attention should be noted upon other man-made critical assets, not always linked to civil works, such as frontiers and crowd gathering events. Overall, there is a wide coincidence between man-made critical assets and what is commonly addressed to as critical infrastructures (civil works). Quite often, natural and man-made critical assets concentrate in space giving rise to the so called critical areas, herein understood as territories where the adjacency of singular criticalities add up to greater dangers, risks, vulnerabilities and potential chained impacts.

The products offered within this Security domain are aimed at improving existing monitoring and surveillance services and support situational awareness in border areas and along routes subject to migration and temporary settlements or urban extensions.

Even if the main critical assets referred to in the normative frames mentioned above , the focus on man-made civil engineering infrastructures, the service developed within the GMOSAIC project combined natural critical assets and man-made critical assets. The perception of criticalities linked to specific assets varies across countries, time and relevance of economic activities. GMOSAIC mostly services security needs outside Europe. Critical assets are rather different in African, south American or Asian contexts to those defined for Europe or north America; differences lay in volume, concentration, maintenance, construction materials, assigned security buffers, etc. Hence, EO data analysis for critical assets monitoring in developing countries requires skilled image interpreters for feature extraction.

The countries monitored during the project duration were: Haiti (Gonaïves area and Port-Au-Prince area earthquake monitoring), Colombia (various activations for the monitoring of inundations during 2010), Chile (earthquake monitoring) , Guinea Bissau, Burundi,Democratic Republic of Congo Libya (activated within RGR mapping during the Arab spring), Bulgaria ,Russia , Poland/Ukraine .

In the context of critical assets protection, the services were intended to provide support for critical asset monitoring in two different scenarios:

-Monitoring critical assets to control and prevent possible events or actions that may threaten citizens security

-Post-crisis assessment to support follow up activities, after the detection of security breaches

During the project duration, the service was activated for 9 countries worldwide.

The core products delivered (for 20 activation sites for Critical Assets Monitoring and 7 activation sites for Geospatial support for crisis) were:

-Baseline and update maps of natural critical assets (by optical and sar images processing)

-Baseline and update maps of man-made critical assets (by optical and sar images processing)

-Change detection of critical assets (by optical and sar images processing)

-Low resolution thermal anomaly detection

G-MOSAIC has required a previously non-tested flexibility, on the side of Service Provider. End users have requested a much faster service than ever provided before, and in a variety of environments beyond any planning. For instance, the need to service ever cloud covered areas in the equator-tropical world, has tested the limits of VHR optical data, cloud masking or multi-temporal cloud-free mosaics, together with the benefits of the coordinated use of SAR data.

Yet, another lesson learnt may be catalogued under the subject of 'scale'. In this case, scale refers to the following aspects:

-The 'institutional scale' of the end user: GMOSAIC work package providing EO services for critical assets has handled requirements from international agencies as well as from national administrations. The range of requirements varies considerably but, in the context of maximizing the use of VHR EO data for security purposes, no end users should be despised as 'small users', just by the fact of not enjoying the status of a large international agency. The national demand market share for the security of national critical assets is particularly high in those geo-political areas that are consolidating democratic processes.

-The actual 'spatial scale' of the critical asset under analysis. The experience of over 20 activations handled throughout GMOSAIC shows that the spatial coverage demanded may vary from large geographic regions (e.g.: water sheds regulated by dams) to just few hundred meters occupied by the critical infrastructure at stake.

-Security domain and cross cutting aspects: Critical Assets are ever-present cross cutting elements to security, safety (and emergency response). Relevance and specificity requires individual analysis, extraction methodology, legend and GDB structure definition.

-User involvement and requirements collection: importance of large institutional end users but National end users not to be despised.

-Validation activities: the field validation has been not always carried out due to budget constraints.

-Non EO data supply: end users were not fully open to share in situ data.

-Liability and SLA: positive reception of services, but users demonstrated to be reluctant to commitments.

Crisis Management

The services provided in this Security domain aim at providing geospatial intelligence in response to crisis situations. 'Crisis' in this context refers to wars, civil conflicts or natural disasters leading to humanitarian emergencies. The services developed by G-MOSAIC in the context of crisis management and assessment address different phases of the crisis cycle:

-Planning and preparedness, responding to user needs related to a 'pre-crisis' situation. The Contingency Plan Preparation service supports planning for civil evacuations and the preparation of operational plans for strategic missions, through the provision of geo-spatial information (e.g. city maps). The service has been designed for situations of forthcoming crisis, addressing areas in which there is a need for imminent action;

-Crisis response, through the provision of information oriented towards rapid response (e.g. RGR). The service provides information on transportation networks, logistics, facilities (e.g. hospitals), critical assets and infrastructure (e.g. airports, harbours), highlighting helicopter landing areas and areas appropriate for use as population gathering sites;

-Post-conflict damage assessment and reconstruction, in order to improve the rehabilitation process, notably through the provision of change detection products.

The first phase address the needs related to situation of forthcoming crisis, in the area in which an imminent action is foreseen. The main Users are the national foreign affair ministries which are in charge of repatriating EU citizens from crisis areas outside EU lacking of embassy or a consular post, according to the EU policy concerning consular protection in third countries. In the occurrence of a crisis contingency plans are prepared and maintained in the areas of interest, providing information for planning civil evacuations and preparing strategic military interventions. A typical situation is the evacuation of EU citizens from an hazardous city, with a monitoring service of road network and some critical assets - bridges, airports, city exit-ways. This evacuation plan could be combined with a parallel military intervention for crisis management.

The services related to the Contingency Plan Preparation, within the Crisis Management security domain, represent the operational tool for crisis preparedness and can support both civilian and military interventions. During the G-MOSAIC project several products were developed and validated in strict cooperation with the Users. The geospatial information provided by the G-MOSAIC products have been used in supporting humanitarian missions, as for the Haiti earthquake, and in updating tactical cartography in those areas where map production is not available or obsolete, as for the Tyre urban map updates.

The contingency plan preparation was based on the delivery of the following products:

- Urban map, derived from an optical satellite orthoimage with geo-spatial information in support of emergency planning for evacuation and intervention for the greater city area.

- Multitemporal Coherent analysis based on SAR, false colour composite images obtained from linear combination of the SAR detected interferometric coherence of two CSK images

(GSDS 3 m) acquired in interferometric mode, including a report on the MTC Map analysis results focusing on land use/land cover changes.

- Detailed Land Cover and City Map, produced from very high resolution satellite orthophoto, IR band, 50 cm spatial resolution.

These service chain products have been provided on several areas of interest: Harare (Zimbabwe), Asmara (Eritrea), Tyre (Lebanon), Al Daraweh (Egypt), Aden (Yemen)

A test with updated City Maps extracted from VHR satellite imagery was performed on Pretoria College in Pretoria area, where the Italian football team was based on the occasion of the South Africa 2010 World Cup Championship.

The Crisis response is focused on the management and creation of information of geographic nature in the context of a crisis, in order to support the EU crisis management operation both for humanitarian aid missions and peacekeeping tasks. When the crisis takes place the issues are focused on the provisioning of enough data for decision-makers in order to make a first assessment on the delivery of people or material to the area. In the same context of crisis situation, due to a lack of knowledge of the transportation network in the moment of a crisis, plus the possible inaccessibility of the area it may be of significant importance to provide information about the possibility of movement in the area.

The RGR Service was oriented to provide operational response, however it was implemented in a Research and Development (R&D) environment.

The service evolved during the project, developing a basic portfolio adjusted to the user needs, which included the following products:

-Reference maps, including several informative layers as transportation networks, logistic facilities (hospitals and first-aid centres, security forces, fire brigades, administrative buildings, educational and sport areas, etc); critical assets and infrastructures (airports/airfields, harbours, industries, communications lines, helicopter landing areas, population gathering areas)

-Rapid damage assessment : providing qualitative estimation of the damages, spatial distribution of damaged assets and infrastructures

-Radar analysis: related to major changes (detectable regardless of weather conditions)

-Activity analysis and reporting: Interpretation / explanation of the nature of changes

-Evacuation support: Several features related to evacuation activities, such as potential helicopter landing areas and evacuation routes from gathering areas

-Critical infrastructure analysis: Airports, harbours and industrial installations, such as refineries

-Automatic change detection: Detection of changes in large areas using trained algorithms

Several activation were triggered during the project,(12 public activations, e.g. Haiti Earthquake, Lybia and Egypt unrests , with 5 in cooperation with the SAFER project).For each of these actions a number of products were delivered fulfilling the operational requirements of quality and timeliness.

From the point of view of foreground, the information itself could be reusable, but the strength of the service is its definition to respond rapidly to the specific (unpredictable) events and thereto related needs. The products have to be contextualised to the specific event. The major events triggered were. Civilian Unrest, Border Monitoring, Earthquakes, Piracy, Chemical Spill and electoral Processes

The experience gathered during the several activations carried out, contributed to demonstrate the following results:

-The service was able to respond operationally to the needs of the user.

-The products delivered by the service were fully operational and highly appreciated by the users.

-The RGR service contributed to the Research and Development (R&D) community, developing concepts of geospatial validation.

-The RGR service established the background of a cooperative and coordinated approach of rapid geospatial reporting to be developed in future iterations of this type of services.

-The RGR Service implemented protocols to keep information confidential whenever requested by the user.

-The RGR Service played an active role in coordination with other projects and service of GMES through approved (EC, REA, GMES Projects involved) guidelines for synergistic approach on complex emergencies

Finally, after a crisis a detailed analysis of the damage resulted by the crisis is needed.

Wars or civil wars have dramatic humanitarian and financial consequences to the affected countries. The damaged infrastructure (e.g. houses, streets, industry, electricity and water network), hinders the normal life for the population for a longer period even after the combat operations. The impact on the society is also through indirect damages e.g. to the normal flow of goods and services. Post-conflict situations therefore call for the assessment of damages to infrastructure and buildings. Such assessments, which are the key output of the pilot service 'Damage Assessment for Post-Conflict Situations' (DAP) supply core information for the overall assessment of the severity of a conflict and its consequences, and support needs assessment and recovery planning. On the other hand, the 'Support to Reconstruction Missions After Conflicts' (SRM) pilot service offers e.g. (1) longer-term monitoring of reconstruction operations, which allows donor agencies to ensure that funds are being correctly allocated and utilised and (2) up-to date and reliable information for the repatriation phase of refugees, the awareness of the environmental circumstances in the refugees' area of origin and potential long-term environmental impacts of the refugee/IDP camps.

In the beginning of the project different scenarios were defined together with the users from EEAS, BmEIA, and UNEP. For four areas of interest (damage assessment in Georgia and Haiti, reconstruction monitoring in Indonesia, environmental impact assessment of a refugee camp in Chad), satellite data of various time slots (before conflict, directly after conflict, sometime after conflict, i.e. data one year apart) were ordered. Two service chains were developed and applied to the different data sets. The results were analysed and compared with in-situ data if that were available to assess the quality of the service chain results. The main steps of the service chain are as follows: pre-processing of the data consists of geometric and radiometric correction.

For automatic change detection a high co-registration accuracy is needed, which can be achieved by automatic co-registration processes by now, unless the poor data quality (e.g. cloud coverage) hinders the processing. The main step is the change detection of the different time slots and the interpretation of the results. Main technique in crisis mapping is still visual (manual) interpretation of the data. Automatic methods are developed as described below. Finally, the results are presented as maps, web-based geoinformation (e.g. kml-files) and explanatory reports, where the content can be modified according to user requests. Depending on the level of detail the damage assessment maps show the extent and location of damages to buildings and infrastructure (e.g. bridges). The reconstruction monitoring maps are e.g. indicating the progress (or lack thereof) of reconstruction activities such as reconstruction of roads and houses or the environmental impact of refugee camps as well as up-to date information for repatriation mission planning etc. The reports offer brief descriptions of how to interpret the maps, used methods / data sources and a summary of major results.

During the project, new change detection methods were developed and analysed. Different approaches were followed: pixel-based as well as object-based methods on optical image data in 2D, 3D (stereo data and derived digital elevation models), 2D change detection of SAR data, as well as post-classification change detection. Some of the methods had to be discarded due to the poor accuracy of the results. Other methods led to promising results, scalability to larger areas of interest and further automation are main goals of the service development.

Further to the provision of pre-operational pilot services and products in support of GMES security activities, the G-MOSAIC project has demonstrated the long term sustainable provision of the services required by end users, by providing:

a) study of service interoperability and data exchange standards

b) study on architectural models and prototype suitable solutions for security services provision, addressing specific requirements related to confidentiality of sensitive data and information handling

c) a funding model for GMES Security Services

a)The activities related to the information exchange analysis, were aimed at maintaining a link between G-MOSAIC and the current European and international activities in interoperability and standardisation of geo-information in order to support GMES Security Services definition with state of the art knowledge on the structure of the geo-information.

This was achieved by analysing relevant standards in mapping for security purposes and led to the proposal of guidelines for the use of standards at the various interfaces of G-MOSAIC data exchange. In addition, interoperability concepts, which are relevant for the implementation in G-MOSAIC, were analyzed and recommendations were provided taking into account expressed user needs and the state of the art for building sustainable applications in view of future security services.

The work on standards for security services started with an analysis of the G-MOSAIC workflow at all levels in order to identify the different levels of information exchange and the data types that are exchanged. The focus was on the most complex exchange level service provider-service platform-user. Based on this analysis the focus was put on those services that provide access to the results of the service chains at a high level of interoperability (aiming at maximum automation of processes). After that the focus for the standards requirements was defined, a range of G-MOSAIC precursor projects funded through EU framework programs for research (e.g. OASIS, ORCHESTRA or LIMES) was screened for their interoperability proposals and standards proposed. In addition, the state-of-the art initiatives in the interoperability domain were analysed. These included international bodies like the Open Geospatial Consortium (OGC), the International Organization for Standardization (ISO), the Committee for European Standardization (CEN), the World Wide Web Consortium(W3C), the Defence Geospatial Information Working Group (DGIWG) and the Multinational Geospatial Co-production Program (MGCP), the Infrastructure for Spatial Information in Europe (INSPIRE) as well as the national bodies of the American National Geospatial Intelligence Agency (NGA) and the American National Standards Institute (ANSI).

An inventory of standards was created taking into account the relevant technology standards, information extraction and semantic standards. Criteria were defined to support the selection of standards in cases, where more than one is available for a given application. The analysis revealed that several standards are already linked or built one on another. Most important for G-MOSAIC is the link between the DGIWG, ISO and MGCP specifications. While MGCP develops to be the de-facto standard in the security domain, its specifications are limited to participating military bodies. However, MGCP is based on public ISO and DGIWG standards, which could provide the basis for producing operational interoperable and compatible vector data. This would make G-MOSAIC products compliant to products already applied by some users, which is an important aspect promoting the future use of G-MOSAIC services. Another basic prerequisite is the compliance with INSPIRE.

Having these considerations in mind, two metadata profiles were defined for G-MOSAIC. Taking into account the project lifecycle a two-step process was adopted. The G-MOSAIC light profile was defined in the first step. It addressed only the discovery of generic products through the definition of a small set of metadata that are meaningful for any product (e.g. space and time extent, keywords, etc.). Compliancy with relevant standards was considered the primary constraint for this action. In the second step, recommendations for the definition of a G-MOSAIC full profile were formulated. It is the extension of the light profile by metadata for product-specific discovery and addresses also the evaluation and use of products.

The monitoring of the implementation of the standards in G-MOSAIC provided important information on the current practice and showed potential for future service developments. It revealed that the services are mostly using standard formats for vector and raster data (e.g. ESRI Shape Files and KML for vector, Geo-TIFF for raster data). Furthermore, the results of the survey showed a gap between these formats and the formats supported by the service dissemination platform. The data access and discovery is OGC compliant. Thematic mapping standards remain an issue, also for future GMES security services, as some users require compliancy to standards like MGCP to guarantee the integration of products in their workflows. However, in case of mixed user communities (military and NGO's), a case by case implementation might be an appropriate solution. Most G-MOSAIC users did not specify a request for MGCP compliant products and this standard does not provide relevant features for all services. One solution could be to agree on basic features which are used by all services such as roads, administrative units, rivers, etc. and to define those according to MGCP.

The second part of this activity analysed the interoperability concepts of the service architecture for security in close loop with both the work on standards as well as with the developers of the G-MOSAIC common portal. The analysis of existing interoperability concepts and the standards revealed that some are essential to reach a minimum level of interoperability. Others instead would significantly increase the level of interoperability and should be taken into consideration in particular for future operational GMES security services.

Based on the interoperability analysis a series of technical standards were proposed. For product delivery these are File Transfer Protocol (FTP) and the encrypted secure FTP (SFTP). For exchange of small amounts of data or when strong rules for the network security apply, the Message Transmission Optimization Mechanism (MTOM) can be used. Also email can be considered, in particular when interacting with users and sending limited amounts of data. Web-based Distributed Authoring and Versioning (WebDav) allows having a strong integration in a client application and allows sharing a storage area for any kind of data between users.

For the data access, the use of the OGC standards (WMS, WFS and WCS) for exchanging data is mandatory. To optimise the visualisation of data we recommend the use of JPEG2000 with JPIP, which allows to visualize data as soon as possible and when data need to be transferred using a low bandwidth.

In view of future security services we recommend the installation of Sensor Web Enablement (SWE) for managing in-situ sensors in a standardized way in order to allow data mining between EO data and non-EO data. Implementing SWE would increase the level of interoperability and improve the performance of services as it would increase the automation of processes inside each service.

The service discovery should handle both services and data products. We recommend CSW as minimum requirement the catalogue allows managing metadata for web services but also metadata for data products.

Two deployments are possible in a Service Oriented Architecture (SOA): the first one, where all services are hosted in each service platform and into the common portal, and the second one, where all core services can be hosted in a centralized common platform of core services and used on demand (remote call) by the different components of the G-MOSAIC platform (building blocks, service chain, common portal). The main advantage of the latter is the capability to share common services and to have benefits regarding the maintenance, development, improvement and automation of the system. However, this type of deployment requests to have a well-structured and equipped community.

b) The G-MOSAIC architecture was made up of the following components:

-WEB-GIS interface for the service domain information and data access; the EO data provided through the GMES Data Access System were processed into the G-MOSAIC service chains and the final products published through the Common Portal, with integration of external resources (external WEB-GIS, Globe Viewer facilities/other clients at users premises, in-situ systems, etc).

-Data mining interface (based on text or geographic based) for information search and retrieve.

-SSC: performance monitoring system.

-SHG (Shattering Grid): it is able to apply, according to the access level of the user , data filtering of maps (masking or blurring of areas with confidential contents) and vectorial data (hiding attributes and generalizing features).

Furthermore, the architecture was integrated with:

-Service Platforms, specific tools not included into the Common Portal acting as web service sources for the Common Portal, exporting to it the information according the OGC WMS standard by HTTP(S) requests/responses.

-SIL (Security Interoperability Layer) which acts as a centralized security layer.

The infrastructure within the G-MOSAIC project was based on a very distributed architecture in which there was a single node of the network in each service providers' site. The architecture was designed to provide the most cost effective solution to meet the needs of the project (R&D), minimising the costs for new hardware, by building on existing infrastructure available within the partner's facilities. Indeed, concerning the security aspect, collaborative platforms assure the physical storage of service chain products in service providers' sites, and only the transfer of information on server.

This kind of distributed architecture was chosen in order to take advantage of being strategically in line with a distributed European architecture of Spatial Data Infrastructure (SDI), even though it requires increased operational cost of Hardware and Maintenance expenses over a more centralised architecture.

Moreover keeping the map products stored in service providers' facilities is a key feature in terms of security and confidentiality of data.

On the contrary, the G-MOSAIC experience showed that the concept of one node for each service provider is not easy to put into practice because it requires specific skills and capabilities on Spatial Data Infrastructure that some Service providers do not seem to have.

The future infrastructures for the security domain of GMES, should be implemented taking into account the aim of rationalising resources and costs in a view of fully operational activities, and with the objective of minimizing the potential points of failure, valuating the opportunity of a simplified Architecture with one central Node, which is considered as a more efficient and sustainable solution for a future service. Indeed, the implementation of a distributed architecture implies the increase of the complexity of security implementation and also the occurrence of informatics threats.

The G-MOSAIC architecture, can be considered as the baseline to define the evolution of a pre-operational infrastructure for the security domain of GMES.

c) The feasibility of future GMES services for security applications in the domain of EU External Actions is dependent on an accurate assessment of the costs which such services will incur, both initially (as one-off investments to set up service infrastructure) and in the longer term (as regular and recurrent costs of maintenance). Following a methodology similar to that used within BOSS4GMES to assess the service costs of the Land, Marine, Emergency Response and Atmosphere services, the G-MOSAIC project has produced a preliminary analysis of the currently disclosed costs of GMES services in the Security domain.

The assessment of the costs of the services produced during the lifetime of the project can lay the basis for the forecasting of future trends in the economic realm. Similarly to the previous work, the analysis is based on the G-MOSAIC situation: a project consortium delivering pilot services in an Research and Development (R&D) setting.

This was the first task; the identification of current costs, collectively referred to in this document as cost assessment.

With this analysis in hand, the activity was initially conceived as the locus for developing a second analysis related to the definition of long-term scenarios demonstrating the monetary impact of different service configurations. Unfortunately, this activity, referred to as the cost modelling exercise, has been hindered by the lack of cost data. Nonetheless, a second task was performed through the identification of variables that could drive future costs. In this document we refer to this task as the cost analysis activity, which identifies the key service parameters that can drive future trends in cost scenarios. Despite the availability of partners and their keen attitude towards the cost modelling activities, only few data provided during the lifetime of the G-MOSAIC project were accurate and of sufficient quality to allow for the modelling task to take place. Due to poor data quality, it has not been possible to run a proper sensitivity analysis. Such analysis is recommended in prospective future project(s), as new cost information becomes available and released by the key actors in GMES.

In order to accurately depict the service costs of the G-MOSAIC project, it was important to devise a cost template which would be intuitive for the service chain leaders and partners, as well as detailed enough to be able to perform the required analysis. Initially, the methodology was based on that used by the BOSS4GMES WP4 team, in fulfilment of the extended analysis of GMES service costs for Land, Marine, Emergencies and Atmosphere. In the G-MOSAIC project this analysis was extended in the domain of Security, and the principles were minimally revised to reflect this.

The formal development of the cost template was preceded by the production of an initial cost assessment covering only the G-MOSAIC activation for Haiti. In addressing this task, an initial template was developed which served as the starting point for the iterative development which followed, and the results were incorporated into the final analysis.

The lack of an adequate amount of information received on costs and values led to a reworking of the cost analysis template. It was deemed more important to have an idea of the cost of a product, for example, than of a Building Block or service chain. In the new template, the main difference is the requirement for estimates of effort, not monetary values. From this starting point, information from the project budget was used to deduce a monetary value for each unit of effort.

At the release of the first version of the costs deliverable, of the seven service chain leaders and 16 service chains, responses were received from five service chain leaders, partially covering eight service chains. By the end of the third round of data collection, all service chain leaders had responded, with differing amounts and quality of data.

The two key cost types considered in the cost model analysis are those that are linked to service production and delivery ('Service-linked') and those costs not associated with the delivery of a specific service, but utilised by all service chains ('Transverse'). The service-linked costs are generally variable dependent on production (although some could be fixed in an operational setting), whilst the transverse costs can be considered generally fixed (i.e. invariant to production volume).

The aim of the analysis, given the limitations, was to provide an indication of the costs of representative products and services delivered by G-MOSAIC, per activation and per product. The final figure in of approximately 1M Euros for two years of activities for consolidated cost by service chain should therefore be treated as an interim result along the path to a full cost analysis.

Some considerations may nevertheless be inferred by the status of costs. It is, for instance, interesting to underline that circa 60% of the total consolidated cost is represented by Labour Operating Costs. Non-Labour operating costs account for an additional 20%, thus making Operating Costs the most relevant in determining the Total Cost.

There are a number of methodological points, which could not be overcome in the current shortage of cost data. The use of an arithmetic mean in the calculation of FTE rates across partner groups could be improved by using a range of values (for example, one standard deviation above and below the mean), and thus producing low, middle and high estimates for the final costs. Another option would be to assume uniform FTE rates for different types of partner (commercial, academic, institutional), which whilst simplifying the methodology would distort the data somewhat with respect to the existing outliers.

Ultimately, the labour costs of service production are completely dependent on the assigned FTE rate. The benefit of separating out the effort from the cost in Euros is that it allows different totals to be calculated based on differing value of the FTE rate.

The Rapid Geospatial Reporting service is considered separately from the other service chains in this analysis. The reason for this is that within G-MOSAIC, Rapid Geospatial

Reporting is taken collectively as a service, rather than seen as a set of individual products. The analogy used by the contributing partners is that of a fire service; one cannot imagine charging for the extinguishing of individual fires. In the words of one of the consortium members:

'The RGR Service is oriented to service and not to product. The final and configuration of products is decided under the premise of the product design composed for each activation. The effort of the activation is to support the user in their needs, and for this reason the number of maps is not a trustable figure of cost. In fact, all the maps, briefing notes, tools, layers, etc., delivered to the user could be considered as one product. One composite product that represents the response of RGR Service to one particular call, one activation. The cost of this 'product' will vary highly, depending on the needs, the area and the resolution of work. '

(RGR partner, adapted from email communication)

Therefore, in G-MOSAIC, the study of costs was oriented towards viewing each activation as an indivisible unit, each comprised of multiple and differently-specified products.

The cost analysis was performed in order to derive qualitative information about cost parameters. The focus was primarily on two activations: Haiti and Costa Rica-Nicaragua. The analysis highlights the uniqueness and event-dependency of RGR activations.

Lack of data has been the major obstacle to the progress of work in this activity, owing in part to the complexity of the request and the effort required by partners to conduct retrospective assessments of effort, time and cost. In particular, had the required types of data been made available, it would have been possible to run a sensitivity analysis. For the purpose of proposing future avenues for research, the G-MOSAIC Consortium believes that this kind of analysis would bring about important insights on the economic sustainability of the security dimension of GMES.

Potential Impact:

The main results of the G-MOSAIC project relate to:

-the dissemination of the knowledge on GMES potential impact on Security related User Community and to contribute to building a political consensus on GMES Security Services

-direct involvement of users in scenarios definition, to be continuously updated based on feedback collection, in order to guarantee the integration of geo-information into their workflow and decision making process

Further improvements are needed in the consolidation of the Security Portfolio and in the definition of the operational aspects related to the service provision (e.g. Rapid Mapping activation procedures, validation activities, service level agreement and specification).

The G-MOSAIC project contributed to the GMES sustainability, by:

-assessing a sustainable provision and funding model for GMES Security Services

-studying architectural models and prototype suitable solutions for security services provision, addressing specific requirements related to confidentiality of sensitive data and information handling

-providing effective involvement of user organizations in the services/products definition and deployment

-adopting a collaborative scheme between different Service Providers inside the Service Chains

-demonstrating the maturity of security services for operational use

-establishing an effective synergy with Emergency Response Service for a seamless response to the various User requests covering both emergency and security domains

-increasing visibility of the GMES Security dimension

The dissemination strategy developed within the G-MOSAIC project is based on a set of recommendations that have been defined by the BOSS4GMES project and fine-tuned to match the specificities of the Security field as addressed by G-MOSAIC.

Some of the most relevant concepts of the communication guidelines that were used to develop the G-MOSAIC communication strategy are the following:

-It is important to increase awareness over the potential benefits of GMES applications and services and to foster support from potential GMES shareholders such as Member States, European Institutions and Agencies etc.;

-A basic and nevertheless fundamental segmentation of communication is to separately address, on the one hand, those who do not know about GMES and, on the other hand, those who are already familiar with GMES;

-A clear distinction must be made between the GMES potential shareholders (Government officials, MEPs, MPs etc.) and the real GMES end-users (i.e. General Staffs, Military Intelligence Departments, crisis centres in Ministries of Foreign Affairs, NGOs, EU and UN Agencies etc.);

-Highlight the benefits of GMES through the experience and feedback of the engaged users.

-There is a great variety of users of GMES services for Security applications; their sometimes conflicting standpoints and centres of interest must be taken into account.

These basic guidelines have been used to set up the overall communication strategy of G-MOSAIC, which has so far resulted in the following products and actions:

-GMES Services for Security applications logo

-General presentation of the G-MOSAIC project

-Brochures

-Website

-MultiMedia Presentation (MMP)

-Window on GMES

-Product portfolio

-Exhibitions and workshops

-Data sheet

The GMES Services for Security applications logo was designed with the main purpose of federating all Security-related projects under one banner. After several iterations it was decided, in accordance with the GMES Bureau, that the combination of the shield and the yellow European stars provides the clearest symbolism relating to GMES services for Security applications.

A general PowerPoint presentation of the G-MOSAIC project was developed in early 2010. The purpose of this presentation was to provide members of the consortium with a standard presentation of the project should they need to present an overview of G-MOSAIC during events and/or seminars. The presentation details the overall organisation of the project as well as the key concepts embedded in G-MOSAIC (i.e. Security domains and Service Chains).

A set of brochures have been prepared within G-MOSAIC to present both the various pilot services and the project overall. These brochures have strongly supported user engagement activities undertaken within the project itself.

The graphic charter of the multiple-page brochures was designed so as to be consistent with the official GMES graphic charter developed by the European Commission. Following the communication guidelines developed for GMES, these brochures aimed to present G-MOSAIC products through examples while avoiding complex product descriptions.

The service-specific brochures were updated three times during the course of the project (although not all service chain leaders decided to update their brochures on each occasion): in October 2010, in March 2011, and in June 2011. In the updated version the latest products, progress of Research and Development (R&D) and new activities were introduced.

The G-MOSAIC partners have tried to preserve the overall balance between text and illustrations to ease readability and facilitate the understanding of the products. Also, in order to give GMES a 'phone number', each of the brochures includes a contact point, so that potential G-MOSAIC product stakeholders can further enquire about the benefits derived from these products.

Based on the G-MOSAIC Common Portal webpage, the G-MOSAIC public website presents a taxonomy of GMES services in support of External Actions, an overview of the GMES programme, and detailed information about each of the Security service domains. Two major releases of the website have been issued; the first on June 5th, 2009, and the second on June16th, 2011.

In the second version of the website, the new taxonomy that reduced the G-MOSAIC areas of benefit from eight to six was introduced.

The site provides details at both the service domain and service chain level. Service chain brochures can be downloaded on the relevant pages, whilst a general Publications section offers the possibility to download other documents, such as the general project brochure and relevant articles from previous issues of Window on GMES. A Links page offers a selection of related sites, whilst the Team page presents the members of the consortium with links to their respective web pages. There are also sections for Press and News and the Project Calendar.

A specific MultiMedia Presentation (MMP) of GMES Services for Security applications, targeting potential shareholders as well as users, has been produced.

The MMP has been made available on the G-MOSAIC website. In addition, the MMP can be copied onto CD-ROMs so that project partners can disseminate the MMP directly to their contacts, or during events, such as the User Committee meetings of the BRIDGES project. Copies of the G-MOSAIC MMP were distributed to attendees of the GMES User Forum Preparatory Workshop on GMES Security, held in Brussels on June 19th, 2012.

In the framework of G-MOSAIC, a special issue of Window on GMES with a focus on the Security domain was published.

This edition of Window on GMES contains the following elements:

-a collection of articles, of which the overwhelming majority will be published for the first time;

-user portraits;

-success stories;

-interviews with GMES shareholders and stakeholders in the Security domain.

This issue of Window on GMES shall be disseminated to relevant targets at European and national levels as well as to NGOs and other relevant stakeholders. Dissemination shall be implemented by members of the G-MOSAIC consortium, taking advantage of their geographical distribution across Europe.

The publication is finalised, and printed with a print run of 1,500 copies in the following weeks. Dissemination of physical copies will be carried out by the BRIDGES project.

The G-MOSAIC product portfolio is a glossy 16-page promotional document designed to showcase the various products and services which G-MOSAIC has developed to corroborate a future set of services in support to EU External Actions. The portfolio consists of two sections: 'Pre-operational products' and 'Products in development'. Service chain leaders were asked to indicate in which category their products should have been placed. 'Pre-operational' products are considered to be practically ready for operational deployment, whilst the characterisation of a product as being currently 'in development' stresses the need for further Research and Development (R&D) before an operational status can be reached. The images follow show key pages from the G-MOSAIC product portfolio. 1,000 copies of the G-MOSAIC Product Portfolio have been printed and distributed to the G-MOSAIC partners for dissemination.

During the G-MOSAIC project, two project workshops were dedicated to the Security dimension of GMES. The first User Workshop organised by G-MOSAIC was held from June 23rd to 25th, 2010 at the Joint Research Centre of the European Commission in Ispra, Italy. This event targeted representatives from institutions and organisations involved in Security-related activities and was organised to foster interaction and fruitful dialogue between Security stakeholders and G-MOSAIC consortium partners and the User Community itself.

The 2nd G-MOSAIC User Workshop was held in Madrid on June 20th and 22nd, 2011, at the premises of the host organisation, the European Union Satellite Centre (EUSC). Attendees represented a range of current and potential users including EU Council entities, various UN agencies and related organisations, Member State national ministries, and national and international civil organisations. In total, 42 participants representing 30 user organisations attended the workshop, among which 4 were EU institutions or agencies.

Beginning with an introduction and welcome by Pascal Legai, Deputy Director of the EUSC, the first day provided an overview of the G-MOSAIC products and services through poster sessions and presentations from service leaders. Parallel sessions were held on the second day, providing hands-on training and practical demonstrations of services across four Security domains (Natural Resources and Conflicts, Migration and Border Monitoring, Critical Assets, Crisis Management and Assessment). Examples of products and services delivered up to now include damage assessment, trafficability and reference maps supporting EU, Member States and international (including UN) interventions in response to the earthquakes in Haiti (January 2010) and Chile (March 2010); evacuation support maps in response to the recent civil unrest in Egypt, Libya and Yemen as well as monitoring of border crossing activities on the Costa Rica-Nicaraguan border.

Several publication and dissemination activities (user trainings, conferences, flyers, presentations) have been conducted by the G-MOSAIC partners in order to identify possible synergies with other EU initiatives and disseminate the G-MOSAIC project activities and main results.

The results obtained within the Research and Development (R&D) project activities (algorithms, methodologies, products, operative workflow and services developed within the G-MOSAIC service chains, the Common Portal and Service Platform infrastructures) will be exploited in further projects aimed at bring the GMES Security Dimension towards the operational phase.

List of Websites:

http://www.gmes-gmosaic.eu