Summary of Earth Observation and Remote Sensing methods used in FP7 ImpactMin

General methods

The overall objective of ImpactMin is to develop new methods and a toolset for impact monitoring of mining operations using Earth Observations and in-situ data, it points towards a future wherein decision making is based on coordinated, comprehensive and sustained Earth Observation and information, which is the main objective of the **Global Earth Observation System of Systems (GEOSS)**. ImpactMin addressed the need of the provision of timely data and products for policy makers, thereby harmonizing observations, real- or near real-time monitoring, integration of information from in situ and airborne and satellite observation through data assimilation and models.

Project Name	**Impact monitoring of mineral resources exploitation (ImpactMin)** Ref. Num.: 244166 (FP7)
Concept & Method	The use of optical, (multi/hyperspectral, visible, near Infrared, shortwave infrared, thermal infrared), radar and geophysical data for direct measurement of environmental variables associated with mineral mining were thoroughly evaluated. Note that mainly academic and research studies were used for those compilations.
Short description	Project activities demonstrated that conventional and innovative tools could also be used for identifying and monitoring the consequences of mineral resources exploitation. Environmental assessment studies can be successfully complemented or even upgraded with state of the art and upcoming techniques. Once the different Earth Observation means will be accepted and adopted by relevant legislative instruments and the proper regulations will be in place the widespread use of the demonstrated novel tools and services can be exploited. Demo Sites: • Kristineberg (Sweden) • Rosa Montana (Romania) • Mostar Valley (Bosnia and Herzegovina) • Orenburg - Chelyabinsk (Russia)
Link	http://www.impactmin.eu/work_structure.php

Tools

In the ImpactMin project the tools means mostly "hardware" assets that consist of satellite "imagery systems" and the imagery itself, as well as airborne imaging systems and outputs. The actual imagery is the imaging sensor system output with well-defined parameters (spectral, radiometric etc. resolution). Furthermore tools are the in-situ (ground based) measurement techniques such as spectrometry and well established field data - laboratory analyses "combinations". Methods are the analysis activities that need human resources and logic for interpreting EO data and process it to (geographic) information.

<table>
<tr><td>Project Name</td><td>Impact monitoring of mineral resources exploitation (ImpactMin)
Ref. Num.: 244166 (FP7)</td></tr>
<tr><td>Methodology</td><td>Airborne hyperspectral imagery</td></tr>
<tr><td>Concept & Method</td><td>A generation of airborne sensors operating in the VIS/NIR-SWIR range of 380 - 2500 nm, provides superior spectral and spatial imaging with negligible sub-pixel distortions (smile, keystone). The advanced sensor design has an excellent spatial resolution without compromising the imaging speed and signal-to-noise ratio. The advanced performance from a light weight sensor allows integration into variety of airborne platforms, some of them even unmanned. The compact new technology is particularly designed to increase the spatial resolution of push-broom hyperspectral imagers, and works with detector arrays up to 24 mm wide in the spatial dimension. The design is optimized for operation in harsh conditions, and provides the option of a user exchangeable fore-optic.</td></tr>
<tr><td>Short description</td><td>Use of tools:
SpecIM Eagle II sensor selected for the mission because of the best performances of working in challenging conditions
Numerous areas were flown and covered over Mostar valley inclusive of Vihovici, Neretva River and Red Mud storage area
Certain areas were flown and re-flown in opposing directions to minimize the effects of glint coming from the roofs and numerous areas of pounded water
Processing method:
Raw data converted to radiance using SpecIM caligeo software: noted high radiance values because of how SpecIm expresses FWHM
Re-ran radiance through SpecTIR raw-to-radiance program and spec-cal parameters derived from LabSphere data
Radiance to reflectance done with ATCOR using 3nm atmospheric model – ATCOR overestimated NIR section, re-adjusted to 5nm model
Fixed ATCOR reflectance to Empirical Line reflectance using 1 dark (deep water), 1 bright (limestone gravel road) target and then improved using 16 other intermediate ground reflectances
Input Geometry – Orthogeorectification based on BH Geodetic</td></tr>
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	survey mesh 1:25,000 • Made vegetation index and used it to: determine vegetation stress, make vegetation mask to apply when analyzing for mineral targets • Used standard ”hourglass” processing to determine potential endmembers in the scene • Refined endmembers with the actual field data • Ran classification using MTMF/SAM/Neural composites to isolate target groups of minerals
Link	http://www.impactmin.eu/downloads/impactmin_d61.pdf

Project Name	**Impact monitoring of mineral resources exploitation (ImpactMin)** Ref. Num.: 244166 (FP7)
Methodology	**Optical satellite imagery (vegetation monitoring and status)**
Concept & Method	Vegetation monitoring A typical application of optical remote sensing and imagery analysis is to define change by estimating the land use and land patterns over large areas. The nature of the changes that can be investigated can vary considerably. One typical change is the short term land cover change that can be a result of mining activity induced pollution (e.g. acid drainage affected ecosystem degradation) and another type of change can occur due to mining area expansion. This latter can be observed over a longer period of time. The MODIS time series (1999-), SPOT Vegetation (1998-) and AVHRR extracted NDVI time series (1990–2002) can also aid various aspects of mining impacted vegetation analysis. This type of instruments has the strength of getting images very frequently (minimum one image per one day) thus seasonal variations can be detected in terms of vegetation. Although one cannot focus on local impacts but the derived data and information can sufficiently help to understand the complex affects of different impact sources (e.g. climate change and the natural “greening” of vegetated areas).
Short description	High, medium and low resolution satellite imagery and processing methods have been proposed and used for several ImpactMin demonstration sites. On the one hand the integrated handling of these imagery types proved to be useful in mapping the mining activity impacts and on the other hand some of the image sources could reveal important connections between mining and vegetated environment alterations. For temporal change detection, detection algorithms can be attributed to: i) Directly comparing different data sources (direct comparison method) ii) Comparing extracted information (post-analysis comparison method) iii) Integrating all data sources into a uniform mode. The detection elements of direct comparison method include pixel, basic image features and transformed features. The texture features and edge features are always taken as basic image features.
Link	http://www.impactmin.eu/downloads/impactmin_d61.pdf

Project Name	**Impact monitoring of mineral resources exploitation (ImpactMin)** Ref. Num.: 244166 (FP7)
Methodology	**Unmanned Aerial Systems (UAS)**
Concept & Method	Generally speaking the application of Unmanned Aerial Vehicles give the environment impact assessment a whole new dimension, because these tools are very flexible to use, easy to mobilize (react on certain issues) and thus it can be tailored to exact objective of the task (e.g. creating ultra high precision DTM). Nevertheless since there are some legislative aspects of operating UAVs "legally" (due to close-to-field activity) the use of such tools requires more advanced planning before actual surveying and data acquisition activity. For the above reasons it needs to be investigated if the purpose of the project can be achieved with already available EO data or if purpose-tailored UAS information is needed. Licensing, safety issues are just some of the aspects in UAS use for mineral resources exploitation monitoring.
Short description	Very high resolution unmanned aerial photography acquisition was prepared for several areas in the Mostar study area, including the open pit area and several sections of the Neretva River that were sampled for water quality analysis. The availability of 4 cm-resolution imagery significantly enhances our ability to interpret the much lower resolution hyperspectral and WorldView2 imagery. In addition the photo's are used to build accurate and detailed digital elevation models (DEMs), thus these data contribute significantly to the understanding of the distribution of certain soil minerals, and to evaluate the factors that play a role the geotechnical stability in the open pit area.
Link	http://www.impactmin.eu/downloads/impactmin_d61.pdf

Capacity and infrastructure building

Project Name	**Impact monitoring of mineral resources exploitation (ImpactMin)** Ref. Num.: 244166 (FP7)
Objectives	**Support of the relevant GEO tasks and GEOSS components** **SB-05-C2: Impact Monitoring System for Geo-Resource Exploration and Exploitation - Infrastructure**
Concept & Method	ImpactMin was a small scale research project and the available resources and current research infrastructure was used to the limits to achieve the goals and objectives of the project combining space-borne and in-situ capabilities coupled in many case with resource-intensive airborne surveying. The efforts were creative in using existing data and research infrastructure and the participating SMEs exploited their background efficiently to create the targeted tools and services for the benefits of monitoring the impacts of mineral resources exploitation.
Short description	The activities of the mining industry in most of the cases directly affect the environment and it is many times measuring or control the emitted pollution by law. In Europe there are strict rules apply for instance in the use of cyanide and the Mine Waste Directive (Directive 2006/21/EC(1)) prescribes requirements for the safe deposition of mining wastes. However in many non-EU European countries (e.g. Bosnia and Herzegovina) where the mining industry has great potential and in several other countries mining related activities can cause various effects on environment and human health. Earth Observation techniques that record continuous datasets over significant sized area can largely aid impact assessment studies. Geospatial modeling can reveal connections between variables in the system and bring different data sets into the right context. One of the demo sites of ImpactMin project was Karabash town in Russia, where the environment impact is so severe and the effects of the activity of the mining industry on the local population was inherent. This environment gave "excellent" opportunities for several research fields to combine available resources and techniques for instance satellite based observations and ground based air quality monitoring. There is still a great potential in establishing the correlation between environment degradation (environment impact monitoring) and human health and exposure thus making the outreach of environmental studies performed by ImpactMin consortium for other SBAs to improve health and well being for example.
Link	http://www.impactmin.eu/downloads/impactmin_d63.pdf

Project Name	**Impact monitoring of mineral resources exploitation (ImpactMin)** Ref. Num.: 244166 (FP7)
Objectives	**Support of the relevant GEO tasks and GEOSS components** **SB-05-C2: Impact Monitoring System for Geo-Resource Exploration and Exploitation – Institutions and Development: Capacity building**
Concept & Method	As many EC funded project ImpactMin has also the element of converting research knowledge (background and foreground) into a digestible scientific learning material. There are more ways of disseminating project information to more specific or to a wider audience. Smaller meeting and workshops can target focus groups to transfer project information. Since lifelong learning and e-training activities are active nowadays one effective method to share project related information is the internet-based trainings. ImpactMin had foreseen this opportunity to disseminate knowledge on environmental monitoring techniques, geo-data management and inform the wider scientific community about current framework of organizing earth observation and data sharing.
Short description	There are many initiatives that target capacity building especially in developing countries however it is evident that a simple e-based learning material can reach tens and hundreds of scientist, managers that works on the field of environmental monitoring. ImpactMin e-training showcasing how European and/or global initiatives (e.g. INSPIRE or GEOSS) coordinates the "everyday" work of scientists. The people who access(ed) the training facility can have enhanced knowledge on data sharing policies and techniques thus making them able to adopt the provided information into their daily operation, for instance appropriate standards usage. Cross border education and dissemination is very effective with the use of the internet showing also what are the short and longer term benefits of Earth Observation with appropriate case studies. Ultimately, with the deployment of the ImpactMin e-training facility and through its dissemination (via LinkedIn, via direct emails) the professionals from ImpactMin project are sharing their research methods and results with third parties across the internet. The core of the e-training is about the fundamentals of impact monitoring of mineral resources exploitation and case studies, examples are also included in order to ease the understanding of the training material.
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