Multi Scale and Multi Hazard Mapping Space based Solutions - MEMpHIS

Title	**Multi Scale and Multi Hazard Mapping Space based Solutions - MEMpHIS** Response to ITT Nº AO/1-8130/14/F/MOS
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1.0	16/12/2014	all	Creation of the document

APPLICABLE DOCUMENTS

[AD 1] Statement of Work. ESA Express Procurement "EXPRO". Disaster Risk Reduction using innovative data exploitation methods and space assets. Reference: ERAN-DTEX-EOPS-SW-14-0002

[AD 2] Request for Proposal(s) for Disaster risk reduction using innovative data exploitation methods and space assets

REFERENCE DOCUMENTS

[RD 1] Duro, J., Inglada, J., Closa, J., Adam, N. and Arnaud A., 2003. High resolution differential interferometry using time series of ERS and ENVISAT SAR data. Proceedings of the FRINGE 2003 Workshop (ESA SP-550). 1-5 December 2003, ESA/ESRIN, Frascati, Italy.

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[RD 3] Cloude S.R., "The dual polarisation entropy/alpha decomposition: a PALSAR case study", Proceedings of the POLinSAR Workshop, Frascati, Italy, 2007.

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ACRONYMS AND ABBREVIATIONS

ALTA	Altamira-Information
AOI	Area of interest
CIOP	ESA Cloud Computing Interoperability Pilots
CLS	Collecte Localisation Satellites
CNR	Consiglio Nazionale delle Ricerche
CR	Corner Reflector
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DOI	Digital Object Identifier
DInSAR	Differential InSAR
DLR	German Aerospace Center
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
ESA	European Space Agency
EO	Earth Observation
FP7	Seventh Framework Program
M	Milestones
MSMHS	Multi-Scale Multi-Hazard SAR
MT	Meetings
GBSAR	Ground Based Synthetic Aperture Radar
GIS	Geographic Information System

GNSS	Global Navigation Satellite System
GSNL	Geohazard Supersites and Natural Laboratories
IaaS	Infrastructure as a Service
ICA	Independent Component Analysis
ICT	Information and Communication Technology
IGME	Institute of Geology and Mineral Exploration
INGV	Istituto Nazionale di Geofisica e Vulcanologia
InSAR	Interferometric Synthetic Aperture Radar
ITT	Invitation To Tender
KO	Kick-Off
LIM	Landslide Inventory Map
ML	Maximum likelihood
NDVI	Normalized Differential Vegetation Index
NKUA	National and Kapodistrian University of Athens
ngEO	Next Generation User Services for Earth Observation
OGC	Open Geospatial Consortium
PCA	Principal Component Analysis
PSI	Persistent Scatterer Interferometry
RB	Baseline Report
RFP	Request For Proposal
SAR	Synthetic Aperture Radar
SPN	Stable Point Network
S1	Sentinel-1
S2	Sentinel-2
TEP	Thematic Exploitation Platform
TOPS	Terrain Observation by Progressive Scans
TP	Third Party
TPM	Third Party Mission
SoW	Statement of Work
SPOT	Satellites Pour l'Observation de la Terre
SVM	Support Vector Machine
PICSE	Procurement Innovation for Cloud Services in Europe
WBS	Work Breakdown Structure

WP	Workpackage
WPS	Web Processing Service

1. TECHNICAL PART

1.1. TECHNICAL REQUIREMENTS AND OBJECTIVES

1.1.1. Understanding of the main technical objectives of the RFP/ITT

The Contractor, having read the Statement of Work of the tender [AD 1], confirms the understanding of ESA's technical requirements and goals associated with the contract. The main objectives of the activity are summarized as follows:

- To study the widening of use of space technologies, especially EO with the contribution of cloud infrastructure, in the DRM field, notably focusing on DRR. An analysis will be carried out on the users' geo-information requirements fulfilment potential with the use of current space technologies, with the aid of real trial cases on EO data exploitation for DRM. Special focus will be put on the assessment of the benefit of cloud infrastructure in EO data processing, particularly in view of the Sentinel program, which will provide massive EO data volume.
- To propose a new innovative solution based on the latest EO data processing methods to measure ground surface displacements related to landslides and tectonic motions. These processing methods are semi-automatic and suitable to be implemented in the cloud infrastructure, and can produce measurements at different scales and over wide regions. The processing methods consider different approaches and different input data (optical and SAR data with consideration of ancillary data if available) in order to deal with different types of landslides (slow and fast moving landslides, debris flow) and different types of seismic displacements (long wavelength displacements related to tectonic motion and fast motion caused by earthquakes). Therefore the technological solution proposed will allow for the production of global and local hazard maps in order to perform a proper evaluation of the contribution of EO based solutions in DRR for local or regional authorities and organizations.
- To assess the current in-orbit capabilities concerning DRM and to outline the main features of future missions targeting DRM and specially DRR, taking into account the gap between current capabilities and derived baseline requirements regarding space technologies.

With the objective of getting meaningful project outcomes, the activities will be built up on the trial cases of two main themes: landslides and seismic hazards, which have been identified by the Contractor as relevant hazards, responsible for a significant percentage of disaster events. Additionally, landslide hazard is not yet being addressed within the current list of CEOS DRM pilot projects or in GSNL (Floods, seismic and volcanoes). The project outcome will be contained in the set of project deliverables established by ESA and described later in this document.

Aiming at achieving the mentioned main goals, the Contractor presents a competitive highly qualified consortium with the optimal balance between scientific and technical background and key users of EO data in the DRM domain. The consortium gathers wide experience in EO data processing, cloud computing for massive EO data volume processing, landslides and seismic phenomena mapping with EO data and new mission definition and design.

Project activities developed under the present contract will be divided into three different phases according to the essence of the activity:

- Phase A) Information gathering:

  A set of activities will be oriented to obtain the necessary information in order to determine what the DRM users' requirements are in terms of geo-information and what space technologies, in federation with cloud infrastructures, can do to meet those requirements. The handling of the increasing volume of EO data generated daily is one of the main challenges to come in EO community, and cloud infrastructure is seen as a potential efficient solution to cope with it. Particular effort will be dedicated to the assessment of the portability of EO processing algorithms to the cloud infrastructure. The first part of the project will be devoted to defining a board of users, in addition to those users already enrolled in the project consortium, this will allow for a wide range of potential users of the proposed solution resulting in richer feedback. These activities will be covered in the three first work-packages of the project (1000, 2000, 3000), including a users' consultation event at ESA premises.

- Phase B) Trial cases exploitation:

  Part of the project activities will be devoted to the exploitation of EO data for the two trial cases defined in the project. These activities will be developed concurrently by providers and users of space based solutions for DRM. Pilot cases will be divided into two categories: the first one will be demonstration areas where a good knowledge of the associated hazards exists and abundant ground truth and ancillary data is available. The second category will be the test sites where EO based solutions are not well established and not much additional information or former results are available. The objective over those sites will be to perform an extrapolation of the solution in order to evaluate the performances in sub-optimal conditions and to recruit users not so familiar to EO solutions. The exploitation of EO data will be carried out in the cloud infrastructure as far as possible, according to the conclusions of the analysis on this topic performed at Phase A. Work-package 4000 will be dedicated to these exploitation activities.

- Phase C) Requirements baseline for future space assets addressing DRR:

  Finally, an important set of activities will be oriented to the development of a requirements baseline for future space assets focused on DRM and especially to DRR. The requirements baseline will be obtained through the cross analysis of the user requirements and the current in-orbit capabilities, leading to the gap analysis which will generate the requirements of the future space assets oriented to DRR. This set of activities will be covered in a wide work-package (5000) with multi-disciplinary contributions.

In order to satisfy the ITT Management requirements, the Contractor will name a Project Manager with a strong scientific and technical background as well as one with wide experience in managing international projects. The Project Manager will ensure that the project activity remains on schedule and within budget while covering the scope of the project. Project Management will be carried out with compliant progress monitoring, meetings' agenda and minutes, promotion and deliverables, as described later in this document.

1.1.2. Proposed approach to reach the main technical objectives of the RFP/ITT

The proposed solution is based on the *innovative exploitation methods* of SAR and optical data processing for ground motion detection and the combined use of ancillary data to produce advanced products for landslides and seismic hazard mapping. Those maps will be generated on different scales depending on the EO data and will consider the use of Sentinel-1 and 2 data (among other sensors), therefore large volumes of data will be managed and high computational capacity will be required. The role of new ICTs will be investigated in depth and in particular how they can bring these EO-based technologies to users for DRR during the preparedness and prevention phases. To support this activity, some of the methods will be tested over cloud computing jointly with users to carry out a proper analysis of data and technology readiness. Finally, the results of the project will be analyzed for performing a baseline requirement study which will give the in-orbit feasibility analysis for the two main hazards considered. This will be the main input for the future mission's analysis which will produce recommendations for better characterization of the considered hazards in terms of current and future EO data and missions as well as proposing new acquisition concepts.

This project proposes a set of EO data processing methods and ITT solutions to produce landslides and seismic hazard maps. Four reference organizations in landslides and seismic hazards with demonstrated experience in the processing and the use of EO data and measurements will be the main actors for producing the hazard maps in the pilot test areas and for leading the user utility report. Additionally, during the first stages of the project a user board committee will be defined in agreement with ESA which will complement the user requirements and which will also take part in the trial cases demonstration examples.

Hazard mapping requires the use of a broad set of information and data for the spatio-temporal characterization of the considered phenomena. This project will provide EO solutions to analyze the benefits of space technologies for hazard mapping and in particular for landslides and seismic activity. In such a way, production of the hazard maps will be performed in two steps: first the production of EO based measurements and later on the synergic processing with ancillary data for producing the hazard mapping. Concerning the SAR data usage, the detection and characterization of the phenomena will be done in terms of their motion behavior and their land cover change. The former will be done employing PSI and offset tracking techniques while the latter will be done employing polarimetric techniques. The polarimetric approach has to be considered under a concept demonstration phase. Even though it has been extensively tested in other areas (agriculture, land cover,…) it is still under development for hazard mapping. Regarding the optical data, multi-spectral properties will be analyzed along the temporal axis under a multiple change detection approach.

The first stage of the project will compile all these processing tools and methods as well as the user needs. Depending on the information gathered from the users and on the availability of ancillary data and the capabilities of the pilot test areas the priorities will be set in order to test the different solutions and processing approaches. This will be proposed by the consortium during the WP1000 and WP2000 and it will be decided during the consultation meeting (WP3000).

1.1.2.1 SAR data Analysis

Regarding the PSI and the offset tracking analysis an innovative Multi-Scale Multi-Hazard SAR (MSMHS) processing method is proposed for the measurement of large scale ground surface displacements (like the ones originated by plate tectonics or active faults) as well as the measurement of local movements at high resolution (active slopes or groundwater subsidence). MSMHS can process and concatenate several frames of SAR data to produce large scale motion maps without any constraints on the sensor and acquisition mode used. It is important to mention that the PSI and offset tracking solution offered in this project can exploit measurements based on point targets as well as distributed scatterers-like pixels within the same stack of data. This is relevant in order to maximize the density of final measurement points over the study areas for an improved mapping of the hazards, which is extremely important when working in rural or mountainous areas.

The core of the proposed technology is based on the Stable Point Network (SPN) technique and DIAPASON which correspond to the PSI and InSAR processing chains of ALTAMIRA INFORMATION (**[RD 1]**, [RD 2]). MSMHS is based on a successive and adaptive processing from low to high spatial resolution. Large scale motion detection requires vast extension analysis which can involve a lowering of resolution when required. Therefore, a PSI and an offset tracking processing are applied to the averaged stack of interferograms. From this step, a low resolution motion map is generated where, together with large scale patterns (plate, tectonics and earthquakes motion), extensive local events can be also identified once a proper compensation of the atmospheric perturbations has been performed during the processing. In landslide classification, generally speaking two groups can be identified: active-like (long term) and event-like (rapid or debris flow, generally destructive). The former would be the most likely to be detected in this first processing step. This is mainly due to the destructive behavior of the latter. Since the useful signal is not maintained over the whole temporal period, there is a lack of displacement information in the corresponding area.

These local episodes will then be added to the general inventory (including faults and both types of landslides), created by means of ancillary data (geological map, DEM …), the optical data, SAR polarimetric data or/and based on an existing one. Afterwards, high resolution processing will be performed on those spots, paying attention to the displacement series in order to characterize large motion gradients.

Depending on the type of landslides mentioned, different temporal data coverage will be employed to calculate the motion series. The whole temporal coverage of the image stack will be employed on the active-like ones. Nevertheless, In the case of the landslide being event-like, efforts will be focused on the pre-event period, in order to identify triggering mechanisms.

SAR polarimetry (**[RD 3]**, **[RD 4]**) is a recognized tool in different remote sensing applications, such as land classification, and a very promising one in other fields as addressed in this project. Proof of that is the inclusion of polarimetric capabilities on new EO missions such as Sentinel-1 and PALSAR-2. By means of the use of polarimetric SAR images, it is possible to infer the backscattering properties of the studied area, and thus the type of land cover. By calculating and analyzing different polarimetric parameters (co-polar and cross-polar ratios, alpha and entropy parameters among others) a land cover classification can be performed on every image. Therefore, extending this to the temporal axis it can be estimated when the event takes place, as well as its extension. It is widely known that certain events cause a significant change on the surface affected such as the debris landslides, where vegetated areas are covered with rocky material. Consequently this approach can be considered complementary to the interferometric one, since it will mainly detect and characterize event-like landslides. Similarly, as mentioned, having established exactly when the event occurred, the interferometric approach can be employed in order to investigate for precursor motion.

To sum up, SAR interferometric, offset tracking and polarimetric approaches will provide (or update) diverse information about tectonic, seismic and landslide episodes. This information will include an inventory of events as well as spatial extension, motion history, event date and pre and post material type. The general workflow of the SAR data analysis previously described is depicted in Figure 1. A first level of mapping products can be generated from the measurement outputs of Figure 1 like for instance active slopes inventory maps, tectonic and seismic motion maps and large debris flow landslides mapping and damage assessment mapping. A great part of the expertise involved in this project was gained in RTD activities within different projects dedicated to landslides and seismic mapping like DORIS, SAFER and TERRAFIRMA as well as commercial services that ALTAMIRA provides for landslide detection in different areas of application (railways, highways, bridges, …)

All the exposed techniques deal with a significant amount of data, both temporal, due to the fact of working with a set of images, and spatial, as they cover vast extensions. Furthermore, certain processing steps are very demanding, such as image coregistration, image filtering and phase unwrapping, among others. In this framework, cloud computing represents an optimal tool to reduce the processing time and improve memory handling. Consequently, all SAR methodologies to be applied in the trial cases will run on a cloud computing infrastructure.

The SAR data to be employed is ERS and Envisat-ASAR, in order to generate and/or analyze an historical inventory of events, Radarsat-2 dual-pol or full-pol and Sentinel-1 dual-pol images. Additionally, ALOS-2 data will also be considered since the performances of L-band data in rural areas highly affected by temporal decorrelation are much more effective than C-band or X-band. Furthermore, by processing the same area with different wavelengths and resolutions a broad figure of performances will be provided, which is very useful for future missions and in-orbit capabilities feasibility analysis.

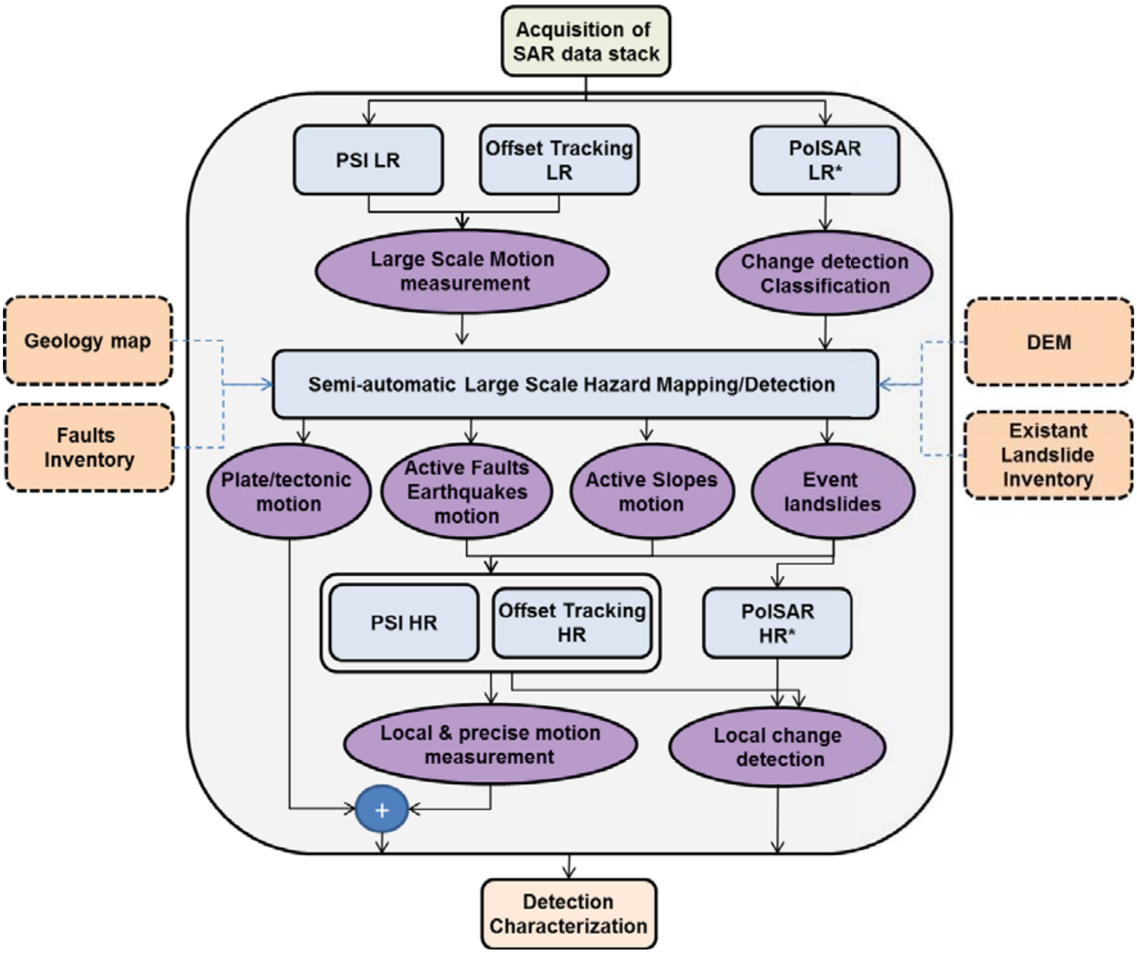

Figure 1: General scheme of the SAR data analysis.

Some examples of the PSI performances for hazard mapping are given in the following, both in the seismic and the landslide analysis frameworks. These examples show different study cases carried out by the Contractor where phenomena are characterized according to their displacement map.

The first example displayed in Figure 2 shows a wide area PSI analysis made by merging two parallel tracks of ERS1&2 for large scale displacement measurements at 20 meter resolution over north-eastern Greece. Thanks to the wide area analysis, different hazards can be mapped with InSAR derived measurements. Here, zone A and B give large scale subsidence originated by piezometric level changes of two known aquifers. Zone C shows different motion patterns over a zone with known active slopes. Finally a large scale regional tectonic displacement rate is obtained. It goes from 5 mm/year to stable values from south-east side to the center of the area. This pattern is corroborated by a significant horizontal DGPS motion up to 25 mm given by several permanent stations spread along the analyzed area.

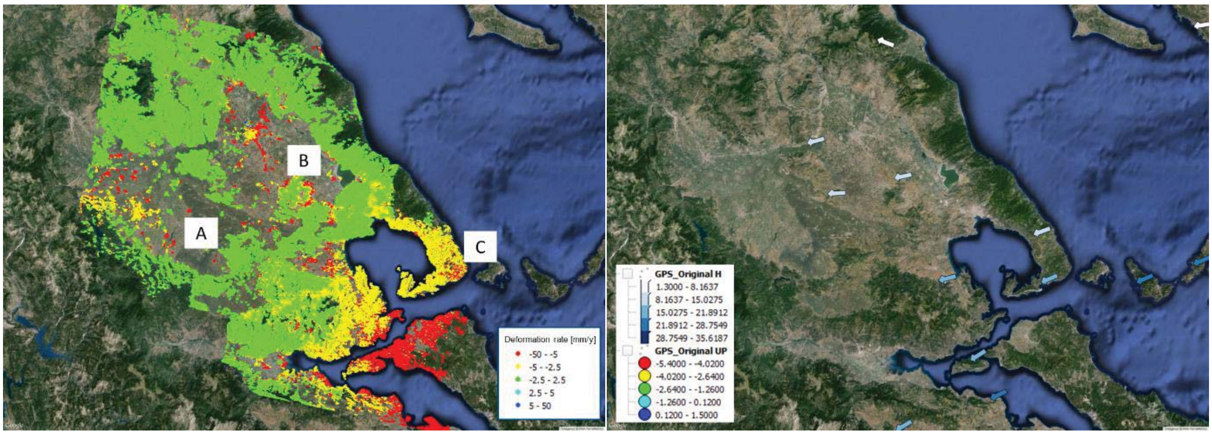

Figure 2: PSI motion map over two ERS parallel tracks on North-East of Greece (left) and DGPS horizontal motion component on several points over the area (right).

Figure 3 shows a large scale PSI processing for historical slow moving landslides identification made with ERS1/2 data at 30 meter resolution over Tena Valley in the Spanish Pyrenees. Landslides are well identified according to their motion behavior. The slow moving landslides detected by InSAR were considered when generating a Landslide inventory map over the whole valley in order. In that way the generated landslide mapping were more complete as different types of landslides were mapped (rockfall, debris, active slopes,..).

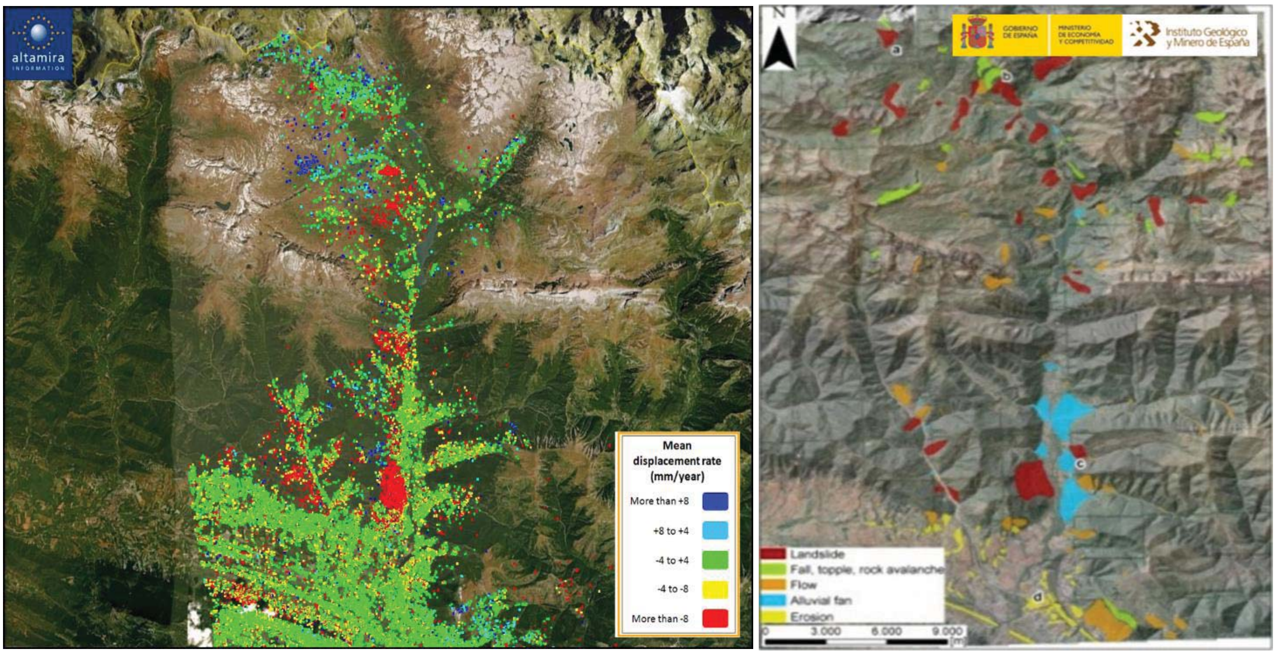

Figure 3: Mean displacement map over Tena Valley in the Spanish Pyrenees for landslides identification (left). Advanced regional landslide inventory map produced for the whole valley by the integration of the InSAR data with other data produced by Spanish IGME (right).

Another interesting study is shown in Figure 4. It represents a local and precise PSI analysis carried out with TerraSAR-X stripmap data at three meter resolution. An advanced InSAR phase filter based on non-local mean approach **[RD 5]** has been applied to increase the final density of measurement data as far as possible in order to achieve an improved characterization of the active slope. In comparison with standard phase filtering approaches (sliding box-car) the density is increased by a factor of three, allowing for a better coupling with ground data and with 3D FEM models. Within the same study, Figure 5 shows the qualitative comparison of the maximum deformation areas over an active slope detected with different technologies: the 3D FEM model, GBSAR campaign, DGPS survey and TerraSAR-X advanced processing. These have been performed within the EU FP-7 Lampre project over El Portalet area in central Spanish Pyrenees.

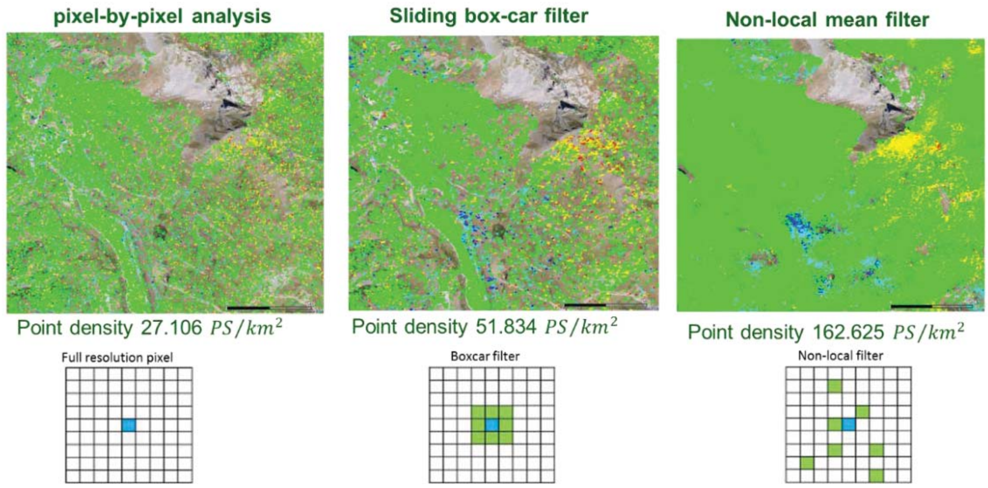

Figure 4: Motion maps over the El Portalet area (Spanish Pyrenees) employing different filtering techniques.

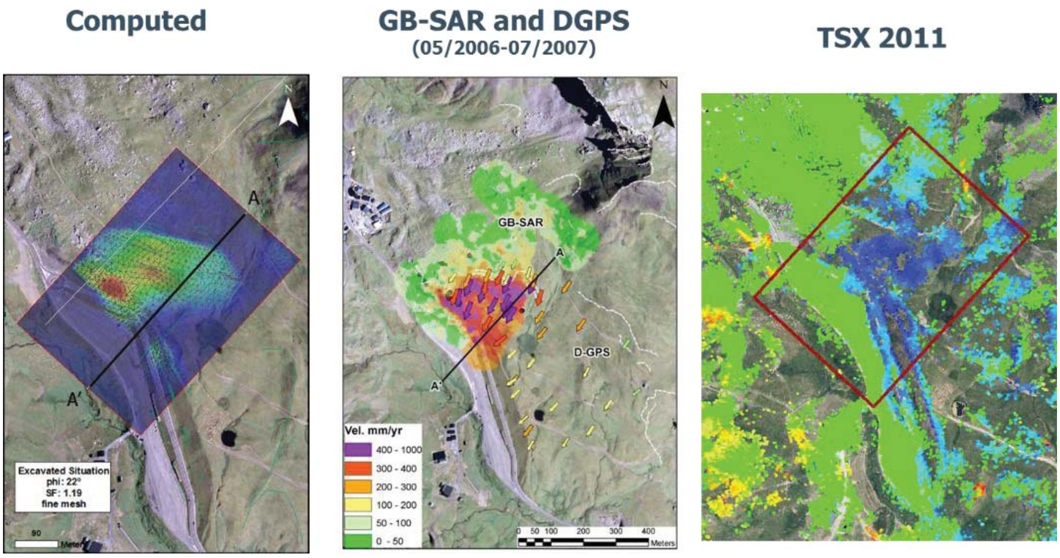

Figure 5: From left to right, 3D FEM model (provided by Spanish IGME), GBSAR campaign and DGPS survey (provided by Spanish IGME), and TerraSAR-X PSI processing motion maps over the El Portalet (Spanish Pyrenees).

It is important to mention that significant modifications must be performed on the DInSAR processing chain to work with Sentinel-1 images. In order to cover vast extensions, Sentinel-1 images are acquired in TOPS mode which overlaps different bursts in range and azimuth directions. Due to the large Doppler centroid variations within a burst, small coregistration errors can introduce severe azimuth phase ramps hiding the displacement signal on the interferogram. In order to achieve the required corregistration precision, spectral diversity techniques have to be adopted.

These modifications have already been incorporated in the contractor DInSAR processing chain, allowing the generation of sentinel-1 interferograms. Two S1 interferograms are shown in Figure 6. They correspond to the region of Emilia-Romagna (Italy) and the region of Murcia (Spain). Both are seismic affected areas.

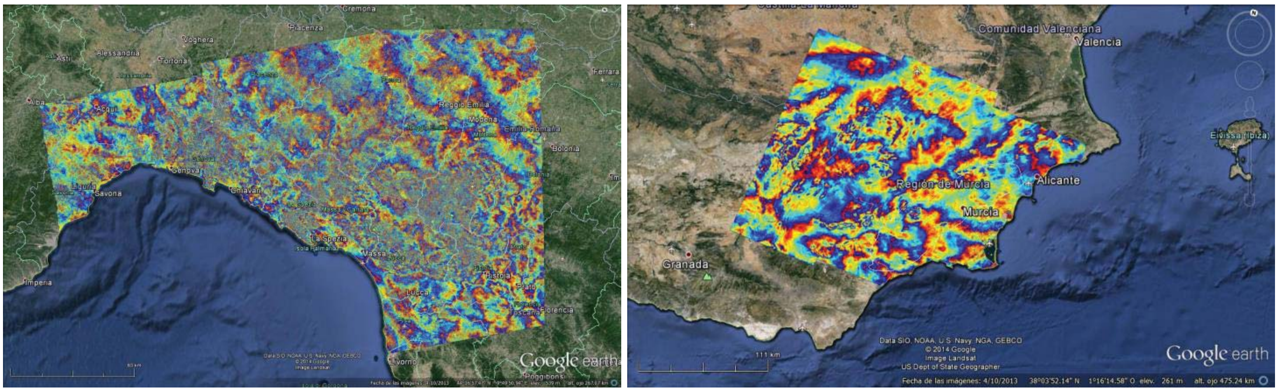

Figure 6: Sentinel-1 interferogram over (left) the Emilia-Romagna region (Italy) and (right) the Murcia region (Spain) processed by ALTAMIRA

1.1.2.2 Optical data Analysis

By exploiting the multi-spectral properties of the satellite optical images, the characteristics of the soil covers are inferred allowing its classification. Therefore, once a post event image is available, an event that has changed the land cover, including new landslides, can be detected and characterized. Traditional photo-interpretative approaches, or semi-automatic analysis can be used according to the typology of the event, and other different factors including the time requested for the production of the map, the extension of the event, and costs.

Recognition of a landslide through the visual analysis of a satellite image is an empirical process based on the expertise of an interpreter. The interpreter detects and classifies features based on the experience and on the interpretation of elements captured by the images including shapes, sizes, colors, changes of tones, mottling, textures, and pattern of objects. Stereoscopic view, when available, contributes in the interpretation through the vertical exaggeration of the terrain morphological appearance. Stereoscopic view is almost mandatory for the identification and mapping of slow moving deep seated landslides.

Supervised semi-automatic approaches for landslide mapping are based on the recognition of training areas consisting on fingerprints of characteristic elements or land cover classes, including landslides, and eventually object shapes. The recognition of these elements is mainly done through manual interpretation, or when available, through the exploitation of already available catalogued libraries of fingerprints or shapes. In case of change detection approaches, for every pair of consecutive images, metrics of changes that have occurred between the two images can be first estimated. These metrics include: change of Normalized Differential Vegetation Index (NDVI), reflectance changes, spectral angle, Principal Component Analysis (PCA) and Independent Component Analysis (ICA). Training areas are then selected on the metrics compositions. Training areas are used to drive classifiers in the recognition of portions of territory captured by the satellite images with similar statistical properties. Supervised classifiers include Maximum likelihood (ML) and other similar like Support Vector Machine (SVM) and Bayesian approaches.

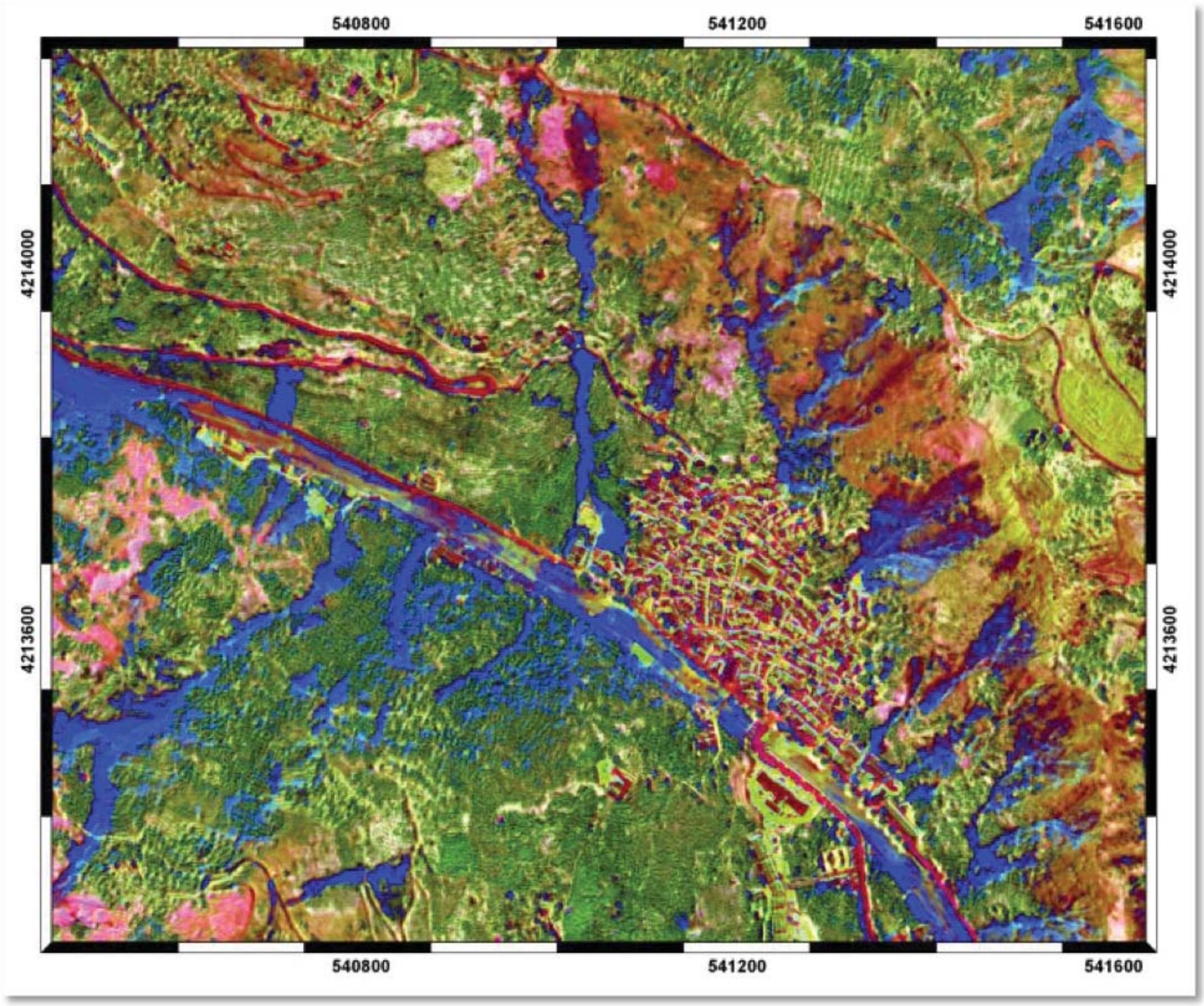

Figure 7: Multiple Change Detection indices (D-NDVI, 2-PCA, SA) composite for a pre- and post-event (Messina, October 2009) QuickBird images.

For some particular geo-environments and events, it is possible to fully automatic classify, that is without any operator action, the pre-processed images to extract clusters of pixels associated to landslides (Figure 7) [RD 6].

For both the approaches, the pre-processing of the satellite images can include pan-sharpening, geometric and radiometric corrections. Geometric corrections in particular require accurate ancillary data like DTM or DEM, and Ground control Points and a set of manual operations that can be facilitate by the use of proprietary software like ENVI or ERDAS that already ingest Rational Polynomial coefficients or sensors rigorous models for the ortho-rectification process.

While the photo interpretative approach is almost fully manual, the semi-automatic approaches benefit of a long list of routines already available in proprietary software and open source as well. Some of them like pan-sharpening, estimation of the ICA, and partially of the PCA, that must work on the entire multi-temporal scenes captured by the satellites, but more the classifiers like SVN are time consuming and, especially if done in a routinely way, can benefit the use of the cloud. An example of a Landslide Inventory Map (LIM) can be found in Figure 8.

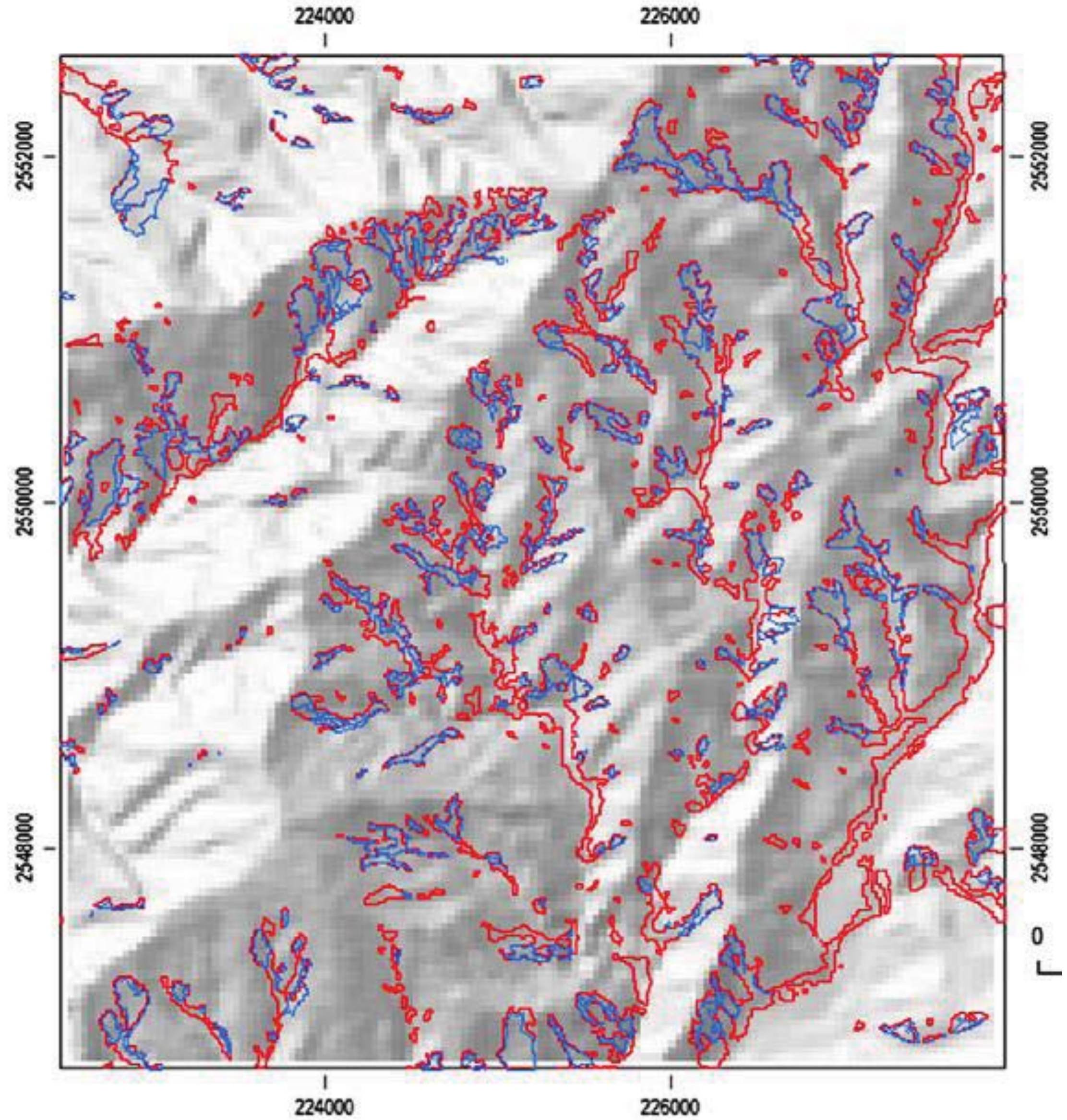

Figure 8: Landslide inventory maps: In red polygons source areas and runout features obtained through automatic classification of satellite images (unsupervised ISODATA applied to a Multiple Change Detection composition of two Formosat II), in blue landslide source areas mapped by an operator (Taiwan, Soil Water Conservation Bureau) on orthophotos. Both inventories refer to the Morakot event that struggled Taiwan in October 2009.

Summarizing, optical data exploitation will provide an inventory of landslides (Landslide Inventory Map) as well as information about its extension, event date and its pre and post material type. The general workflow of the optical data analysis is depicted in Figure 9. It is important to mention that by exploiting the temporal axis a multi-temporal LIM can be obtained, as it will be later on commented. Great part of this experience has been gained in RTD projects like LAMPRE, MORFEO and agreements between IRPI CNR national and regional authorities (i. e. National Civil Protection Department, Umbria Region Government, and Lombardia Region Government).

The optical data which has been considered to be employed is RapidEye, SPOT and Sentinel-2 images.

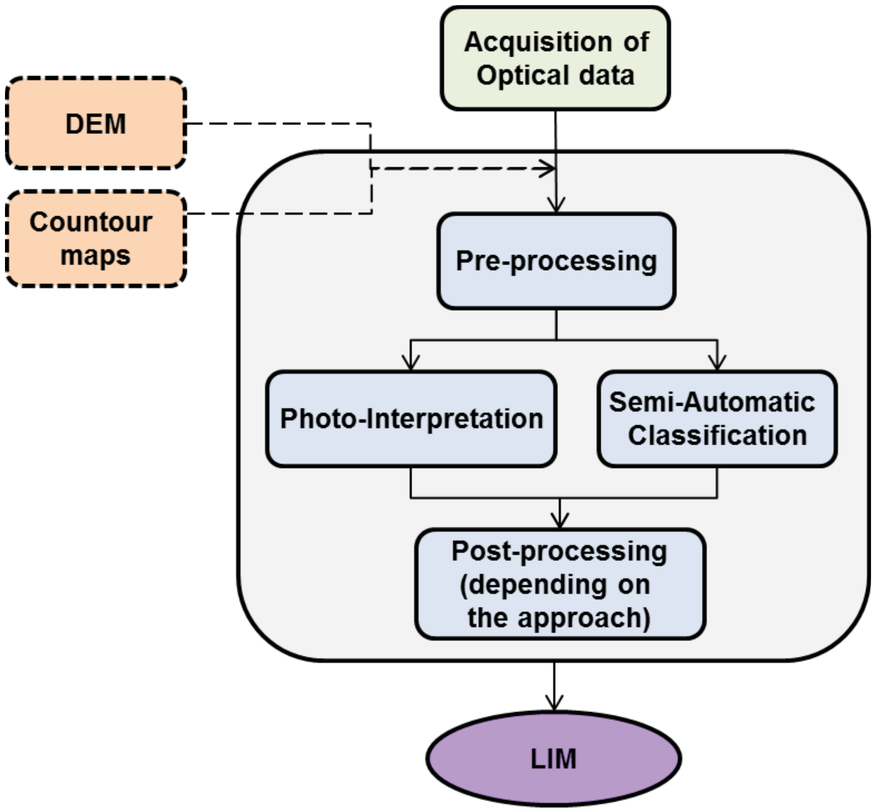

Figure 9: General scheme of the optical data analysis

1.1.2.3 Generation of hazard maps

1.1.2.3.1 Landslide hazard maps

Landslide hazard is defined as the probability of occurrence within a specified period of time, within a given area of a potentially damaging phenomenon of a given magnitude. Therefore, the hazard map will be conceived as the result of combining spatial, temporal, and magnitude information. To this matter, geomorphological and multi-temporal Landslide Inventory Maps (LIMs) are used to derive (i) a landslide susceptibility map, (ii) the temporal recurrence of landslides, and (iii) the landslide event magnitude. A geomorphological inventory map shows the cumulative effects of many landslide events over a period of tens, hundreds or thousands of years. In such maps, the age of the landslides is not differentiated, or is given in relative terms i.e., recent, old or very old. An event inventory shows landslides caused by a single trigger, such as an earthquake, rainfall event, or snowmelt event. In an event inventory the date of the landslides corresponds the date (or period) of the triggering event. By exploiting multiple sets of aerial or satellite images of different dates, multi-temporal inventory maps can be prepared. Multi-temporal inventory maps show landslides triggered by multiple events over long time spans (e.g., years to decades). Here, the date (or periods) of the landslides is attributed based on the date (or periods) of the triggers, and the date of the imagery used to compile the inventories.

The spatial probability of landslide occurrence, also known as susceptibility, is the probability that any given region will be affected by landslides, given a set of environmental conditions. Susceptibility maps are built using DEMs and derivative products (i.e. slope and curvatures), lithological, hydrological and structural data and information on land use/cover types, including spatial and temporal changes. Heuristic, statistical, deterministic models (depending on landslide type and available data) can be used to determine landslide susceptibility. Given the characteristic of susceptibility maps of predicting the probability of landslides spatial occurrence, these maps are directly used for urban and infrastructure planning.

As a first approximation, landslides can be considered as independent random point-events in time. For this reason, to evaluate the temporal recurrence probability of landslides in a study area, two probability models are commonly used to investigate the occurrence of naturally occurring random point-events in time: the Poisson model and the binomial model. The Poisson model allows for determining the probability of future landslides for different times t (i.e. for different numbers of years) based on the statistics of past landslide events, under the following assumptions: (i) the number of landslide events that occur in disjoint time intervals are independent; (ii) the probability of an event occurring in a very short time is proportional to the length of the time interval; (iii) the probability of more than one event in a short time interval is negligible; (iv) the probability distribution of the number of events is the same for all time intervals of fixed length; and (v) the mean recurrence of events will remain the same in the future as it was observed in the past. As an alternative to the Poisson model, a binomial model can be adopted. The binomial probability model is a discrete-time model consisting of the occurrence of random-point events in time. In this model, time is divided into discrete increments of equal length. Within each time increment a single point-event may or may not occur.

The probability of landslide size (magnitude information) is defined as the probability that a landslide will have an area greater or equal than a certain size, and can be estimated from the analysis of the frequency–area distribution of known landslides, obtained from landslide inventory maps. Analysis of accurate landslide inventories reveals that the abundance of landslides increases with landslide area up to a maximum value, where landslides are most frequent, and then it decays rapidly along a power law.

For the demonstration study area, where geomorphological, event based and multi-temporal inventory maps are available, as well as accurate environmental information, hazard maps will be produced. For the extrapolation site, the possibility of producing landslide hazard maps will be evaluated according to the available information and data.

At the same time, mainly from the optical data analysis (additionally from the motion series of the PSI analysis or the polarimetric analysis), the initially stated LIM can be progressively updated on every image of the stack. This temporal behavior is consequently confronted with other temporal data contained in the event model.

The global flowchart which has been described in this section is summarized and depicted in Figure 10.

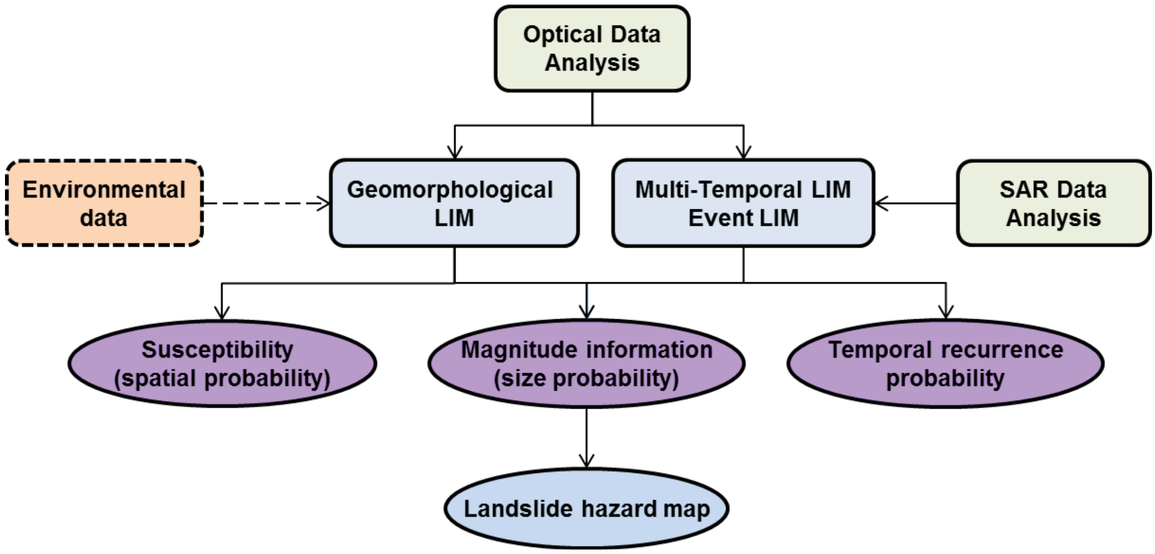

Figure 10: General scheme of the proposed methodology.

1.1.2.3.2 Seismic hazard maps

The seismic susceptibility is the inclination of a territory to be affected in a certain level by earthquake effects. Such parameter allows assessing seismic hazard in territorial planning.

The determination of the level of susceptibility is based on the integration of different data and outcomes, from the Quaternary active faults up to the induced surface effects. In particular, the activity is based on multidisciplinary studies stemming from the following issues: geomorphological characteristics leading to local responses causing relative amplification of seismic waves and/or earthquake-induced instability; litho-technical characteristics for the identification of the areas which may show homogeneous or non-homogeneous litho-technical behaviour when an earthquake occurs; InSAR time series and related velocities are the satellite based information concerning the level of slow deformation occurring all along the investigated region. Such inputs allow determining the seismic susceptibility of the study area.

The maps of seismic susceptibility are characterized by zones where specific features potentially cause amplification of the seismic response. Therefore the features responsible for earthquake induced instability are cross combined with “seismogenic features” (active faults) and with the measure of ongoing surface deformation (provided by multitemporal InSAR). The collected information can be stored by means of Geographic Information Systems (GIS) in order to obtain a “Map of seismic susceptibility”.

The global flowchart which has been described in this section is summarized and depicted in Figure 11.

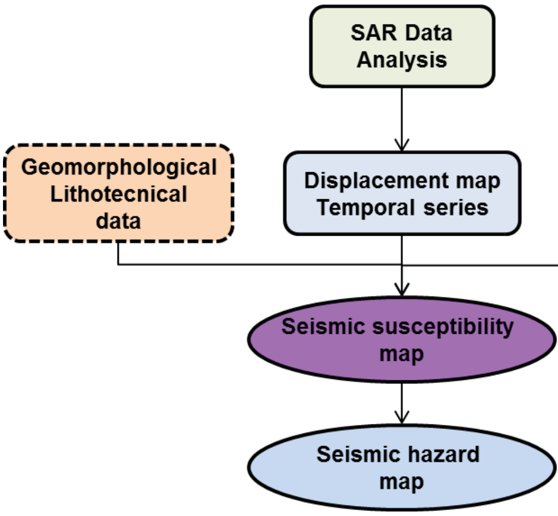

Figure 11. General scheme of the proposed methodology.

1.1.2.4 Available ICTs solutions and tests

The latest developments in Information and Communication Technology (ICT) facilitate the handling of large volumes of data and service creation and, most importantly, have started to modify the expectations that companies and institutes on new service development and support to EO data exploitation. This study will analyze how the new volumes of EO data can be integrated with data-intensive applications and how the different new ICT paradigms will define the next generation of Earth Science services dedicated to risk prevention.

In these new ICT paradigms the focus is to move the processing to where the data is and to optimize the connectivity of the data centres with new discovery and processing methods. New data exploitation capabilities brought by Cloud technologies allow the creation of enablers, helping users to access and process data on the Cloud, from their facilities. It also provides virtualized work environments and the necessary interfaces to leverage the computing resources of Cloud providers. These key features need to be analysed on the scope of supporting for collaborative development and validation of Earth Science workflows, the facilitated access to large Earth Science data repositories, as well as the publication and reuse of algorithms and processing chains to reproduce risk hazard maps or adapt them to new contexts. We need to evaluate the different opportunities for EO to move beyond data discovery bottlenecks and focus on the computational science for data intensive analysis. Among other topics the analysis will focus on how:

- The use of Infrastructure as a Service (IaaS) enables data and resource sharing, provides optimized costs and allows for a massively scalable ICT infrastructure.
- The adoption of pay-per-use models gives access to resources that users would not be able to afford on their own.
- Evaluate the "application stores" and Software as a Service (SaaS) concepts and their promotion of processing over the network, sourcing content (data) and applications (processors) from commercial or free interactive ‘stores’.

This analysis will take advantage of the extensive knowledge acquired by Terradue on the development and maintenance of the Agency's Grid Processing on Demand (G-POD) system, and the integration of scientific applications and services for the EC projects GEOWOW and SenSyF. It also considers the new assets brought by the developments of Virtual Sandbox services through the ESA Cloud Computing Interoperability Pilots (CIOP) project, the implementation of the Agency's Next Generation User Services for Earth Observation (ngEO), the data challenges platform E-CEO under ESA project, and the experience gained with integration and deployment APIs for the SuperSites Exchange Platform (SSEP) leveraged within the Helix Nebula initiative.

The GeoHazard TEP being developed by Terradue for the Agency will also provide a good potential platform for the trial cases. This project gives a first view of a thematic platform by focusing on a better understanding of seismic hazards, evolving the GEO Geohazard Supersites and Natural Laboratories (GSNL) and showcasing EO-based science products for rapid response to earthquake events. The GSNL is already supported by numerous partners including GEO, ESA, JAXA, NASA, DLR, ASI, CSA, NSF, UNAVCO and EPOS that provide several observations and measurements from different sensors. The GeoHazard TEP continues and enlarges the support of information and the scientific partners offering new tools that enable the delivery of advanced products focusing on rapid science product generation.

HELIX NEBULA

The Helix Nebula Initiative started as a Public-Private-Partnership (PPP) with the goal of evaluating the needs of European compute -intense scientific research organizations and their exploitation of a Cloud Computing Infrastructure. The aim was to define a federated Cloud Computing Infrastructure that would provide resources and agreements needed for the IT-related operations from research institutions, enterprises (incl. SMEs), governments and society at large. The basic principle is that it could be possible to establish a sustainable European cloud-computing infrastructure, supported by industrial partners, which would provide stable computing capacities and services. Through the Helix Nebula Science Cloud initiative, a partnership was established between leading IT providers and four of Europe's biggest research centres, CERN, EMBL, ESA and PIC that deployed and tested the infrastructure.

Initially the PPP Helix Nebula members provided manpower, know-how and/or in-kind (data, communities, tools, etc.) resources to enable this ecosystem to be created. The European Commission strongly supported the Helix Nebula initiative, considered as a forerunner of the forthcoming Integrated Cloud Computing Strategy for the European Union. The European Commission participated to its funding with a two-year (2012-2014) FP7 Support Action project oriented at the framework and the dissemination activities.

Terradue was one the Helix Nebula early adopters. Through an ESA contract, Terradue supported the Agency in the development of an Earth observation flagship project focusing on earthquake and volcano research. The SuperSites Exploitation Platform (SSEP) developments contributed by Terradue comprised an instance of an exploitation platform for radar imagery in the context of geo-hazards, for the sharing of SAR data and the exploitation of interferometry processing on those data. The SSEP project brought together existing software components and EO data allowing geo-hazard scientists to apply their algorithms and tools to analyse the data.

The SSEP flagship use case enabled Helix Nebula to mature its federated Cloud architecture, and ultimately served as a template to bring the same benefits to other suitable projects. It allowed the Agency to analyse the feasibility and benefits of cloud deployments and broke new ground that ultimately lead the way to the development of the *Thematic Exploitation Platform* initiatives.

With the closure of the EC FP7 support action funding, Helix Nebula now directs its focus in two parallel initiatives: PICSE and HNX MarketPlace. The PICSE (Procurement Innovation for Cloud Services in Europe) is an EC H2020 funded project focused on facilitating the procurement of cloud services for the public sector. Its overall goal is to establish a *European Procurers' Platform* that assists the procurement of cloud services based on a set of procurement use cases from the science domain. This initiative is of extreme importance for this project (in particular for Task 2) because it aggregates information about procurers, cloud services market and implications of on-going work under the European cloud computing strategy.

Conversely, the HNX MarketPlace is focussed on the federated cloud and brokering technology to deliver large-scale access to a range of commercial Cloud Services. From the experience gained on the CERN, EMBL and ESA flagship applications, the new born HNX MarketPlace will allow user communities access to a pool of resources made available by cloud providers. This federated European Cloud Marketplace service is supported by European Cloud Providers and will integrate existing e-Infrastructures (e.g. EGI and GÉANT) to form a hybrid cloud. Its governance is under discussion with a major milestone occurring on November 26-27th (http://www.helix-nebula.eu/events/helix-nebula-initiative-5th-general-assembly-picse-event-26-27-november-2014-esaesrin). HNX will allow cloud providers to participate competitively in line with European regulations and with a suitable quality of service. Likewise, during the activities of Task 2, this initiative will be evaluated and assessed in order to understand how it would support the different DRR scenarios.

Terradue Cloud Platform

The Terradue Cloud Platform will present a solution for hosting services and access to large data flows defined by the trial cases. This infrastructure has the flexibility and elasticity to scale up and/or scale down the resource requirements (computing, storage and network) as the number of users, services and data collections increases and/or decreases in response to demand. Based on Cloud computing, in which application can be integrated using “virtual machines” with their own specifications (disk size, processor speed, operating system and so on) it can run on a shared private (physical deployment over local hardware) or commercial Cloud infrastructure (IaaS).

The Developer Cloud Sandbox service from Terradue will help develop and deploy trial cases with new Earth Observation services requiring a wide variety of data sources. The use of Infrastructure-as-a-Service (IaaS) will enable data and resource sharing guarantees, optimized costs and allows for massively scalable ICT infrastructure. By presenting a common environment the trail cases can be developed, deployed and evolved. The cloud sandboxes components support the full life cycle of the hosted data and processing services by:

- Providing a development platform – give access to a development platform to implement and test applications on a stable environment identical to the application exploitation phase using computing resources provided by infrastructure;
- Providing a Continuous Integration and Delivery service cycle using GitHub for open or private source versioning, Travis as Continuous Integration for Open Source projects and Jenkins for private source projects and Puppet for Configuration management;
- Providing access to EO data – support the discovery and access to EO data by linking processors with specific collections or product types guaranteeing the individual access at product level supporting data caching and original data provider policy
- Providing application management – includes application management tools to keep track of changes, development, versioning, application integration and floating licensing (e.g. IDL);
- Providing parallel processing – provides parallel processing capabilities during exploitation phase with high level of configurability.

- Providing support for large-scale deployment – once processor fully integrated and successfully tested, it is ready to scale according to the ever-growing large volumes of datasets and according to the processor needs;
- Providing a standard interface – each application can be configured to be accessible by an OGC WPS interface;
- Assigning a Digital Object Identifier (DOI) – each application gets a DOI to track the service impact in the citations. DOI are assigned and curated by CERN's ZENODO platform that provides a safe and trusted free service by providing archival and digital preservation strategies according to best practices.

GENERAL EVALUATION INDICATORS

As one of the objectives of this project, an evaluation of the exposed methodologies will be carried out as the different phases of the project progress. The idea is to establish the degree of usability through their relation with the available resources and the profile of the user.

Results from this analysis will be summarized in a table where different indicators will be measured. This will be helpful in order to describe them to a new user so they can fit them according to their needs and resources. An initial proposition considering four indicators is now done, defining them in terms of their degree of intensity. Nevertheless, these indicators may be redefined or widen as the project evolves.

Degree of Automation:

- Low: human operator dependent, Medium, High: human operator independent.

Technology Maturity:

- Low: boundary condition dependent- inaccurate methodologies, poor data disposal, Medium, High: Robust and accurate methodologies.

Cloud Computing Applicability:

- Low: non-significant increase of processing time, Medium, High: significant increase of processing time.

L1 product dependency:

- Low: Superfluous data source for L1 generation, Medium, High: Main/Important data source for L1 generation.

Before performing any user requirements survey, an initial evaluation of the proposed indicators has been done for both landslides and tectonics/seismicity frameworks just following technical considerations. These evaluations are summarized in **¡Error! No se encuentra el origen de la referencia.** and **¡Error! No se encuentra el origen de la referencia.** respectively. Once the user requirements are set during phase A, an equivalent table will be re-done considering them. That new table will be employed in order to prioritize the methods that will run on the cloud in the trial cases.

As an example, if using **¡Error! No se encuentra el origen de la referencia.** as a reference, PSI would be the first process to execute on cloud computing infrastructure in the corresponding trial case test as it presents the highest overall indicator's values.

Table 1: Methodologies indicators for landslides mapping.

Landslides	Degree of Automation	Technology Maturity	Cloud Computing Applicability	L1 product dependency
PSI	Medium/high	high	high	high
Offset Tracking	high	high	high	medium
Optical MCD	medium	medium	medium	high
Polarimetry	low	low	low	low

Table 2: Methodologies indicators for tectonics/seismicity mapping.

Tectonics Seismicity	Degree of Automation	Technology Maturity	Cloud Computing Applicability	L1 product dependency
PSI	Medium/high	medium	high	high
Offset Tracking	medium	medium	high	high
Optical MCD	low	low	medium	low
Polarimetry	low	low	low	low

1.1.2.5 Description of the trial cases tests

Two different levels of trial cases have been planned for the exploitation phase of the project depending on the level of maturity of the use of EO data:

- Demonstration: These are first level full capabilities test sites, deeply analyzed and with an entire set of quality (good spatial resolution, multi-sensor, multi-temporal,…) ancillary data available. The behaviour of these sites has been extensively studied with EO data playing a key role and therefore they will be used for demonstration purposes of the best that can be achieved out of the new exploitation methodology proposed. The expertise of the sites exploitation owners will be a valuable feedback for tuning the methodology as well as identifying the limitations, which will be further used in the creation of the future space assets requirements.
- Extrapolation: These are second level test sites where EO solutions are not well established and ancillary data is poor or at lower resolution. Monitoring of these test sites is not based on EO data, and therefore these test sites will provide valuable information on the benefits of the use of the exploitation methodology on general scenarios for DRM and DRR, where there is a lack of complementary information enhancing the obtained results.

Below, a description of the test sites is provided. First, the description of the two demonstration level sites is provided, and secondly the two extrapolation sites are as well presented.

1.1.2.5.1 Demonstration trial cases

Hitherto the description of the two demonstration sites is provided.

1.1.2.5.1.1 Landslides hazard mapping area

The Collazzone area extends for about 90 km2 in central Umbria, with elevations ranging from 145 m along the Tiber River flood plain to 634 m at Monte di Grutti (red polygon in Figure 12). The Montecastello di Vibio and Fratta Todina study area extends for 52 km^2, with elevations ranging from 147 m to 637 m, and is separated from the Collazzone area by the Tiber River valley (blue polygons in Figure 12).

The rock and sediment in this area include: (i) fluvial deposits along the main valley bottoms, (ii) continental gravel, sand and clay, (iii) travertine, (iv) layered sandstone and marl, and (v) thinly layered limestone. The terrain is hilly, valleys are asymmetrical, and slopes are controlled by lithology and the attitude of bedding. Annual rainfall averages 884 mm, and is most abundant in the period from September to December. Mass movements are abundant in the area, and range in type and volume from large translational slides to deep and shallow flows.

For both the study areas, five sets of color and black and white stereoscopic aerial photographs flown in 1941, 1954, 1977, 1985 and 1997 are available as printed copy. Furthermore, for the Collazzone area several monoscopic and stereoscopic satellite images are available (2009, 2010, 2013, and 2014). For the study area a geomorphological and multi-temporal landslide inventory map prepared exploiting the whole sets of aerial and satellite data, as well as several event landslide inventory maps (1997, 2004, 2005, 2010, 2013 and 2014). In the multi-temporal landslide inventory map prepared for the Montecastello di Vibio and Fratta Todina area, a total 819 landslides were mapped, ranging in size from 36m^2 to 0.99 km^2. Landslides are not uniformly distributed, showing a high spatial persistence. In the multi-temporal landslide inventory map prepared for the Collazzone area, a total 2500 landslides were mapped, ranging in size from 78 m^2 to 1.45 km^2.

Finally, a set of accurate environmental data is available, including: (i) a 10m ground resolution DEM, (ii) a land use map, (iii) lithological and geological detailed maps, (iv) structural domains map.

For these study areas, the available information allow for the preparation of accurate landslide hazard map following the schema proposed in section 1.1.2.3.1.

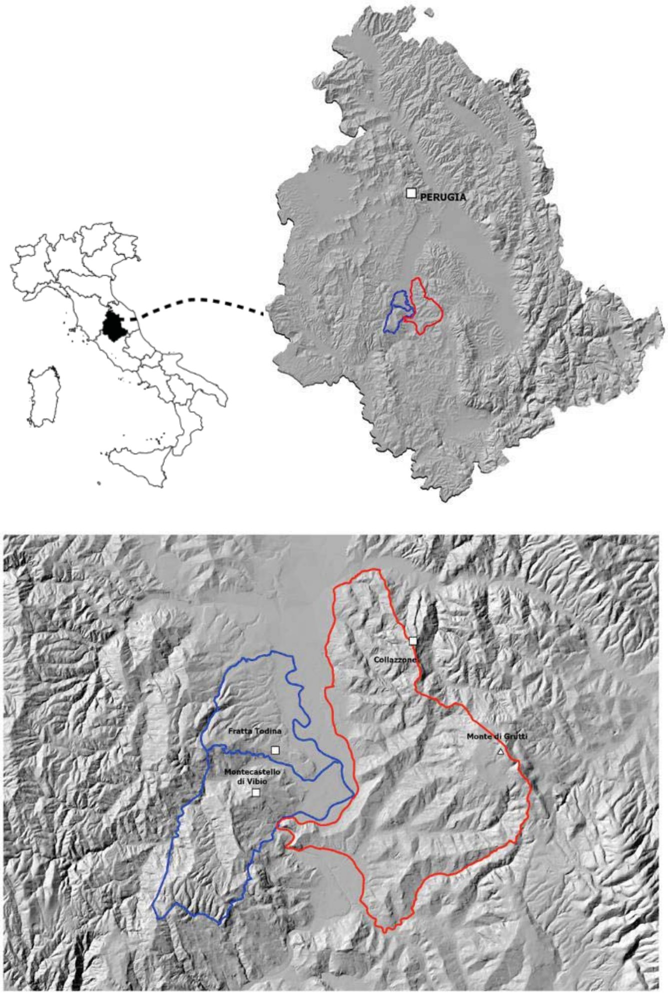

Figure 12: Landslide mapping trial area, Collazzone Central Umbria, Italy. Red polygon represents elevations ranging from 145 m along the Tiber River flood plain to 634 m at Monte di Grutti. Blue polygons represent The Montecastello di Vibio and Fratta Todina study area with elevations ranging from 147 m to 637 m.

1.1.2.5.1.2 Tectonic hazard mapping area

Crustal faults are complex natural systems whose mechanical properties evolve with time. Thus, the understanding of the multi-scale physical-chemical processes responsible for earthquakes and faulting requires considering phenomena at the boundaries between different research fields (road of integration) and the availability of long time series of high-resolution data.

With this aim we have been working for the past five years in the creation of what we called a Near Fault Observatory (NFO), consisting of a multidisciplinary research infrastructure based on state of the art observational systems continuously recording high quality data related to the underlying tectonic processes over a broad time interval. Such methodological approach based on an extremely high spatial resolution can be more easily applied at the local scale.

There are four main requirements for an area to be a suitable candidate as NFO: 1) it has to host active faults; 2) it has to be relatively small in terms of spatial scale (determined by the fault dimensions); 3) it must be characterized by a relatively high seismicity rate and 4) it has to be instrumented with multidisciplinary monitoring systems.

The area we selected as natural laboratory is located along the upper Tiber Valley within the inner sector of the northern Apennines. According to the interpretation of few hundreds of kilometers of seismic reflection profiles ([RD 7][RD 8]), the existence of a 60 km long extensional fault system active in the Quaternary and dominated at depth by an east-dipping low angle normal fault (dip 15°-25°), named Alto Tiberina Fault (ATF) ([RD 9][RD 10]), is documented in this area.

The ATF bounds the western flank of the high Tiber Quaternary basin and has accumulated a minimum time-averaged long-term slip rate of about 1-3 mm/year in the last 2 year ([RD 11],[RD 8]) without large historical events unambiguously associated with this fault. Whilst, a set of synthetic and antithetic high angle faults that generated moderate events both in historical and instrumental epoch (Figure 13 A) are located in the hanging-wall of the ATF. The NFO is devoted to the identification and understanding of the short- versus long-term deformation processes linked to the seismic and/or aseismic activity along this normal fault system. The presence of very high fluids (mostly CO2) pressure (85% of the lithostatic load) at 4-5 km of depth further motivated the deployment of this observing system.

The construction of this research infrastructure was initiated in 2009 relying on both INGV (Istituto Nazionale di Geofisica e Vulcanologia) dedicated resources and Italian and European projects funding. In order to optimize the data acquisition, the new deployed monitoring stations have been built complementarily to the existing stations of the INGV national and regional seismic and geodetic networks. The network is now totally up and running, covering a 120 × 120 km2 zone surrounding the ATF system.

A huge set of SAR data has been processed all over the ATF region. ERS 1-2 and Envisat images, either along ascending or descending path have been analysed in order to generate surface velocity maps and relative time series. Multi-temporal InSAR techniques have been used to such aim. The area has been also instrumented by a network of artificial Corner Reflectors at X-band. CRs have been deployed in proximity of GPS and seismic sites. A dataset of COSMO-SkyMed (CSK) Stripmap data covering the region has been processed spanning 2010-2013. CSK velocity maps can be scaled at the CRs in order to reduce possible orbital ramps and error noise. CSK measurements can be also compared with 3-D GPS vectors to make quantitative analysis of detected displacements.

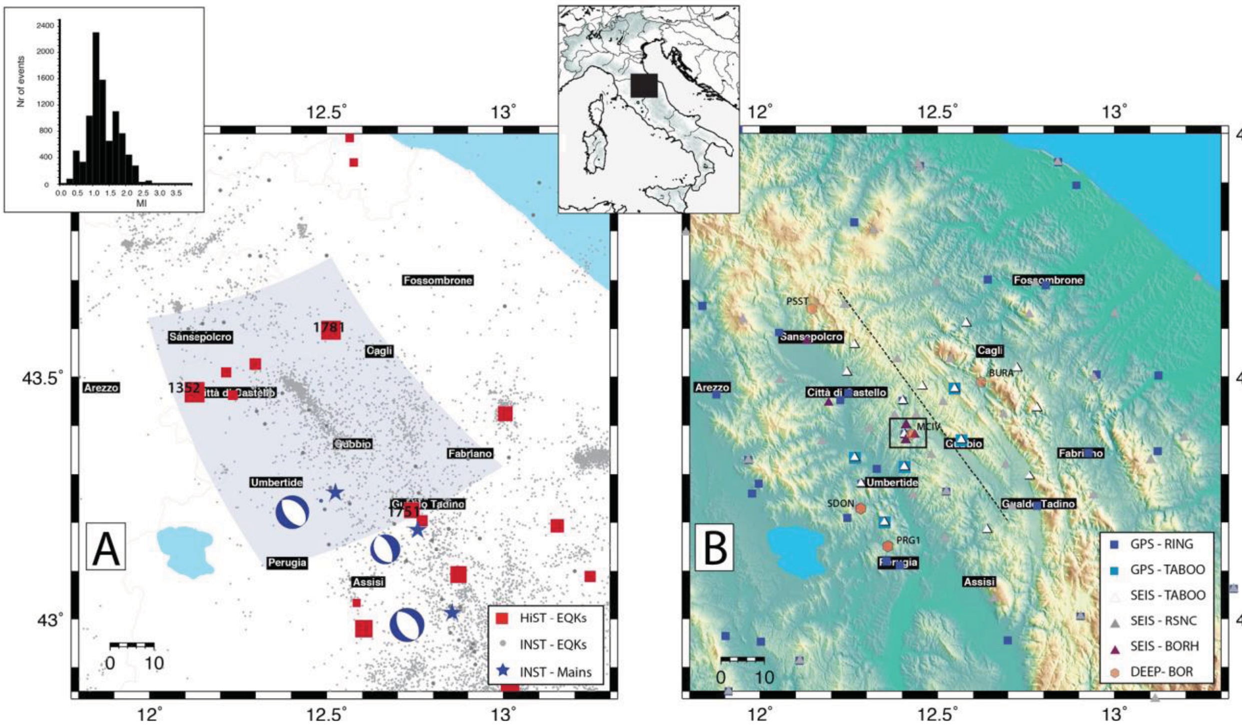

Figure 13: Map of the study area located in the inner sector of the northern Apennines (see inset on the right). (A) Largest historical and instrumental seismicity of the area. The red squares (scaled with magnitude; [RD 12] **represent the macro-seismic location of the largest events occurred in the past 1000 years. Grey points represent the epicentral location (from the catalogue of the INGV national network available at: http://iside.rm.ingv.it/iside/standard/index.jsp) of the earthquakes occurred in between 1995-2010. The inset on the left shows the magnitude distribution for this catalogue with completeness around M 1.5. The blue stars and beach balls are the locations of the largest instrumental earthquakes and focal mechanism solutions, respectively. See text for details. The light blue box represents the projection at surface of the Alto Tiberina fault plane (**[RD 8]**). (B) Map of the station distribution and location of the already existing deep boreholes.**

1.1.2.5.2 Extrapolation trial cases

Hitherto the description of the two extrapolation sites is provided.

1.1.2.5.2.1 Landslides hazard mapping area

The city of Patras, a major center of population and industry in western Greece, is the third largest city of the country. During recent years, several problems of landslides have arisen due to the expansion of urban settlement of nearby villages without taking into account the engineering geological environment. Problems are induced mainly by progressive instability phenomena of hill slopes triggered by heavy rains, especially during extreme meteorological event. Moreover, the area shows now great interest because of the expansion of the road that leads to Archaea Olympia, a well-known historical Site, the site of the Olympic Games in classical times, and the additional constructions that take place at the national highway from Athens to Patras.

Some of the greater landslides at the area are: Platanos, Panagopoula, Platani, Karya and Chimaron forest, which are all located close to the edge of Panahaikon Mountain. The study area, generally, shows unstable slopes caused by past intense tectonic action. The geological formation in the wider area belongs to the Pindos-Olonos geotectonic zone and consists of chert, schist and limestone of Triassic-Jurassic age, as well as Flysch of Eocene age, consists of fine-grained thin bedded sandstones alternating with shale, and with sporadic conglomerate lenses, in multiple folded scales formed by intense tectonic procedures. The regional area is also closely related to active faults and to still geodynamically active grabens that could also cause large earthquakes and induced landslides.

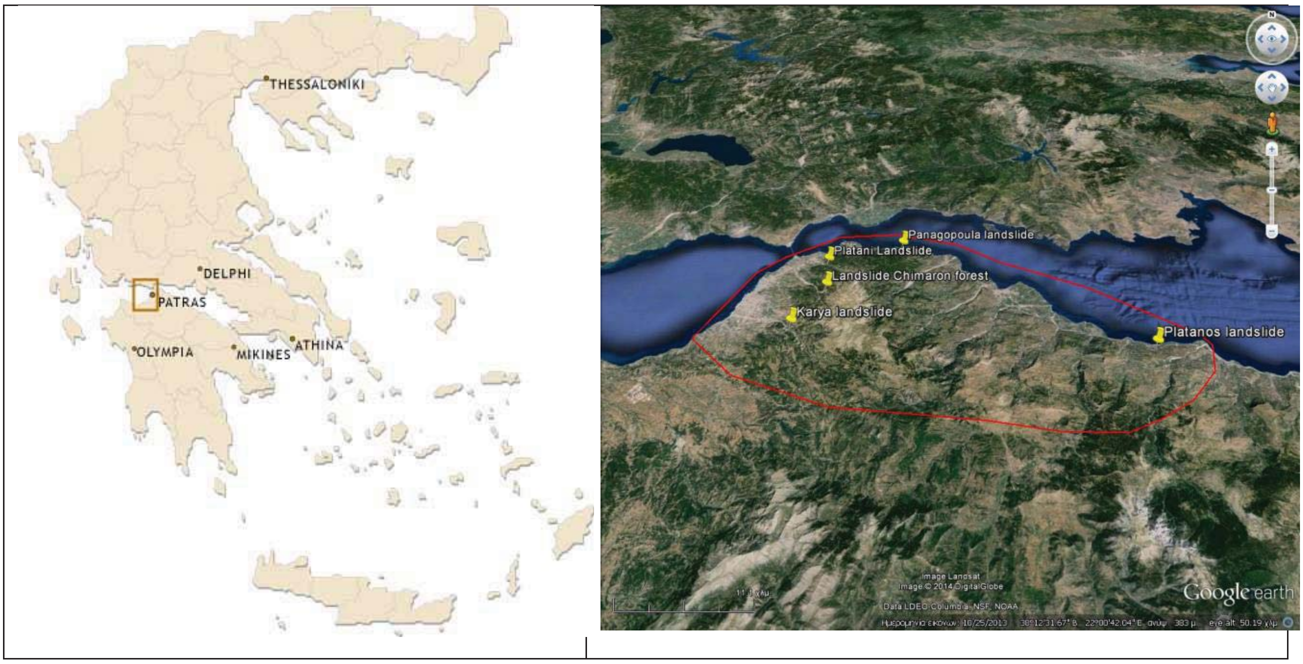

Figure 14. Study area location (left) and study area indicating major landslides.

1.1.2.5.2.2 Tectonic hazard mapping area

Cephalonia and Zakynthos lies within a seismotectonically complex area that is undergoing rapid and intense ground deformation. The area plays an important role in the kinematic processes of the Eastern Mediterranean. In particular, the Eastern Mediterranean lithosphere is being subducted beneath the Aegean lithosphere along the Hellenic Arc. The highest seismic activity in Europe currently occurs in the region of the western part of the subduction zone that includes the Central Ionian Islands of Ithaca, Cephalonia and Zakynthos Figure 15.

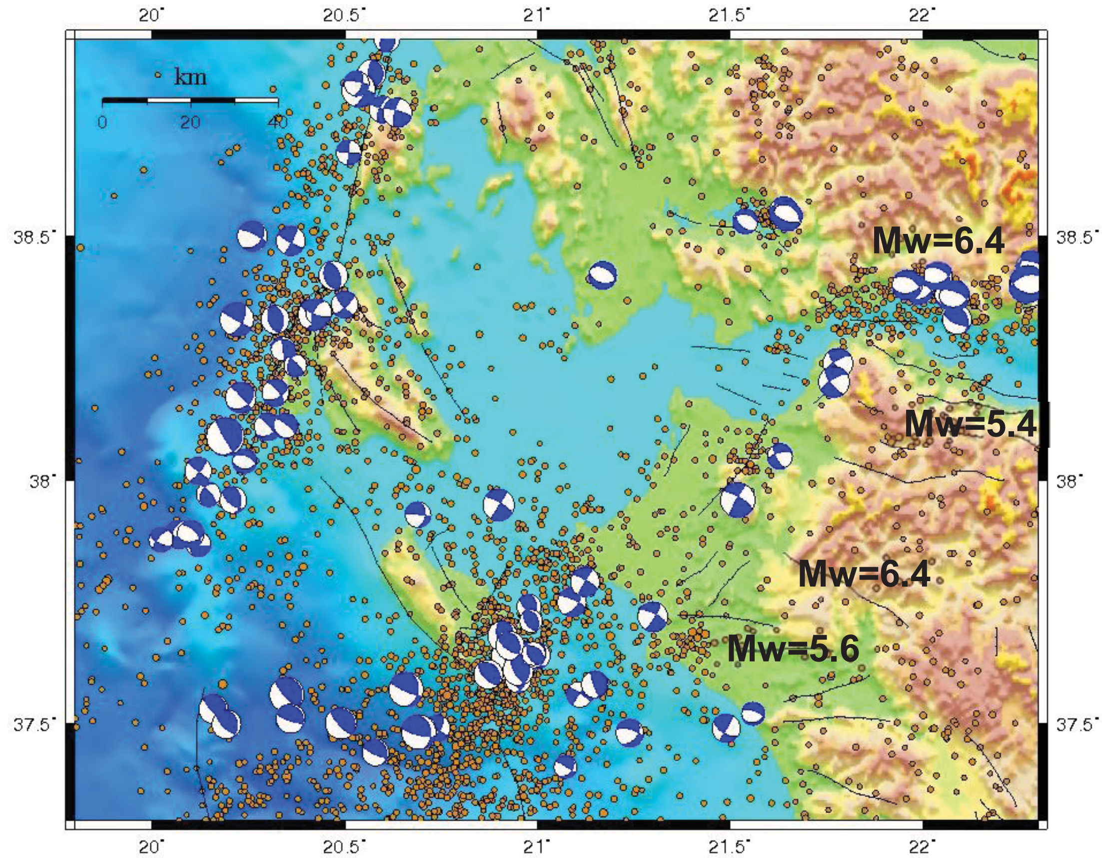

Figure 15: Seismic activity in the broader area of central Ionian Islands and Patras Gulf (1980-2013).

NKUA has established an extended GPS network in Cephalonia, Zakynthos and Ithaca islands since 2001 (Figure 16) to study the local tectonic motions and the ground deformation due to pre-, co- and post-seismic activity in the Central Ionian Islands. These networks of about 40 stations were tied up with an older GPS network (since 1994) in the broader area of Patras Gulf. Several reoccupation campaigns have been conducted since the installations of the local GPS networks, and a few differential interferograms were produced for Lefkas and Cephallonia islands ([RD 13],[RD 14]).

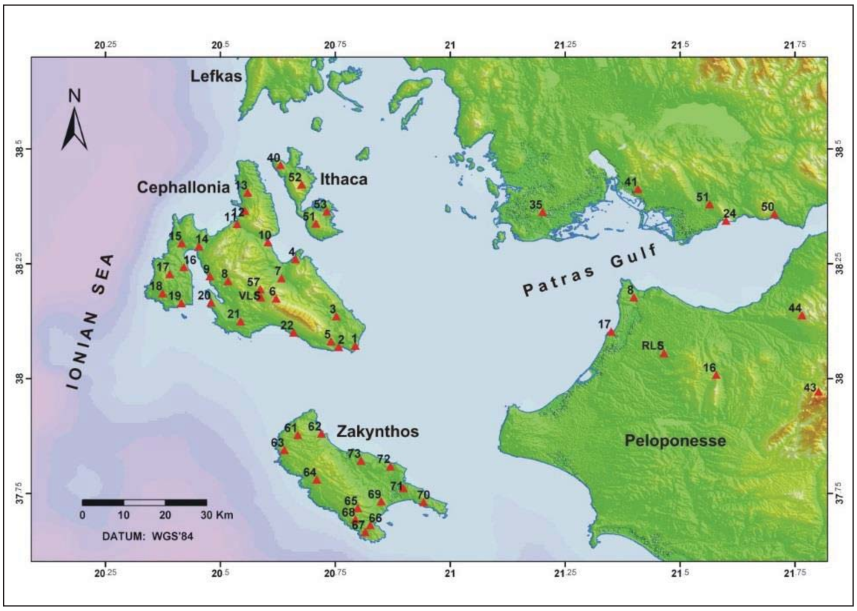

Figure 16: GPS networks in Patras Gulf, Cephalonia, Ithaca and Zakynthos Islands operated by NKUA since 2001.

All the available GPS campaign data, including continuous GPS time series from the broader area together with detailed seismological and geo-tectonic data from the area will be used to evaluate the final deformation image deduced by radar data. Modeling of the deformation vectors will be performed to approximate the observed ground deformation.

The recent earthquake sequence that took place in Cephalonia in early 2014 (Mw=6.1, Mw=5.2 and Mw=5.9) (Figure 17) will be incorporated in our study together with the associated fault modeling. Together with the application of the conventional Interferometry, the involvement of the PSI technique in the area is of important interest since it offers spatial coverage, good accuracy and periodically update of available information providing a reliable tool to accurately define and investigate the seismic hazard in the area, especially after the occurrence of the recent catastrophic early-2014 earthquakes.

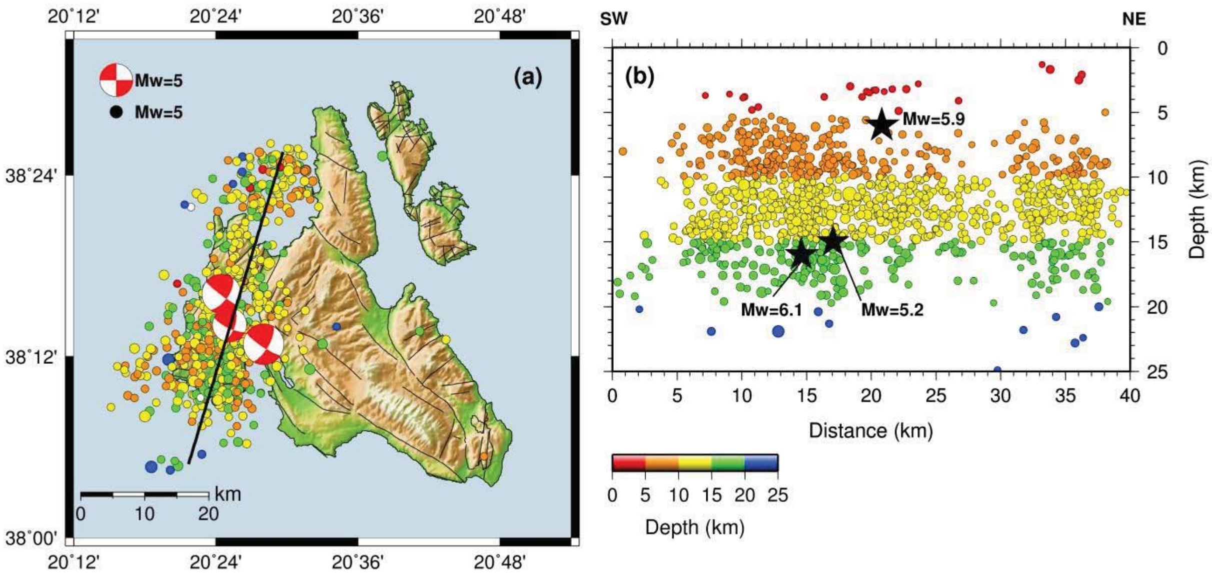

Figure 17: Earthquake epicenter distribution in Cephalonia (M>3) for the period January to April 2014.

1.1.2.6 Recommendations for future EO missions planning

The final phase (C) of the project will be dedicated to the third objective: to outline the main features of future space missions targeting DRM, taking into account the cross analysis between the current in-orbit capabilities and the geo-information users' needs concerning DRR and DRM. Notice that the activities of this phase of the project will require, as inputs, the outcomes that will be progressively generated along with the development of the first two project phases (A & B). The importance of the activities of this third phase of the project must be highlighted, since the overall conclusions and lessons learned from the whole project development will crystalize at the deliverables of this phase.

This final phase will start with a detailed user needs analysis whose combination with the exploitation of trail case results will lead to a baseline of requirements concerning DRM and DRR. Then, a cross analysis between these requirements with the current in-orbit capabilities will allow the identification of the gaps, thus resulting in a list of ideas to be proposed for further investigation to be fulfilled in order to have the appropriate in-orbit capabilities for addressing DRM and DRR. Finally, based on this gap analysis new mission concepts addressing DRM will be evaluated and feasibility will be assessed for the most relevant ones. As established in the temporal work-plan, these project activities will extend from month four until the end of the project and therefore the information coming from other phases will be progressively available in such a way that the activities of this phase will be carried out incrementally, refining the tasks outcomes with each new input available.

As introduced, the work carried out in this phase of the project will be divided into three different task categories:

- User Needs Analysis and derivation of baseline requirements: Information from phases A and B of the project will be jointly analyzed in order to derive a set of precise user requirements for each of the hazards exploited. Requirements must address concepts such as spatial and temporal resolution, accuracy, measurement techniques, geophysical parameters monitored, etc… Out of the identified needs, the baseline requirements will be achieved.
- In-orbit capabilities and gap analysis: Current and firmly planned missions will be critically analyzed in order to assess the capabilities concerning DRM and DRR, in such a way that gaps can be identified between capabilities and baseline requirements.
- New mission feasibility analysis: In order to fill the gaps identified in the previous task, a study will be carried out on novel concepts for future missions specially conceived for addressing Disaster Risk Management and Risk Mitigation. Many different elements will be taken into account (new orbits, new frequencies, multi-payload,…) in order to find the combination that would optimize DRM applications. For those identified key elements and concepts that could characterize a new mission, a more detailed assessment will be provided in the form of preliminary mission feasibility studies.

1.2. POTENTIAL PROBLEM AREAS

1.2.1. Identification of the main problem areas likely to be encountered in performing the activity

After a risk analysis the Contractor has identified a set of issues that can be the source of problems for the nominal project activities development. They are listed as follows:

1) The foreseen launch calendar for Sentinel-2 involves that during the first period of the project activities, no data will be available. Moreover, if any unexpected delay affects the due launch date, April 2015, optical data availability in the project could be endangered if only relying on Sentinels for the supply of EO data.
2) Some difficulties producing hazard maps over the secondary pilot areas might be encountered due to the lack of the required ancillary data in those areas. It has to be taken into account that secondary pilot areas are not well established sites for the validation of EO data use in DRM.
3) Some difficulties may arise in the interpretation and validation of large scale landslide inventory and hazard maps over secondary pilot area where available landslide inventory maps are obsolete and at very low resolution.
4) The reduced observation time window available with Sentinel-1 might lead to difficulties measuring tectonic motion, whose movement can be detected in the scale of years.
5) The integration of the EO data processing in the cloud infrastructure, such as the Geo-hazard Thematic Exploitation Platform or Helix Nebula, might meet some difficulties due to the little experience in performing the complete processing chain migration to the cloud
6) The DRM users fatigue mentioned in the SoW could threaten the success of the users' consultation event foreseen in the project activities.
7) Some difficulties may arise if the Cloud Platform software isn't mature enough to integrate the trial cases.
8) Some difficulties might be encountered due to the inherent complexity integrating the trail cases in the Cloud Platform

1.2.2. Proposed solutions to the problems identified

Listed below, the ordered proposed solutions for the ordered problems presented in section 1.2.1:

1) In order to tackle the potential lack of optical data due to the non-availability of Sentinel-2, other similar missions' data will be ordered such as RapidEye or SPOT.
2) When the generation of hazard maps are not possible due to lack of information or data, proceed to generate simpler products such as landslide inventory of multi-temporal landslide inventory maps at different scales and tectonic motion maps.
3) For the validation and interpretation of the results in secondary areas that might lack an exhaustive data set, derive error bars or confidence intervals of the produced information, and if necessary, perform some in-situ inspections. In any case, the implication of key expert users with a great knowledge of the test area and the thematic field will it make possible to perform a proper evaluation of the provided measurements and their utility during the different phases of DRR.
4) Regarding the measurement of tectonic motion, perform assisted processing with ancillary data (tectonic motion models, GNSS data) as well as processing of long time series of archive EO data such as ERS and Envisat ASAR.
5) Divide the processing into modules and perform cloud demonstration test just over the more robust parts of the processing: IW coregistration and interferograms generation for S1 (one of the most critical parts of the processing of S1 IW data), S2 NDVI index computation, low resolution wide area ground motion maps with S1 or long archives of ERS/ENVISAT data.
6) The approach of the consultation event will be very focused on the presentation of an integrated solution based on EO for DRM and the roadmap for its demonstration in the trial cases.
7) The platform development started in 2010 and is in use in several ESA and EC FP7 projects with stable and operational environments.

8) Since 2011 Terradue already supported the on-boarding of more than 30 complex EO applications with more than 80 active developers from different institutions and commercial companies. Terradue's team has the experience and established procedures to manage successfully the integration of the trial cases expected in this project.

1.2.3. Proposed trade-off analyses and identification of possible limitations or non- compliances

Concerning further trade-off analysis of possible limitations or non-compliances, besides the identified issues described in sections 1.2.1 and 1.2.2 , the Contractor has identified a possible limitation in the level of significance of the project results due to the fact that only two hazard types will be addressed. Indeed, a trade-off must be found between the search of general conclusions in DRM and DRR with space based technology and the depth and quality of the results obtained for each hazard analyzed. The Contractor considers that working with two types of hazards will provide at the same time quality results as far as each hazard analysis is concerned, but as well an overview on the general case of DRM with the use of space technologies, that can be easily transformed to a sort of methodology used for a rapid analysis on further types of hazards. Nonetheless, the Contractor is aware of the fact that results obtained throughout the project will be especially tailored to the two hazards chosen for analysis: landslides and seismic.

1.3. TECHNICAL IMPLEMENTATION / PROGRAMME OF WORK

1.3.1. Proposed Work Logic

The proposed work logic that will guide the activities of the project is described from the point of view of the presented project phases as well as the work-packages the work has been organized in. The proposed work logic, depicted in Figure 18, is compliant with the scope as well as with the schedule of the project. The project work to be carried out is divided into five work-packages:

- WP1000: Assessing geo-information needs
- WP2000: Contribution of EO technologies and new ICTs
- WP3000: User consultation
- WP4000: Trial cases
- WP5000: Future space assets for DRR

There is as well an additional transversal management work-package that accounts for the project management activities, which won’t be included in the description of the technical implementation work-flow. As already presented in previous sections, the project activities have been divided into three different phases according to the three identified objectives of the project. Figure 18 shows the relationships between phases and work-packages. The critical path, being the longest necessary path through the project activities taking into account their interdependencies, is marked in red in Figure 18. Recall that WP5000 activities can be started before the end of Phase A work-packages and extended until the end of the project, whereas Phase B requires the Phase A outputs to be started, extending as well until the end of the project.

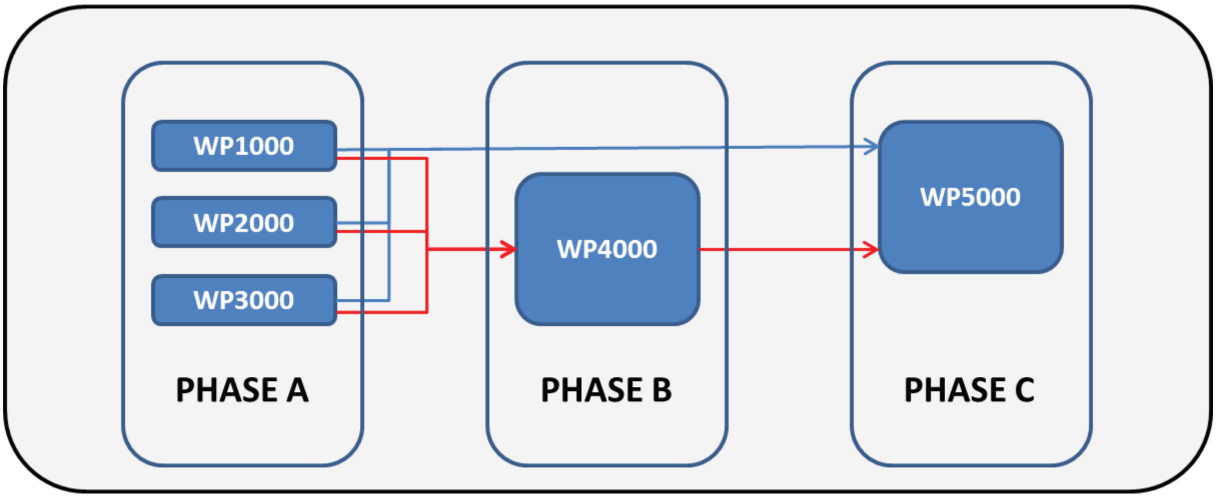

Figure 18: Work-logic

The rationale of the work-logic is to devote the first phase of the project to gathering the needed information on user needs and capabilities of current EO technologies in association with cloud infrastructure on DRM and DRR, as well as fixing with the user community the scope of the work carried out in the Trial Cases Exploitation (WP4000) activities. The outcomes of this initial phase of the project that last six months will feed both Phases B and C. Notice that Phase B activities, trial cases exploitation, cannot be started until the end of Phase A, as pointed in the work-logic schedule of the SoW [AD 1], since their detailed scope will be determined as the result of Phase A activities. Phase C will concentrate and merge the outputs of the two previous phases in order to compile a set of recommendations for future missions addressing DRR, through a multiple analysis of three components: user needs information, results of the trial cases with the current EO technologies and gaps in the fulfilment of the user needs by means of the current technologies. The combination of this analysis with the contractor's broad experience in new missions feasibility assessment and design will lead to the achievement of the third goal of the project: derive future missions' roadmap concerning DRM and DRR.

1.3.2. Contents of the proposed work

1.3.2.1 Work Breakdown Structure (WBS)

The Work Break Down structure for work-packages and tasks involved in the project is provided in following Figure 19.

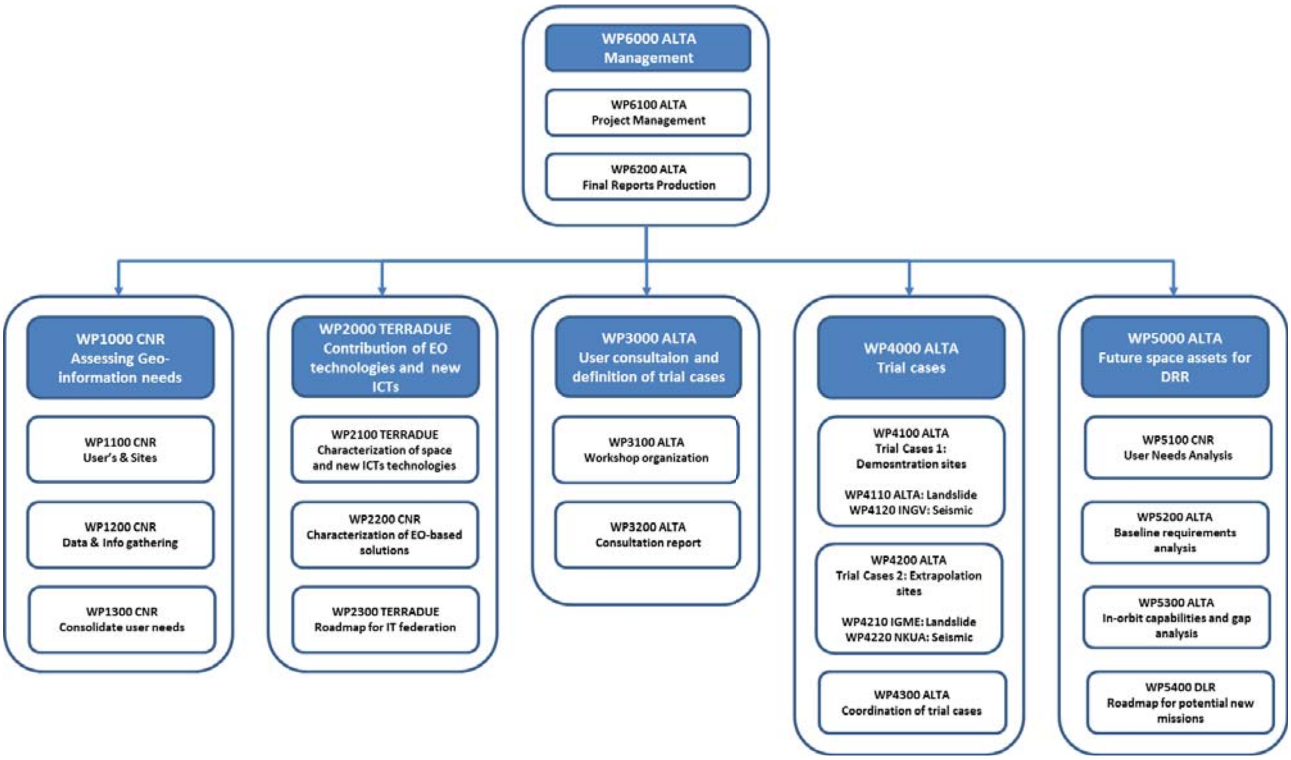

Figure 19: Work Breakdown Structure (WBS).

1.3.2.2 Work Package Description (WPD)

1.3.2.2.1 WP1000: Assessing geo-information needs

PROJECT: MEMpHIS	PHASE: A	WP: 1000
WP Title: Assessing geo-information needs Company: CNR WP Manager: Francesca Ardizzone Key partners: AI, INGV, TDE, NKUA, IGME Start Event: KO Planned Date: TO End Event: RV Planned Date: TO+6		Sheet 1 of 1 Issue Ref 1.0 Issue Date 16/12/14
Inputs: - Statement of Work (SoW) - Contractor's proposal - Preliminary user needs Tasks:		

The main objective of this task is to characterize and constitute the group of users in agreement with ESA and starting from the initial list of users of the proposal. Then identify, gather and prioritize user needs as well as other information regarding how they operate, what tools and data they have and use. This task is organized in 3 main sub-task all managed by CNR:

- WP1100 User and sites characterization
  - Consolidate with ESA the proposed user board of the project
  - Identify their risk assessment procedures for supporting the prevention and preparedness phase
- WP1200: Data and information gathering
  - Identification of user needs
  - Produce an inventory of tools, data, methods and technology for the prevention and preparedness phase
  - Prioritize user needs for each of the proposed pilot areas and according to the hazards
- WP1300: Consolidate user needs
  - Identify gaps between needs and current inventory
  - Consolidate user needs according to the feedback given in the consultation workshop and the DRR themes
  - Definition of trial cases according to the considered hazards. Consolidation of the performance tests and products which should be carried out for each scenario.

Outputs:

- D1.1: Baseline report
  - User needs assessment
  - User inventory of tools, data, methods and processing capabilities
  - Gap analysis
  - Definition of trial cases and performance test

1.3.2.2.2 WP2000: Contribution of EO technologies and new ICTs

PROJECT: MEMpHIS PHASE: A	WP: 2000
WP Title: Contribution of EO technologies and new ICTs Company: Terradue WP Manager: Herve Caumont Key partners: CNR, AI, INGV Start Event: KO Planned Date: TO End Event: RV Planned Date: TO+6	Sheet 1 of 1 Issue Ref 1.0 Issue Date 16/12/14

Inputs:

- Statement of Work (SoW)
- Contractor's proposal
- Bibliography
- Preliminary user needs

Tasks:

The main objective of this task is to characterize the contribution of current Earth Observation data and technologies in Disaster Risk Reduction and preparedness phase. In particular this task will focus on the readiness level of EO data, processing algorithms, cloud computing and data storage solutions as well as synergic exploitation with ancillary data for the two selected hazards, landslides and seismic. This task will produce therefore a state-of-the-art regarding the contribution of current EO-based solutions and ICTs processing methods in DRR. This task is divided into three sub-task.

- WP2100: Characterization of space and new ICTs technologies [TDE]
  - Identification of all the possible cloud computing, distribute node processing and massive data storage current technological solutions
  - Characterize the role of these technologies and capabilities for EO data processing and storage in DRR
- WP2200: Characterization of EO-based solutions [CNR]
  - State-of-the-art of EO-based solutions for multi-hazard mapping and risk assessment
  - Identification of available EO and non-EO data over the priority areas for the different hazard types
  - Contribution of the EO data and methods for hazard mapping in the selected priority areas with especial emphasis on landslides and seismic/tectonic hazards.

- WP2300: IT Cloud computing readiness [TDE]
    - Analyze the readiness level of the cloud computing solutions for landslides and seismic hazards considering the proposed EO data, methods and algorithms
    - Produce a roadmap for proposing a possible federation of the existing resources

Outputs:

- D2.1: Contribution EO technologies and ICT solution report
    - Contribution of current ICTs technologies and data storage capacities for DRR
    - Contribution of EO data and methods for landslides and seismic hazard and the selected pilot cases
- D2.2: Technical Note for Roadmap for federation of existing ICTs

1.3.2.2.3 WP3000: User consultation

PROJECT: MEMpHIS	PHASE: A	WP: 3000
WP Title: User consultation Company: ALTAMIRA WP Manager: Pablo Blanco Key partners: CNR, TDE, INGV Start Event: PM1 Planned Date: TO+2 End Event: RV Planned Date: TO+4		Sheet 1 of 1 Issue Ref 1.0 Issue Date 16/12/14

Inputs:

- Statement of Work (SoW)
- Contractor's proposal
- First draft of D1.3 Baseline report
- First draft of D2.1 Contribution EO technologies and ICT solution report

Tasks:

The main objective of this task is to organize in agreement with ESA the user consultation workshop at ESRIN premises. The workshop will be focused on presenting to the users the baseline studies performed in task 1 and 2 and to consolidate the proposed technological approach and performance tests over the selected scenarios. This task is divided into two main parts lead by ALTAMIRA:

- WP3100: Workshop organization [ALTAMIRA]
  - Organize the users workshop with the support of ESA
  - Contact users, sent information to users prior to workshop
  - Define meeting agenda and consultation plan
- WP3200: Consultation report [ALTAMIRA]
  - Gather user feedback and review after the workshop
  - Consolidate trial cases plan and performance tests to be run

Outputs:

- D3.1: Consultation plan document
- D3.2: Report of consultation meeting
- D3.3: Report of readiness review for the trial cases

1.3.2.2.4 WP4000: Trial cases

PROJECT: MEMpHIS	PHASE: B	WP: 4000
WP Title: Trial cases Company: ALTAMIRA WP Manager: Javier Duro Key partners: CNR, INGV, TDE, NKUA, IGME Start Event: RV End Event: FM	 Planned Date: TO+6 Planned Date: TO+18	Sheet 1 of 1 Issue Ref 1.0 Issue Date 16/12/14

Inputs:

- Contractor's proposal
- D3.2 Report of consultation meeting
- D3.3 Report of readiness review for the trial cases

Tasks:

The main objective of this task is to run the defined trial cases and performance test jointly with users and in accordance to the trial cases roadmap defined during the workshop. Trial cases are separated into two levels depending on the availability of ancillary data to process in synergy with EO data and on the level of ground truth data to evaluate the performances and to validate the products. Therefore the trial cases are divided into demonstration and extrapolation cases. In the first ones the EO-based solution will be properly evaluated and hazard maps will be produced for landslides and seismic motion. In the second cases the technology will be extrapolated to areas in sub-optimal conditions regarding the input data requirements. In those cases lower level products are expected to be produced. In all cases the performances will be evaluated with respect to user requirements. TERRADUE with the support of ALTAMIRA will make available some of the processing tools (such as binary files) on the cloud to allow users to produce ground deformation measurements by themselves and run trial cases.

- WP4100: Trial Cases 1: Demonstration sites
  - WP4110 Landslide site [CNR]
    - ALTAMIRA will support users for running the processing tools and will provide ground displacement results at low and high resolution for the areas with active slope or slow moving landslides by processing ERS, ENVISAT and Sentinel-1 data. Additionally Very high resolution data will be also processed depending on the user requirements. Especially new modes of ALOS-2 will be considered as L-band data is very suitable for landslides mapping in forested or vegetated areas.

- CNR will process optical data for event landslides mapping
- CNR, with the support of ALTAMIRA and with the use of ancillary data, will gather landslides maps and will produce multi-temporal landslides inventory maps and hazard maps. Maps will be generated on local and regional scales to properly evaluate the performances in DRR.

- WP4120 Seismic site [INGV]
    - ALTAMIRA will support users for running the processing tools and will provide ground displacement results at low and high resolution for the areas with active faults by processing ERS, ENVISAT and Sentinel-1 data.
    - INGV, with the support of ALTAMIRA and with the use of ancillary data, will perform micro-zonation of the areas with active faults for producing seismic hazard maps. Maps will be generated on local and regional scales to properly evaluate the performances in DRR.

- WP4200: Trial cases 2: Extrapolation sites
    - WP4210 Landslide site [IGME]
        - ALTAMIRA will support users for running the processing tools and will provide ground displacement results at low and high resolution for the areas with active slopes or slow moving landslides by processing ERS, ENVISAT and Sentinel-1 data. Additionally, very high resolution data will also be processed depending on the user requirements. Especially new modes of ALOS-2 will be considered as L-band data is very suitable for landslide mapping in forested or vegetated areas.
        - CNR will process optical data to map landslide events
        - CNR with the support of IGME will produce landslide inventory maps at different scales
        - IGME will perform the product evaluation and utility report
    - WP4220 Seismic site [NKUA]
        - ALTAMIRA will support users for running the processing tools and will provide ground displacement results at low and high resolution for the areas with active faults by processing ERS, ENVISAT and Sentinel-1 data.
        - INGV, with the support of NKUA and with the use of ancillary data, will produce seismic motion maps.
        - NKUA will perform the product evaluation and the user utility report.
- WP4300: Coordination of Trial cases [ALTAMIRA]
    - Coordination of the demonstration tests, coordinate the user trial exercises
    - Record results and user feedback
    - Produce reports

Outputs:

- D4.1: Reports of trial cases
    - Compilation of main results

- Performance test - Summary of the test activities – D4.2: User utility report - Product evaluation - Processing tool evaluation

1.3.2.2.5 W5000: Future space assets for DRR

PROJECT: MEMpHIS PHASE: C	WP: 5000
WP Title: Future space assets for DRR Company: ALTAMIRA WP Manager: Javier Duro Key partners: DLR, CNR, INGV, TDE Start Event: WS Planned Date: TO+4 End Event: FM Planned Date: TO+18	Sheet 1 of 1 Issue Ref 1.0 Issue Date 16/12/14

Inputs:

- Contractor's proposal
- D1.3 Baseline report
- D2.1 Contribution EO technologies and ICT solution report
- D3.2 Report of consultation meeting
- D4.1: Reports of trial cases
- D4.3: User utility report

Tasks:

The main objective of this task is to produce a gap analysis between current space technology and user needs for hazard mapping in DRR. As result a requirements baseline will be produced for future space assets in DRR which will account for EO data, processing methods, output products, ICTs storage and processing options as well as current and future planned missions. This task will be performed with the support and expertise of the department of SAR future missions of DLR and the expertise of CNR and INGV for hazard mapping in the prevention and preparedness phase. Landslides and seismic hazard will have special focus although other hazards will also be considered like subsidence, flooding and volcanoes. This task is divided into four sub-tasks.

- WP5100: User needs analysis [CNR]
  - Summarize and describe the final results on trial cases in accordance with the different risk reduction phases
  - Perform a complete user need analysis for each hazard type in the trial cases
- WP5200: Baseline Requirements Analysis [ALTAMRIA]
  - Perform an evaluation of how the proposed EO-based solution can produce hazard mapping on regional and local scales based on the trial cases experience

- Identify specific set of requirements for the considered hazard in DRR regarding data, methods and the user needs.

- WP5300: In-orbit capabilities and gap analysis [ALTAMIRA]
  - Assessment of capabilities of current and future planned EO missions for the considered hazards in DRR
  - Perform a gap analysis between baseline requirements and the in-orbit capabilities
- WP5400: Roadmap for potential new missions [DLR]
  - Investigations of new space assets which could improve the provision of information for the different phases of the DRM
  - Identify and evaluate potential new EO missions concepts
    - Define key performance indicators like revisit time, coverage, resolution, accuracy (among others) and other criteria for proposing concepts for new missions oriented to DRR and with special emphasis on landslides and seismic hazard (although other hazards will be also accounted like earthquakes, volcanoes, aquifers)
    - High level definition of potential new missions (payload, acquisition concept, ground segment)
    - Identify potential new measurement techniques or methodologies
    - Define level of priorities based on user needs analysis and the different hazards
  - Select and further develop new mission concepts from the proposed list
    - Detailed evaluation of the select future mission
    - Define appropriate measurement methods which consider the synergic processing with in-situ or ancillary data.
    - Identify potential products and information which could be derived for DRR

Outputs:

- D5.1: Report of the assessment of requirements
- D5.2: Report of the EO mission capabilities to contribute to DRR
- D5.4: Report of in-orbit capabilities, gap analysis and identification of new missions to support DRR

1.3.2.2.6 W6000: Project Management

PROJECT: PHASE:	WP: 5000
WP Title: Future space assets for DRR Company: ALTAMIRA WP Manager: Javier Duro Key partners: ALTAMIRA INFORMATION Start Event: KO Planned Date: TO End Event: FM Planned Date: TO+18	Sheet 1 of 1 Issue Ref 1.0 Issue Date 16/12/14

Inputs:

- Contractor's proposal
- D1.3 Baseline report
- D2.1 Contribution EO technologies and ICT solution report
- D3.2 Report of consultation meeting
- D4.1: Reports of trial cases
- D4.3: User utility report

Tasks:

The main objective of this task is to produce a gap analysis between current space technology and user needs for hazard mapping in DRR. As a result a requirements baseline will be produced for future space assets in DRR which will account for EO data, processing methods, output products, ICTs storage and processing options as well as current and future planned missions. This task will be performed with the support and expertise of the department of SAR future missions of DLR and the expertise of CNR and INGV for hazard mapping in the prevention and preparedness phase. Landslides and seismic hazard will have special focus although other hazards will be also considered like subsidence, flooding and volcanoes. This task is divided into four sub-tasks.

- WP5100: Project management and coordination
  - Technical management of the project (ensure technical compliance of the deliverables and the achievements)
  - Project coordination (ensure milestones and deliverables, coordinate partners and users, coordinates meetings organization, meeting minutes)
  - Administrative tasks (contracts, payments,..)
  - Produce Monthly Reports and Quarterly Status Reports to ESA

- WP5200: Produce final reports
  - Contract closure summary
  - Final Report
  - Executive summary

Outputs:

- DF.1: Final Report
- DF.2 Executive summary
- DF.3 Contract closure

1.4. BACKGROUND

1.4.1. Existing own concepts/products relevant to the activity and/or to be used

- Methods and procedures to generate the motion maps and the temporal series. The corresponding softwares to be employed will be DIAPASON, Stable Points Network (SPN) and Offset tracking. All of them have been developed and are owned by Altamira (ALTA).
- Methods and procedures to process polarimetric data and to prepare classification maps. The corresponding software to be employed will be DIAPASON (ALTA).
- Methods and procedure to prepare landslide susceptibility maps (CNR).
- Methods and procedure to evaluate landslide temporal recurrence probability (CNR).
- Methods and procedure to analyse landslide size distribution (CNR).
- Methods and technique to prepare landslide inventory maps (CNR).
- Time series and annual velocities at GPS permanent stations or campaigns in the ATF area (INGV).
- Seismicity map, with hypocentral locations and magnitudes, all over the ATF area (INGV).
- Maps of active fault and geological maps of ATF area (INGV).
- GPS Deformation and velocity vectors deduced from our local GPS networks in the trial case 2, exploration site (NKUA).
- Accurately relocated epicentres and associated focal mechanisms of the seismic activity in the - broader area of the exploration site (NKUA).
- Landslides Geodatabase (IGME).
- Reports Archive (IGME).
- Geological Maps (IGME).

Detailed information of the abovementioned items is provided in Section 4.1 of this proposal.

1.4.2. Third party's concepts/products relevant to the activity and/or to be used

- Methods and procedures to process polarimetric data and to prepare classification maps. The corresponding TP software to be employed will be PolSARpro (distributed by ESA) (ALTA).
- Considered SAR input data: Main input will be ERS/ENVISAT and Sentinel-1 (ESA missions) for the generation of long time series of analysis and wide area studies. Occasionally, other high resolution sensors and other wavelengths will be considered to complete the future missions studies like Radarsat-2 (TPM), ALOS-PALSAR (1 or 2) (TPM), Cosmo-Skymed (TPM) images. They will be obtained through a Category-1 proposal (ALTA).

- Considered Optical input data: Mainly RapidEye (TPM), SPOT (TPM) and Sentinel-2 (ESA) once data is available (ALTA).
- Digital Elevation Model. If no other better available, the SRTM and IDEM of DLR will be employed.
- Software to prepare Landslide Susceptibility map (CNR).
- WPS services - Software to prepare landslide frequency distribution parameter statistics (http://alpha.irpi.cnr.it/cgi-bin/pywps.cgi) (CNR).
- WPS services - Software to prepare slope unit subdivision (http://alpha.irpi.cnr.it/cgi-bin/pywps.cgi) (CNR).
- ArcGIS 10 by ESRI - Software for Mapping and Calculations (IGME)
- Engineering Geology Laboratory – University of Patras – Measurements (GPS and Inclinometers) – Permission will be requested (IGME).
- Vinci – Construction company - Measurements (GPS and Inclinometers) – Permission will be requested but is not granted yet (IGME).
- Other construction companies working at the AOI - Permission will be requested but is not granted yet (IGME).

1.4.3. Other technical achievements relevant to the activity and/or to be used

Concerning relevant technical achievements of the consortium to the project activity, refer to the examples described in section **¡Error! No se encuentra el origen de la referencia.** to draft an idea of those partners' achievements that clearly apply to the scope of the present project. Other information about relevant technical achievements is contained in the information about partners' background in section **¡Error! No se encuentra el origen de la referencia.**. In case the Agency requires further information about this aspect, the Contractor could provide additional broadened examples from each partner of the consortium.

1.5. TECHNICAL RESERVATIONS – TECHNICAL COMPLIANCE

1.5.1. Reservations

As described in previous sections, among the technical duties which will be carried out as part of WP 4000 – Trial Cases and test data, we foresee the creation of a landslide inventory map up to regional scale. Despite the fact that the project is planned to create such an inventory automatically by means of a combined processing of Sentinels 1 and 2 data, the contractor is conscious of the high level of difficulty that this technical objective entails. Consequently, given the current maturity status of the processing involved in the landslide inventory generation, the capability of generating it fully automatically is not guaranteed, although the best effort will be devoted to the achievement of this goal. The contractor identifies the described risk as a technical reservation of the project.

1.5.2. Technical Compliance Matrix (Statement of Work / Technical Requirements)

Table 3 demonstrates the statement of compliance to the ESA Statement of Work [AD 1]. The project requirements have been understood and this proposal defined according to them.

Table 3: Statement of Compliance to the ESA Statement of Work [AD 1]

ITT Requirements as stated in [AD 1]	Compliance	Remarks
R01. Identify geo-information user needs concerning DRM ((AD 1 section 3.2.1))	yes	Two different tasks will cover this topic, including an in-depth existing documentation study and a user's consultation event.
R02. Investigate the contribution of current space assets in Disaster Risk Management. (AD 1 section 3.2.2)	yes	A dedicated task will be devoted to the analysis of the contribution of current space technology in DRM field
R03. Study the contribution of cloud infrastructure in EO data processing as an innovative EO data exploitation method. (AD 1 section 3.2.2)	yes	A dedicated partner of the consortium, well known at ESA for prior work in the use of cloud computing for EO data processing, will be in charge of this issue.
R04. At least two different kinds of hazards have to be addressed in the project activity. (AD 1 section 2)	yes	The Contractor proposes focusing on two representative kinds of hazards, involving different DRM user requirements: landslides and seismic.
R05. Sentinel-1 data shall be used in the trial cases exploitation. (AD 1 section 3.2.4)	yes	The trial cases exploitation will be based on Sentinel-1 data, whose use has been already successfully proven by the contractor
R06. Investigate new space mission concepts specifically addressing Disaster Risk Management and Disaster Risk Reduction (AD 1 section 2)	yes	A dedicated important task will cover this topic, with a consortium member especially working on this issue given his widely known experience in this field.
R07. Put emphasis on countries that do not have wide access to space technologies in the field of DRM that would have a benefit in integrating them. (AD 1 section 2)	yes	The trial cases geographic regions will be located at different points of Greece, that haven't yet completed a full integration of the use of EO data in DRM.
R08. Production and evaluation of hazard mapping at basin and at local level for DRR	yes	The fact of having two key trial cases which are natural laboratories of landslides and seismic hazards with a lot of in-situ and ground data and relevant partners that can produce and validate hazard maps at different scales.
R09. Extra hazard mapping for floods	yes	The selected areas are prone to floods. The potential for mapping floods will be evaluated with the processing of optical and polarimetric Sentinel data
R10. Run of trial cases on cloud computing	yes	The proposed methodologies will be put on cloud for allowing users running some tests of the trial cases using this technology.

2. MANAGEMENT PART

2.1. TEAM ORGANISATION AND PERSONNEL

2.1.1. Proposed team

2.1.1.1 Overall team composition, key personnel

The team is organized as displayed in Figure 20. ALTA is the Prime Contractor and sole interface with ESA.

ALTA has the managerial, technical, scientific, financial, and operational capacity and experience to manage this project. Project management and coordination activities are performed under WP6000 according to a management structure and decision making procedures designed to ensure that all coordination, scientific, financial, and organizational activities are carried out on schedule and within budget while covering the scope of the project.

Members of the consortium are:

Altamira Information (AI): Prime contractor, Earth observation company (Spain).

National Research Council of Italy (CNR): Research public institution (Italy).

Terradue: Distributed computing for Earth Sciences Company (Italy).

German Aerospace Center (DLR): Research public institution (Germany).

National Institute for Geophysics and Volcanology (INGV): Research public institution (Italy).

Institute of Geology and Mineral Exploration (IGME): Research public institution (Greece).

National and Kapodistrian University of Athens (NKUA): University (Greece).

The rationale of the consortium will be further explained in section 2.1.3, detailing roles and main responsibilities of each consortium member.

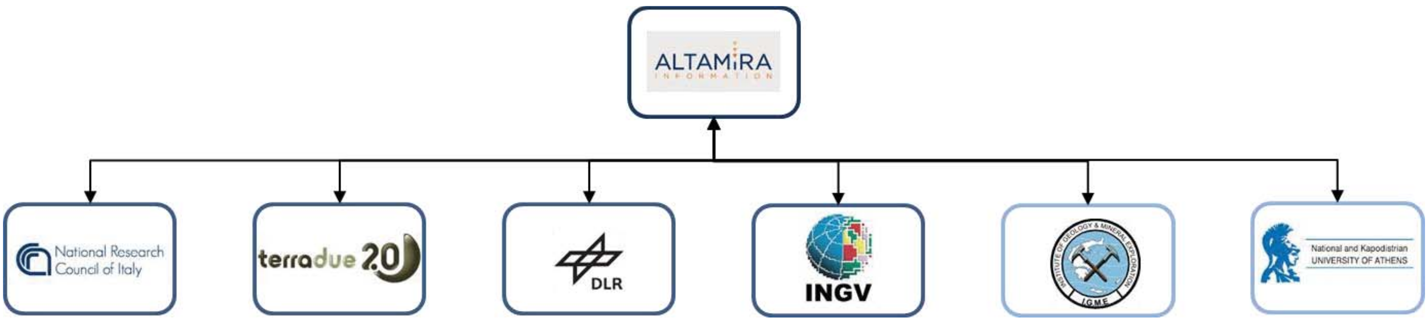

Figure 20: Proposed Consortium

Concerning team composition, the following table summarizes all the project participants

Table 4: Team Composition

Name	Affiliation	Key personnel	Position	Role
Javier Duro	ALTA	Yes	R&D director	Project Manager, WP4000 and WP5000 Lead
Pablo Blanco	ALTA	Yes	R&D engineer	SAR and optical processing methods. WP3000 Lead.
David Albiol	ALTA	Yes	R&D engineer	SAR processing methods
Patrick Ordoqui	ALTA	Yes	Head of ITT	EO processing tools adaptation for NH and ICTs
Alain Arnaud	ALTA	yes	CEO	InSAR reference
Fausto Guzzetti	CNR	Yes	Director CNR-IRPI	Landslides hazards reference Expert in DRM and DRR
Alessandro Cesare Mondini	CNR	Yes	Researcher	Optical data processing methods Methods for automatic Landslide Inventory and susceptibility maps
Paola Reichenbach	CNR	Yes	Senior Researcher	Optical data processing methods Methods for Landslide Inventory and susceptibility maps
Francesca Ardizzone	CNR	Yes	Researcher	WP1000 Lead WP4110 Lead Landslide hazard mapping methods
Mauro Cardinali	CNR	Yes	Senior Researcher	Landslide hazard and inventory mapping methods
Hervé Caumont	Terradue	Yes	Manager Cloud Platform Operations	Expert in cloud computing WP2000 Lead
Cesare Rossi	Terradue	Yes	System Engineer and Cloud Computing Specialist	Expert in cloud computing Integration of tools in cloud computing for the run of trial cases

Francisco López Dekker	DLR	Yes	Head of SAR Missions Group (Radar Concepts Department.)	Expert in new missions Proposition of new acquisition concepts WP5400 Lead
Thomas Börner	DLR	Yes	Research Scientist	Expert in new missions New acquisition concepts
Salvatore Stramondo	INGV	Yes	Head of Satellite Earth Observation unit at INGV, Senior Researcher	Seismic and tectonic hazards reference Expert in DRM and DRR
Christian Bignami	INGV	Yes	Researcher Remote Sensing Unit, National Earthquake Centre	Seismic and tectonic hazard mapping methods EO data processing Products and services evaluation WP4120 Lead
Marco Moro	INGV	Yes	Researcher Remote Sensing Unit, National Earthquake Centre	Seismic and tectonic hazard mapping EO data processing
Evangelos Lagios	NKUA	Yes	Director in the Department of Geophysics & Geothermics and the Remote Sensing Laboratory, University of Athens	Seismic and tectonic hazard reference
Vassilis Sakkas	NKUA	Yes	Team Leader of the Space Applications Working Group, Department of Geophysics & Geothermics, University of Athens	EO data processing and methods user for seismic hazard Products and services evaluation WP4220 Lead
Panagiotis Papadimitriou	NKUA	Yes	Professor of of Seismology in the Department of Geophysics – Geothermics, University of Athens	EO data processing and methods user for seismic hazard Products and services evaluation

Pepy Vassilopoulou	NKUA	Yes	Expert Researcher in GIS, Tectonics and Space Applications	EO data processing and methods user for seismic hazard
Natalia Spanou	IGME	Yes	Engineering Geologist MSc specialized on landslides' assessment and mitigation	EO data processing and methods user for landslide hazard WP4210 Lead Products and services evaluation
Marianthi Stefouli	IGME	Yes	Geologist PhD specialized on Remote Sensing, Geography	EO data processing and methods user for landslide hazard Products and services evaluation

All members of the consortium have accepted to join the project and that the present proposal is submitted by Altamira Information on their behalf. Their authorization letters are attached in Appendix A.

2.1.1.2 Reporting lines within the team

The project communication policy will have two different categories: external and internal. External communications will account for interfacing with ESA. The prime contractor will be the sole actor communicating with ESA, regularly with the monthly progress reports and additionally with dedicated notifications whenever either ESA or the team wants to get in touch with each other. Internal communications will be managed but not limited by the project manager. WP leaders will be in charge of the communication that concerns their WPs scope, having the Project Manager aware of all the communications. As far as general communication regarding project progress is concerned, the Project Manager will maintain the necessary communication lines for the proper project development. As a general rule, all the consortium members will communicate with each other as required by the project progress development, informing the Project Manager whenever they estimate worth it. A regular monthly internal reporting line from the subcontractors to the Project Manager is planned in order to assemble the progress information from each partner so that the monthly progress report can be written to be sent to the Agency. Figure 20 shows graphically the communication flows between the different consortium members, with double sided arrows connecting every partner with each other.

2.1.1.3 Position of each of the team members within his/her own company's (or institute's) structure

The information about the position of each of the team members in their companies/institutes is embedded in

Table 4 at section 2.1.1.1

2.1.1.4 Time dedication

The following table details the time dedication of each team member proposed as key personnel, in the percentage of their total working time to be dedicated to the present project, by WP.

Table 5: Time dedication of key personnel by WP

Key personnel	WP 1000	WP 2000	WP 3000	WP 4000	WP 5000	WP 6000
Javier Duro, ALTA	10%	5%	5%	10%	40%	40%
Pablo Blanco, ALTA	5%		20%	5%	10%	5%
David Albiol		5%	5%	30%	5%	20%
Patrick Ordoqui		10%		25%		
Alain Arnaud, ALTA		5%	5%		5%	5%
Fausto Guzzetti, CNR-IRPI	20%	10%		5%	5%	
Alessandro Cesare Mondini, CNR-IRPI	35%	15%		5%	25%	
Paola Reichenbach, CNR-IRPI	25%	10%	10%	10%	30%	
Francesca Ardizzone, CNR-IRPI	20%	10%	5%	15%	40%	10%
Mauro Cardinali, CNR-IRPI	35%	10%		20%	20%	
Hervé Caumont, Terradue	4%	34%	3%	2%	1%	1%
Cesare Rossi, Terradue				17%		
Francisco López Dekker, DLR					20%	
Thomas Börner, DLR					15%	
Salvatore Stramondo, INGV	25%	12%	56%	74%	15%	12%
Christian Bignami, INGV	40%	30%	60%	80%	28%	13%
Marco Moro, INGV	29%	20%	42%	66%	20%	6%
Evangelos Lagios, NKUA				25%		
Vassilis Sakkas, NKUA				40%		
Panagiotis Papadimitriou, NKUA				20%		
Pepy Vassilopoulou, NKUA				15%		
Natalia Spanou, IGME	10%		15%	40%		
Marianthi Stefouli, IGME	5%		15%	20%		

2.1.2. Curricula Vitae

This section details concise curricula vitae for key personnel.

Javier Duro (ALTA) graduated in Telecommunications Engineering from the Universitat Politècnica de Catalunya (UPC) in 2001, and defended his Doctoral thesis in Persistent Scatterer interferometry with the University Marne-La-Vallée of Paris-Est in 2010. He has over ten years of experience in the radar field and has been working at ALTAMIRA INFORMATION since October 2001. As Director of Research and Development he has led research activities on the stable point network technique, interferometric signal analysis and other specialized areas of interferometry oriented mainly to the detection of ground motion. During the last years he has led research projects on new SAR acquisition modes and new SAR missions for several space agencies. He is one of the foremost authors on Advanced SAR Interferometry. He was participating in different European projects related to the use of EO data for mapping Natural Hazards like LEWIS, SAFER, DORIS, LAMPRE and RASOR. He is the current main technical responsible of the last stage of Terrafirma project and of a SEOM project recently granted devoted to the fusion processing methodology of Sentinel-1 and 2 data for improved land cover classification and change detection. Since last year he is part of the Scientific Developing Team of a new NASA/CNES SWOT mission currently in Phase A.

Alain Arnaud (ALTA) obtained his PhD in Computer Science from ENSEEIHT - Ecole Nationale Supérieure d'Electronique, Electrotechnique, Informatique et Hydraulique de Toulouse (France) in 1997. Prior to this, he received a degree in Engineering from the Ecole Polytechnique (X89) and a Masters degree from the Institut National Polytechnique de Toulouse – INPT (France). He has 20 years of experience in the remote sensing field and is specialized in SAR interferometry. He served as technical officer for SAR projects at both the French Space Agency (CNES) and the European Space Agency (ESA). In 2000, he founded Altamira Information, where he created a team of InSAR and PS-InSAR experts; He had developed ground motion detection and cartographic products for clients from several areas of interest: infrastructures, mining, oil and gas, insurance, environment, natural hazards, as well as space and research. Altamira Information is also responsible for the development and ongoing maintenance of the "Stable Points Network" PS-InSAR chain, which belongs to the company.

Pablo Blanco (ALTA) has a PhD in SAR interferometry and worked for 6 years in the Institut Cartogràfic de Catalunya where he was project manager of DInSAR techniques for ground motion monitoring studies. He joined ALTAMIRA INFORMATION in January, 2014 as an R&D Engineer and has 11 years' experience in DInSAR/PS Interferometry processing techniques. He has developed advanced solutions for atmospheric compensation and persistent scatterers' techniques for wide areas of motion.

David Albiol (ALTAMIRA). After his MSc in Telecommunications Engineering in 2007, David Albiol joined ALTAMIRA INFORMATION. David has now eight years' experience in SAR/InSAR techniques. He has participated and led both operational and R&D InSAR projects. He is currently working as R&D Engineer in SAR/InSAR technology and developing new software and tools for advanced SAR/InSAR processing. David is also responsible for Quality Control of operational SAR/InSAR ground motion studies.

Patrick Ordoqui (ALTAMIRA), MSc. Computer Science at ENSEIRB, joined ALTAMIRA INFORMATION in 2005. Patrick Ordoqui is Head of IT. He has more than 10 years' experience in radar application development, software parallelisation and system administration. He is responsible for adapting DIAPASON software and the SPN processing chain to new sensors. He has participated in the development of a Ka-band radar sensor simulator (SWOT mission), and in advanced interferometric applications and tools (DEM generation with bistatic Tandem-X data, RASOR FP7 project).

Fausto Guzzetti (CNR-IRPI) is a Senior Research Scientist at CNR, and the Director of IRPI. He has a BS in Geology (University of Perugia) and PhD in Geography (University of Bonn). His research interests include landslide cartography, forecasting and risk assessment and reduction. Author of multiples papers in international journals, he participated in national, European, and US projects. He was principal investigator of the MORFEO project, of the Italian Space Agency, and he is the Project Manager for the DORIS EU project. He coordinates the LAMPRE EU project. Guzzetti served as President of the Natural Hazards Division of the European Geosciences Union, and received the EGU Union Service Award, in 2008.

Alessandro Cesare Mondini (CNR-IRPI) is a Research Scientist with IRPI (The Research Institute for Geo-Hydrological Protection). A physicist by training, with a PhD in Earth Science (Title: “Remote Sensing data and methodologies for semi-automatic event landslide mapping) he has significant experience on the processing of EO imagery for landslide detection and mapping. He participates to the MORFEO, DORIS and LAMPRE projects

Paola Reichenbach (CNR-IRPI) is a Research Scientist with IRPI. Here research interests include GIS and statistical modeling for landslide susceptibility, hazard, vulnerability and risk assessment. She participates to the MORFEO, DORIS and LAMPRE projects.

Francesca Ardizzone (CNR-IRPI) is a Research Scientist with IRPI. Her research interests include GIS for geomorphological mapping and landslide hazard and risk assessment, landslide erosion, and geomorphological exploitation of DInSAR analyses. She participates to the MORFEO, DORIS and LAMPRE projects.

Mauro Cardinali (CNR-IRPI) is a senior Research Scientist with IRPI. He is a geologist with consolidated experience on regional and large-scale landslide mapping in different areas of the World, chiefly from aerial photography. He participates to the MORFEO, DORIS and LAMPRE projects.

Herve Caumont (Terradue) is a senior architect with 20 years’ experience in the development and transfer to operations of scientific, environmental and military solutions delivering geospatial end products. His expertise focuses on the implementation of standards within deployment environments that are imposing high requirements for human factors and systems interoperability. In the last 6 years, he developed skills in the coordination of inter-agency and multi-tenant distributed infrastructures, especially platforms relying on business models leveraging Cloud Computing technologies & Cloud services. Previously he developed project management skills through 10 years of experience in charge of several realizations for the space & defence sectors, within international contexts, involving leading organizations in Europe and the United States. His academic background includes an initial Masters of Sciences in Electronics Engineering and a Masters Degree applied in Remote Sensing and Image Processing.

Cesare Rossi (Terradue) area of expertise focuses on developing and maintaining a high performance and distributed computing infrastructure to support EO applications, by leveraging well known programming models for processing and generating large data sets with distributed algorithms (MapReduce). He is involved in performance analysis of EO algorithms in distributed and hybrid Cloud environments, collecting execution metrics and presenting results in a comprehensive manner. He has developed Operations Support skills efficiently performing problem solving steps, managing proper involvement of second-level support for issue resolution, and for handling the different priorities, criticality and timing of multiple daily inquiries. Highly developed team-work skills combined with finely honed resource management skills. He has a strong academic background, with a particular interest in distributed systems and high performance computing (Grid Computing and Cloud Computing), developed during five years at the University of Rome “Tor Vergata” and a year of trainee at the ESRIN - ESA's centre for Earth observation.

Francisco López Dekker (DLR) received the degree in telecommunication engineering from the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain, in 1997, the M.S. degree in electrical and computer engineering from the University of California, Irvine, in 1998, under the Balsells Fellowships, and the Ph.D. degree from the University of Massachusetts, Amherst, in 2003, for his research on clear-air imaging radar systems to study the atmospheric boundary layer. From 1999 to 2003, he was with the Microwave Remote Sensing Laboratory, University of Massachusetts. During 2003 he worked as a research scientist at Starlab, where he focused on the development of GNSS-R sensors. From 2004 to 2006, he was a Visiting Professor with the Telecommunications and Systems Engineering Department, Universitat Autonoma de Barcelona. In March 2006, he joined the Remote Sensing Laboratory, UPC, where he conducted research on bistatic synthetic aperture radar (SAR) under a five-year Ramon y Cajal Grant. At the university, he taught courses on signals and systems, signal processing, communications systems and radiation, and guided waves. Since November 2009, he leads the SAR Missions Group at the Microwaves and Radar Institute, German Aerospace Center, Oberpfaffenhofen, Germany. His current research focuses on the study of future SAR missions and novel mission concepts.

Thomas Börner (DLR) He received the degree in Diploma Physics in 1996 from the Ludwigs-Maximilians-University (LMU) of Munich. He started working on SAR in 1996 with a PhD thesis on coherent modeling for polarimetric SAR interferometry at LMU Munich as an external work at DLR (German Aerospace Center), Oberpfaffenhofen, Microwaves and Radar Institute. From 2000 he is employed as a research scientist at DLR and contributed to the following fields of activities: Coherent modeling of precipitation effects on radar data in collaboration with Dr. D.H.O. Bebbington (Univ. Essex, UK), European TMR framework (2001-2002). Head of the Propagation and Scattering Group at DLR (2002-2009): Tropospheric and ionospheric effects on radar data; operation of DLRs polarimetric weather radar POLDIRAD in collaboration with the DLR Institute for Physics of Atmosphere; research on application of Entropy-Alpha to polarimetric weather radar data to develop a better understanding about polarimetric propagation effects (troposphere); management, engineering and research of/in several projects, e.g. SARCON (SAR CONtrol tool for ERS and ENVISAT/ASAR data), ALOS PALSAR Products verification, GITEWS - concept study and design of a Tsunami Early Warning System with radar sensors. Since 2009 Thomas Börner is a member of the SAR Missions Group, having managed the SIGNAL mission study, and being involved in other mission studies as BIOMASS, CoReH2O, Tandem-L and new Ka-band concepts, and currently leading the MAC-SAR study about ocean current retrieval with multi-channel DBF SAR.

Salvatore Stramondo (INGV) received the M.S. degree in electronic engineering in 1996 from the University “La Sapienza”, Rome, Italy, and the Ph.D. in Geoinformation in 2007 from the University “Tor Vergata”, Rome, Italy. He joined the Istituto Nazionale di Geofisica e Vulcanologia in 1997 where he is currently Head of the Satellite EO Unit. Since 2004 he is Adjunct Professor of “Remote Sensing” and “Cartography and Topography” at the University of Calabria, Rende, Italy. He was Invited Researcher at the CNR-IRECE (Neaples, Italy, 1997), IPGP (Paris, France, 1998), JPL (Pasadena, CA, 2000), IIT (Bombay, India, 2001). His main research activities are in SAR interferometry techniques and geophysical applications. He is author of more than 50 international papers, several contributions to National and International conferences and some book chapters. He has been Chairman and Co-Chairman at several international conferences (IGARSS-International Geoscience and Remote Sensing Symposium, EGU-European Geophysical Union). Since 2009 Dr. Stramondo is Editor of Remote Sensing journal and Associate Editor of IEEE GRS Letters and International Journal of Applied Earth Observation and Geoinformation. He is Senior Member of IEEE Geosciences and Remote Sensing Society, International Society for Photogrammetry and Remote Sensing – Commission VII - WG 6 - Remote Sensing Data Fusion and Associazione Italiana di Telerilevamento. Since 2011 he is in the Board of Directors of the Italian Association of Remote Sensing - Associazione Italiana di Telerilevamento.

Christian Bignami (INGV) received the M.S. degree in Telecommunications Engineering from Sapienza University of Rome, Italy, in 2002. Since June 2008 he is PhD in Electromagnetism. He is currently member of the Remote Sensing Unit of the Istituto Nazionale di Geofisica e Vulcanolgia (INGV) in Rome and since 2002 he has been collaborating with the Department of Electronic Engineering, Sapienza University of Rome. His research activities are focused on remote sensing applications for seismic and volcanic area monitoring by using Synthetic Aperture Radar (SAR) and optical very high resolution sensors. He works on processing and analysis of satellite data, by means of SAR interferometric techniques for surface deformation, and change detection and classification techniques of urban environment with very high resolution optical data. Dr Bignami is involved in Italian and international projects supported by the European Commission, Civil Protection Department, European Space Agency.

Marco Moro (INGV) received the M.S. degree in Geology in 1996 from the University "La Sapienza", Rome, Italy, and the Ph.D. in Geology in 2007 from the University "La Sapienza", Rome, Italy. He joined the Istituto Nazionale di Geofisica e Vulcanologia (INGV) in 2000 where he is currently Researcher. He was Invited Researcher at the CNR-IGAG (Rome, Italy, 2004). His main research activities are in active tectonics by means of tectonic geomorphology studies necessary to identify seismogenic sources (historical and instrumental seismicity analysis, stress field from data break-outs and focal mechanisms, recognition and mapping of tectonic features using photo interpretation, geological mapping and analysis of DEM) and paleoseismology approach aimed at the characterization of the geometric and kinematic behaviour of the seismogenic structures. Analyses and interpretation of coseimic deformations by means of DInSAR images. Analyses and interpretation of interseismic deformations by means of multitemporal DInSAR time series. Quaternary geology integrating the stratigraphyc sequences to paleosurfaces for the geological reconstruction of the quaternary evolution in basins sectors. Study of the deep gravitational slope deformations (DGPV) and their interaction with the active tectonics, through the integration of differential interferometry (DInSAR) and geomorphologic techniques. He is author of more than 40 international papers, several contributions to National and International conferences.

Prof. Dr. Evangelos Lagios (NKUA) is the most senior member and Director in the Department of Geophysics & Geothermics (www.geophysics.geol.uoa.gr), as well as Director of the Remote Sensing Laboratory (www.remsenslab.geol.uoa.gr) of the University of Athens with teaching and research in various disciplines of Geophysics and Space Applications. He has been working in various geodynamic problems in Greece (deep crustal and isostatic studies), and especially along the Hellenic Arc implementing both gravity and long-period Magnetotellurics. He has carried out Microgravimetric and DGPS measurements contributing to the research in seismically active areas of Greece (Atalanti Fault Zone, SW Peloponnese and Western Crete, the broader area of Patras Gulf, and the Cephallonia & Zakynthos islands), together with volcano-hazard monitoring assessments in Santorini and Nisyros volcanoes. He has also carried out extensive geothermal research in all geothermal fields along the islands of the Hellenic Volcanic Arc (Sussaki, Methana, Milos, Kimolos, Santorini, Kos and Nisyros) implementing the Audio-Magnetotelluric methodology since 1986. He is a member of Greek and International Scientific Committees. He is currently involved in real-time transfer of geophysical data, using satellite technologies, and in Space Application Techniques, such as Differential GPS/GNSS, conventional Differential SAR Interferometry (DInSAR), Permanent Scatterers (PS) and Stacking Interferometry (PSI). He has published more than 250 papers in International Journals and Conference Proceedings. For recent publications of his, see Publications in www.remsenslab.geol.uoa.gr.

Dr. Vassilis Sakkas (NKUA) He is Geophysicist and Team Leader in Space Applications working Group and Laboratory Teaching Personnel in Department of Geophysics & Geothermics in the University of Athens. Exploration geophysicist with twelve years' experience in field operations and R&D with emphasis on processing and interpretation of multiple geophysical (Electromagnetic, magnetic, gravity, seismic, geodetic (GNSS), Interferometric (InSAR)) data to investigate earth's interior. He Designed and completed several field campaigns to collect several type of geophysical data in numerous areas of Greece, Europe and during my PhD research in Africa (Kenya Rift Valley). He also has a great experience in joint interpretation of geodetic (GNSS) and interferometric data (Differential InSAR, permanent Scatterrer Interferometry (PSI) and SqueeSAR Interferometry) for ground deformation monitoring due to tectonic, seismic, volcanic or manmade (water/oil extraction) reasons and Great experience in processing and interpretation of Satellite Thermal Images (ASTER – LANDSAT), Satellite Optical Images (IKONOS – Quick Bird). He has published over 15 research papers in leading international journals, and over 15 articles in conference proceedings; is Member of national and international research groups that compiled several funded research proposals for geophysical research in Greece.

Dr. Panagiotis Papadimitriou (NKUA) is an associated professor of Seismology in the Department of Geophysics - Geothermics of the Faculty of Geology and Geo-Environment (University of Athens). He has a B.Sc. in Physics (Maitrise de Physique, Paris, 1982), M.Sc. (DEA) in Geophysics-Geochemistry (Paris, 1983) and PhD (Doctorat) in Seismology (Paris, 1988). He was Research Associate at the University of Athens from 1989 to 1995 and he was elected Lecturer in 1996. His research interests include the following scientific fields: Synthetic body waves, Seismic Parameters, Earthquake Rupture Models, Seismotectonics, Earthquake Prediction, Anisotropy, Spectral Analysis, Propagation of Seismic Waves with emphasis on Structure, Development of Seismological Networks, Process and Analysis of digital signals. He teaches in both undergraduate and postgraduate level courses of Seismology, Earthquake Prediction, Seismotectonics, Seismic Parameters - Earthquake Source Properties, Natural Hazards, Seismic and Volcanic Risk. He has supervised an important number of Master and PhD theses. He has published University lecture notes and more than 110 scientific papers with more than 450 citations. He was Scientific Responsible or Member of Research teams of both Greek and European research projects on monitoring seismic activity and seismic hazard. He is responsible of the "Athenet" permanent digital telemetric seismological network of the University of Athens. He acts as a member of organizing and scientific committees of both Greek and International conferences, reviewer of scientific papers in International and Greek journals and conference proceedings.

Dr. Pepy Vassilopoulou (NKUA) is an expert in Geology, GIS, Tectonics and Space Applications. She has been working since 2001 as Research Associate in the National Kapodistrian University of Athens (NKUA), Faculty of Geology and Geo-environment, Department of Geophysics-Geothermics. She has great experience in use and applications of GIS, Digital Cartography and the development of specific software as well as in Space Techniques (digital processing and interpretation of satellite images, Processing of GPS measurements, etc) relating to Geosciences and Natural Hazards (1992 – Present). She is also expert in processing and interpretation of Satellite Optical Images (IKONOS, QUICK BIRD, SPOT, LANDSAT), Satellite Thermal Images (ASTER, LANDSAT) and Ground Thermal Images. (1992- Present) and has Experience in processing and interpretation of Geodetic (GPS) and Interferometric Data (Differential InSAR, Permanent Scatterrer Interferometry PSI) for ground deformation monitoring due to tectonic, seismic, volcanic or manmade (water/oil extraction) reasons - Collaboration in the Campaigns in the field (1997 - Present). She has published over 40 research papers in leading international journals, and international conference proceedings (1995-Present). She is Member of National and International research groups that compiled several funded research proposals for geological and geophysical research in Greece and abroad (1987 –

Present). Great Teaching Experience mainly in GIS, Digital Cartography and Space Techniques in Geosciences and Geo-environmental Problems (1990 – Present).

Marianthi Th. Stefouli (IGME) has 30 years' experience gained on various fields of geologic and environmental research projects and applications using remote sensing / GIS techniques while working in I.G.M.E., (Institute for Geology and Mineral Exploration) or in other premises. Her research fields are the applications and integration of remote sensing / GIS techniques and methods in terms of geological (Hydrology, Translational river basins, Hydrogeology, Mineral Exploration, Tectonic Analyses, Natural Hazards) and environmental studies. / Interpretation of remotely sensed imagery in terms of spectral, spatial, contextual & temporal environmentally related features. / Analysis of functional requirements and database design for geological / environmental applications. / Digital Remote Sensing / GIS related subjects and dissemination of information on the WEB. / Understanding impacts of human activity through the analysis of multi-temporal databases and the interpretation of land cover/land use change.

Natalia Spanou (IGME) is a Geologist M.Sc. in Applied and Environmental Geology and Geophysics (Engineering Geology) at the Department of Geology, School of Natural Sciences, University of Patras, Greece. Ph.D. candidate in Engineering Geology on the Risk Assessment of Landslides (University of Patras, Greece). Scholar of the State of Scholarships Foundation. Researcher at the Laboratory of Engineering Geology (University of Patras) for 3 years participating in research projects concerning the prevention of the urban risks by in-situ observations, laboratory tests, data processing, evaluation and publication. Engineering Geologist at the Engineering Geology Department of IGME since March 2005, working on natural hazards studies (geotechnical studies and investigation of slope failure phenomena, rockfalls, creeping movements and soil subsidence), compilation of thematic maps, geological – geotechnical studies related to technical works, protection of the cultural heritage monuments and contribution to environmental protection. Deputy Technical Supervisor and Quality Responsible of Soil and Rock Laboratory of Engineering Geology Department of IGME.She is a member of the Editorial Board of "Hellenic Geosphaera", the newsletter of IGME. She has presented and published papers in Greek and International conferences on the subjects of Geology, Geotechnical Engineering, GIS and Earth Observation techniques on natural hazards' monitoring.

2.1.3. Rationale of the proposed industrial organisation

The consortium proposed by the Contractor to bid for the tender is a trade-off between EO data experts (and/or providers) and experienced scientists in the use of EO data and tools for hazard monitoring. The idea behind the consortium composition is to have a good balance between providers and users, so that the experience of one group enriches the performance of the other. Additionally, from a thematic point of view, the main thematic areas addressed by the project are fully coped with key actors: EO data processing, cloud infrastructure, usage of EO data for DRM and DRR and new missions feasibility assessment. Two levels of involvement can be established among the partners according to their participation in the project. There is a so called core group of partners that will intensively participate in many activities of the project and lead the work-packages, whereas there is another group of partners that will have a more reduced participation as expert users of EO data and processing methods and with demonstrated capabilities for the production of hazard maps and therefore, will perform a proper product evaluation and performance analysis based on the trial cases tests. The rationale of the consortium, which is described as follows, is graphically summarized in Figure 21.

The group of 5 partners in the top of Figure 21 is the core group covering the main topics involved in the project:

- ALTA is an expert in EO data processing and an EO based solutions provider for ground monitoring. It will be the prime and the leader of the innovative exploitation method based on SAR and Optical data for ground motion monitoring. ALTA has also a demonstrated experience in the development of new applications from new acquisition modes and satellite data as well in acquisition concepts demonstrations for new mission under an application point of view. Therefore it will participate also actively in the in-orbit sensors capabilities analysis and the proposition for future missions.
- CNR is an internationally known expert in landslide hazards, covering all the aspects involved at DRM and DRR, from monitoring to modelling of the event. CNR will have a double role in the consortium, in project Phase A, as expert provider of scientific requirements and contributing in the development of the methodology for the creation of hazard maps. Additionally, in Phase B it will as well be service provider regarding the processing of optical data for landslide detection and an expert user of the solution. One of the test sites proposed for the trial cases is Collazzone, a natural laboratory of CNR for landslides hazard studies. Consequently CNR will be able to provide valuable feedback about its performance and limitations. CNR will also support IGME during the generation of inventory maps and landslide hazard maps over second proposed test area.
- INGV is a well-recognized expert group in seismic hazards, familiar with the use of EO data and solutions and the synergic processing with other data for their monitoring. Similarly than CNR, INGV will have a double role in the project, contributing expert in Phase A of the project, but being as well expert user during the trial cases exploitation in Phase B which will run the trial cases and that from the measurements will produce the seismic hazard maps. The main test site for seismic hazard mapping is northern Apennines which is a natural laboratory for INGV regarding seismic hazard mapping studies. They have a lot of instrumentation and ancillary data to produce a proper evaluation of the performance provided with the proposed within the project with respect to current technology.

Therefore, CNR and INGV have a double role as represented in Figure 21 with their presence both in the upper core partners group and as expert users in the trial cases. Obviously, their feedback as experienced users will help in the refinement of the exploitation methodology.

- Terradue is a key player in exploiting cloud computing technology and solutions for Earth Sciences. They will lead the task on looking for the potential in the federation of EO data and cloud infrastructure that could benefit DRM and DRR. They will also lead the integration of the different processing modules proposed within the project on the cloud for the performance of the trial cases by the users.
- DLR has a vast experience in the conception, design and development of space missions for EO. Therefore they are perfectly suited to lead the task about new space assets proposition specially tailored for DRM and DRR.

Last but not least, there is a group of partners represented in the bottom part of Figure 21 called to be users of the exploitation methodology of EO data over areas not fully covered by EO solutions in the past. They will have their own test sites, not as a specialized in the use of EO data as those from the expert users group, and therefore their feedback will be very important since it will evaluate the usability of the exploitation methodology developed in not so optimal applications conditions. In this group of partners, two more team members are accounted:

- IGME, a national research institute that will evaluate the exploitation method in a landslides test site.
- NKUA is a University in Athens that will focus on the use of the exploitation methodology in a seismic/tectonics site.

Finally, a user board will be constituted in agreement with ESA during the phase A of the project. This group will complement the group of users already included in the project addressing similar hazards (but in other geographical locations) as well as other thematic areas. In that way, it will be possible to evaluate the capabilities of extrapolation of the proposed solution regarding the same hazards but in other locations and to other application domains. The consortium has already identified an initial list of potential users representative of different countries and regions used to work in DRR during the prevention and preparedness phase which will fit the requirements of the SoW. They are summarized in Table 6.

Table 6: Potential partners for the constitution of the user board which should be made within Phase A.

Decision-makers	National public authorities	- The Italian Civil Protrection Department - Department of Soil and Water Conservation Bureau in the Council of Agriculture set in Taiwan - National Emergency Center of Costa Rica (CNE) - National Agency for Natural Disaster Reduction (CONRED) in Guatemala - EPPO: Earthquake Planning and Protection Organization set in Greece - Indonesian National Platform for Disaster Risk Reduction
	Local authorities	- Civil Protection Department, Liguria Region, Italy
International Panels	- UN OCHA: United Nations Office for the Coordination of Humanitarian Affairs	
Technical experts/Scientific community	- EuroGeoSurveys: The Geological Surveys of Europe set in Brussels. - EPOS: European Plate Observation System	

In conclusion, the consortium allows us to cover all the important identified aspects of the project, both from the expert and the user point of view, leading to a fruitful project outcome that will certainly put some light on DRM and DRR with EO based solutions.

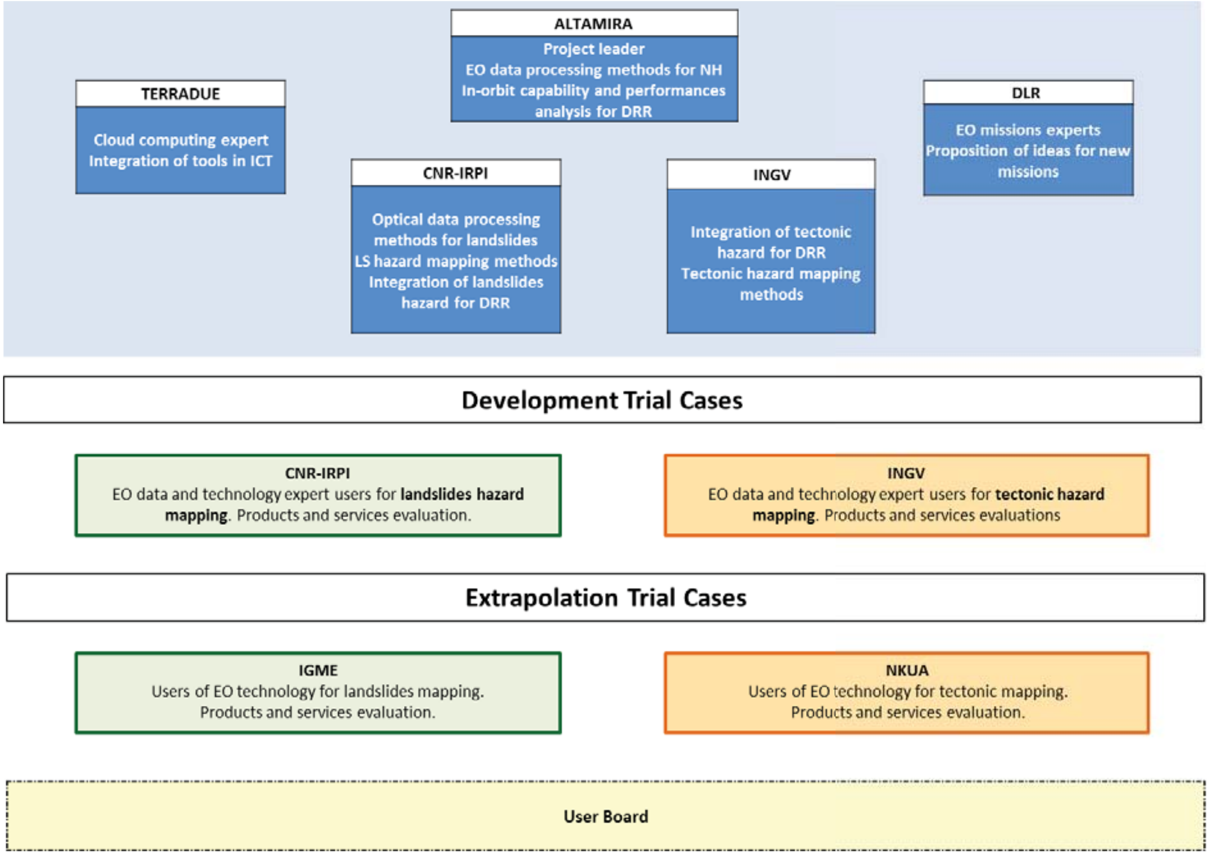

Figure 21: Consortium rationale and functional organization

2.2. PLANNING

2.2.1. Proposed schedule and milestones

The project planning has been drawn on the assumption that the starting date will be the first of February 2015. Since the project duration will be 18 months, the envisioned end of project date is August 2016. In the planning summary presented in this section, Milestones have been identified with an M and Meetings have been identified with MT. Only the relevant Milestones and Meetings are accounted in this planning, nonetheless the project management will involve minor internal milestones and progress meetings within the consortium that are not accounted at this stage. Concerning vacation periods, only the summer vacation break has been considered assuming that shorter vacations (namely Christmas and Easter holidays) won't have a significant impact in the progress development of the project.

The proposed planning for the project activities, with approximate estimated dates is as follows:

– Kick-off project activities	KO	01/02/2015
– First Meeting at ESRIN (MT1)	KO+2	02/04/2015
– Consultation with users event (M1 and MT2)	KO+4	02/06/2015
– Trial Cases Readiness Review Report (M2)	KO+5	02/07/2015
– Trial Cases Readiness Review Meeting (MT3)	KO+6	03/08/2015
– Start of Trial cases exploitation (M3)	KO+6	03/08/2015

− Summer vacation break (2-3 weeks)	KO+6	dd/08/2015
− Review of trial cases+new space assets (MT4 and M4)	KO+12	02/02/2016
− Final Review (MT5, M5 and M6)	KO+18	02/08/2016

Regarding meetings location, MT1, MT2 and MT5 will be held at ESA-ESRIN, MT3 will be conducted via telecom and finally MT4 will be held at prime contractor's premises in Barcelona.

2.2.2. Bar chart

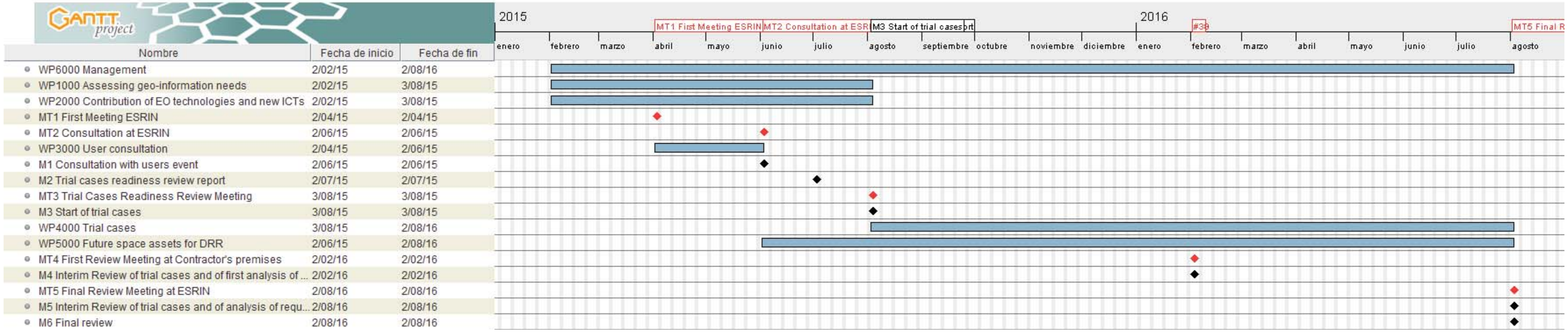

Figure 22: Project Gantt

In the Gantt diagram in Figure 22, the principal Milestones and Meetings are marked in black and red respectively. Note that Management WP6000 spans during the whole duration to fully cover project activities. First of February 2015 has been fixed as the proposed starting date, though this will depend on the tender resolution period.

2.3. LIST OF DELIVERABLE ITEMS – SPECIFICATION OF ANY NON-CONFORMANCE

2.3.1. Deliverable Items

The Contractor undertakes to convey the deliverables as stated in the SoW document. Details about versions, membership and delivery dates are provided in the table below.

Identifier	Deliverable	Type	Due
WP1000: Assessing geo-information needs			
D1.1	Baseline Report (RB)	Document	T0+3 V1 TO+6 V2 TO+18 Final
WP2000: Contribution of EO technologies			
D2.1	Contribution EO technologies and ICT solution report	Document	T0+3 1st draft TO+6 V1 TO+18 Final
D2.2	Roadmap for federation of existing ICTs	Technical Note	T0+6
WP3000: User Consolidation			
D3.1	Consultation planning document	Document	T0+3
D3.2	Report of consultation meeting	Document	TO+5
D3.3	Report of trial cases plan	Document	TO+5
WP4000: Trial Cases			
D4.1	Report of trial cases	Document	T0+12 V1 TO+15 V2 TO+18 Final
D4.2	User utility report	Document	TO+12 V1 TO+15 V2 TO+18 Final
WP5000: Future Space Assets for DRR			
D5.1	Report of the assessment of requirements	Document	T0+6 V1 TO+12 V2 TO+18 Final
D5.2	Report of the EO mission capabilities to contribute to DRR	Document	T0+6 V1 TO+12 V2 TO+18 Final
D5.3	Report of in-orbit capabilities, gap analysis and identification of new missions to support DRR	Document	T0+6 V1 TO+12 V2 TO+18 Final

WP6000: Project Management			
DF.1	Final Report	Document	T0+18
DF.2	Executive summary	Document	TO+18
DF.3	Contract closure summary	Document	TO+18

2.3.2. Non-conformances / limitations / additions regarding deliverable items

Neither limitations, nor non-conformances are foreseen at this stage with respect to the undertaken deliverables list.

Regarding additions, an extra effort will be considered for the run of trial cases in cloud computing by the users. In that way, it might be possible that some part of the EO data exploitation algorithm can be implemented in the cloud. The information about the performance improvement involved in the execution of part of the algorithm in the cloud will be appended with a dedicated chapter in the D4.2 User Utility Report delivery, widening the default scope of this delivery.

2.3.3. Background of the companies

In this section, a brief description of each partner is provided, especially relevant experience for the scope of the project.

ALTAMIRA INFORMATION

ALTAMIRA INFORMATION is an experienced Earth Observation company that offers client-oriented solutions in ground motion and mapping products to major industry sectors: Oil and Gas, Infrastructure, Mining, Insurance, Environment, Natural Hazards, and Research and Space. Specific to hydrology and water management, ALTAMIRA INFORMATION offers cartographic products such as the detection of water bodies and measurements of water heights, hydro-flattening, flooding and wetland monitoring.

ALTAMIRA INFORMATION was founded in Barcelona in 1999 and opened offices in Toulouse (France) and Calgary (Canada). ALTAMIRA team brings together 40 staff with a wide technical and scientific background on (i) Advanced SAR/InSAR developments and applications; (ii) Distributed Information Systems and Visualization applications; (iii) Operational processing of large volumes of EO data (iv) Project management at a European level and a good working knowledge of the structures and procedures of international organisations.

ALTAMIRA INFORMATION main expertise resides in the application of Synthetic Aperture Radar (SAR) especially in the field of Interferometric SAR for the monitoring of ground displacements. Its services are provided using its own advanced InSAR processing chain: GlobalSAR™. Since 2010, ALTAMIRA INFORMATION is part of CLS Group.

Background experience and reference projects

FP7 RASOR 2013-2016

- Service validation WP leader
- Update of InSAR chain to S1 data

- Methodology for cartography of flood extent and change detection method.

ESA-GMES TERRAFIRMA (Pan-European Ground Motion Hazard information service) 2005-2014:

- Project leader managing a Consortium of 22 partners, responsible for InSAR service supplier and interpretation support, and service integration
- PSI supplier
- Service integration

FP7-SAFER (Services and Applications for Emergency Response) 2008-2010:

- PSI supplier. R&D studies in new multi-sensor processing

FP7-BIO_SOS (Biodiversity Multi-Source Monitoring System: From Space To Species) 2010-2013:

- InSAR DEM supplier
- Optical data processing
- Studies to biomass detection and characterization using SAR and optical data

ESA-WB (EO services for natural hazards risk assessment) 2011-2013:

- PSI supplier
- Generation of advanced products

ESA-ERS/ENVISAT (InSAR continuity studies between ERS and ENVISAT) 2002-2003:

- Project leader
- Methodologies for phase continuity assessment and SAR data integration from two different sensors

SWOT (Surface Water and Ocean Topography) 2009-2015:

- Theoretical studies for future mission acquisition concepts
- SAR and InSAR processor and level 2 products definition
- Critical analysis of instrument parameters and processing methodologies for the evaluation of their impact in the application performances
- Simulator design and development from L0 to level 2 products based on bistatic acquisition in Ka-band
- Management of prototype development based on the use of Scrum methods (Agile)

TOPSAR MODE (Performance analysis of TOPSAR acquisition mode) 2008-2009:

- Project leader
- Theoretical studies for the performance assessment of TOPSAR mode and instrument parameters.
- Simulation of TOPSAR data
- Studies of interferometric performances of TOPSAR data with respect to SCANSAR and stripmap modes
- Prototyping of a TOPSAR SAR&INSAR processor.

SCANSAR MODE (Theoretic studies of SCANSAR mode and interferometric processing) 2007-2008:

- Project leader
- Study of theoretical basis of SCANSAR mode and the interferometric capabilities SCANSAR/SCANSAR and SCANSAR/Stripmap
- Burst synchronization requirements and common band filter methods
- InSAR processor implementation and production of SCANSAR interferograms.

Urban DEM (Production of 3D Digital Surface Models for urban areas) 2005-2006:

- Combination of optical and SAR data for the production of 3D DSMs in urban areas
- Coregistration of optical and SAR data
- Classification methodologies to optical and SAR data for object shape recognition
- Multi-baseline phase unwrapping techniques for advanced InSAR DEMs.

SAR ambiguities (Detection and suppression of SAR ambiguities) 2004-2007:

- Studies of azimuth ambiguities in SAR images and in SAR processing
- Characterization of the azimuth ambiguities depending on the instrument parameters and the processing parameters
- Development of tools and methods for the identification and suppression of azimuth ambiguities
- Analysis of impact in future missions and interferometric applications

Advanced InSAR processing methodologies 2003-2005:

- Advanced InSAR stack processing for phase artefact separation
- Implementation of a InSAR stack simulator to analyse the parameters estimation performances under different conditions of phase errors and atmospheric contributions
- Studies of optimum interferometric combinations to maximize methodology performances
- Studies for the identification of coherent scatterers

Geo-epidemologie:

- Generation of advanced and high resolution cartographic products from SAR images
- Water bodies detection based on amplitude and phase analysis of repeat passes

ESA-ENVISAT/ASAR sensor CAL/VAL support 1999-2005:

- Evaluation of instrument performances
- Support in the development of the ground segment SAR processor
- Generation of CAL/VAL products. Advanced SAR processing

ERS/ENVISAT Phase continuity studies 2002-2004:

- Definition of theoretical and demonstration studies for the analysis of the InSAR continuity between former ESA SAR mission ERS1&2 and new mission ENVISAT.
- Provision of PSI processing algorithm for merged processing and for producing long time series with ERS/ENVISAT data.

- Project leader managing a Consortium of 8 partners.
- Adaptation of SPN to use ERS/ENVISAT data.
- Definition of methodologies for phase continuity assessment and SAR data integration from two different sensors. New sensor validation activities

FP-6 LEWIS (Landslides Early Qarning Integrated System) 2002-2003:

- Radar image supplier
- PSI processing
- Methodologies for model integration in InSAR
- Development of fast response EO based service for emergencies

The Italian National Research Council (CNR-IRPI)

The Italian National Research Council (CNR) is the largest public research institution in Italy, the only one under the Research Ministry performing multidisciplinary activities. CNR's mission is to perform research in its own Institutes, to promote innovation and competitiveness of the national industrial system, to promote the internationalization of the national research system, to provide technologies and solutions to emerging public and private needs, to advice Government and other public bodies, and to contribute to the qualification of human resources.

CNR's Departments are organizational units, structured by macro – areas of technological and scientific research, with the task of planning, coordinating and monitoring research activities in the affiliated institutes, by assuring them the necessary financial resources. Each Department furthermore has its national and international relations, dealing with its macro–area of interest. Every Department decides its own research strategies and programmes, also in cooperation with other Departments, and follows up their implementation through specific research projects. An Institute affiliated to one Department, performing research in interrelated scientific fields, can participate in other Departments' projects.

The Department decides, together with its institutes, single project's scientific lines, identifying the research groups to be entrusted with the relevant research tasks, at the same time providing them with the necessary resources. Each group of researchers, in charge of carrying out a single scientific line, thus gives its contribution to the achievement of the Project goals.

The 7 Departments are: Earth System Sciences and Technologies for the Environment, Engineering, ICT and Technologies for Energy and Transport, Humanities, Social Sciences and Cultural Heritage, Chemical Sciences and Technology of Materials, Physical Sciences and Technologies of Matter, Agri-food and Biosciences, Biomedical Sciences.

Technical and scientific areas of expertise are moreover grouped in Institutes. 109 Institutes, located throughout Italy, have the task of managing programmes and implementing the scheduled research activities, coordinated by the departments. The Institutes are not dependent on the Departments but are autonomously responsible for their scientific research and duties. The geographical distribution of the Institutes, and their interdisciplinary and multidisciplinary features, enable them to contribute to the growth of regional innovation systems.

CNR participates with IRPI (Institute of Research on Hydrogeological Hazards) located in Perugia.

The IRPI – Institute of Research on Hydrogeological Hazards

The scientific activities of IRPI focus on geo-hazards and environmental problems exploiting a wide range of technologies, including Earth Observation using remote sensing and in-situ techniques for geo-hydrological applications and risk prediction, prevention, and mitigation. The Institute plays a leading role in the development and promotion of industrial research activities in the field of EO technologies for geo-hazard monitoring and assessment. IRPI is Centres of Competence for the Italian National Civil Protection Department (DPC) and plays a leading role in the development and promotion of industrial research activities in the field of EO technologies for geo-hazard monitoring and assessment.

The main activities at IRPI are:

- Technological and scientific expertise in the identification, mapping and monitoring of different types of ground deformations induced by natural processes and manmade causes.
- Advanced services useful for the detection and monitoring of ground deformations, including the assessment of the damage caused by the deformations, at different temporal and geographical scales.
- Technological infrastructure analysis and system products design;
- Exploitation of EO data capabilities, co-registration of high resolution optical images and SAR data;
- Acquisition and processing of aerial and ground-based Lidar data;
- Electromagnetic techniques for soil moisture evaluation;
- Exploitation of optical EO data for landslide detection, mapping and susceptibility zonation;
- Design of risk scenarios;
- Implementation and management of complex systems.

Background experience and reference projects

CNR's participation in the Seventh Framework Program (2007-2013) is quite large and has reached high numbers in line with those of the most important French, German and British research Centers. In May 2012 the number of projects in which CNR participates has increased to 457 and in well over 18 % of them the Council plays the role of coordinator.

IRPI is in particular currently involved in many FP7 projects related to mapping activities and risk assessment.

- FP7-LAMPRE (LAndslide Modelling and tools for vulnerability assessment Preparedness and REcovery management),
- FP7-CHANGES (Changing Hydrometereological Risk as analyzed by a new Generation of European Scientists)
- FP7-DORIS (Ground Deformations Risk Scenarios: an Advanced Assessment Service),
- INTRETTEG-IIIB RISKAWARE (Risk advanced weather to advise on risk events and management),
- ASI-MORFEO (MOnitoraggio del rischio da Frana con tecnologie EO)

Terradue

Terradue (corporation) was born in 2006 as a Web 2.0 company and always nurtured this culture. Since 2009, Terradue is accompanying the European Space Agency ESRIN transition from Grid to Cloud technology. The company has years of experience in supporting Principal Investigators in their use of EO data within state of the art Exploitation Platforms.

Terradue has an international footprint with offices in Rome, Italy and Harwell Oxford, UK, and a flexible modus operandi as a distributed enterprise, that currently offers representations in Paris, France (Business Development and coordination with EC Initiatives) and Rio de Janeiro, Brazil (Business Development and consultancy for International Institutions).

Terradue Srl (holding company) is a start-up company addressing the Earth Sciences research & education sector, with core competencies aimed at engineering distributed systems & Cloud services, providing consultancy for international organizations, and developing partners programs in support of Terradue's Open Source Platforms & Standardization strategy.

Background experience and reference projects

Relevant ESA contracts:

ESA contract	Technical Officer	Summary and lessons learned
G-POD	Olivier Colin Jordi Farrés Pier-Giorgio Marchetti	The Grid Processing on-Demand is an ESA initiated project that provides a “user-segment” putting EO data and processors together. Initiated in 2003-2004 in EOP-S, transferred in Operations in EOP-G, G-POD project has been industrialized in 2006 by Terradue Srl, which maintains, enhances and integrates scientific and operational applications processors. ESA G-POD is a generic GRID-based operational environment and infrastructure for Earth Observation applications where specific data handling applications can be seamlessly plugged into the system. Coupled with high-performance and sizeable computing resources managed by GRID technologies, it provides the necessary flexibility for exploiting an application virtual environment with quick accessibility to data, computing resources and results.
CIOP	Jordi Farrés	The CIOP project brings the concept of EO Sandbox Service where scientists or companies are provided with a Cloud based application development environment to implement and test their applications. Within the EO Sandbox, the developers will find the same environment as they have on their local workstation, and are provided with data discovery and access tools, project management tools suite (e.g. ticketing, versioning, wiki) and a document management system. Once implemented and tested, the application is then run against the full dataset series of Earth Observation data

E-CEO	Jordi Farrés Pierre-Philippe Mathieu	With the set-up of on-line contests, E-CEO offers an appealing way of conducting research, with scientists tackling new research problems in a “parallel and collaborative way”. The possibility to implement multiple processors, all within a Common Software Environment, facilitates the comparison and evaluation of different problem-solving approaches, which is one of the main requirements raised by scientific experts who develop algorithms in the Earth Observations field.
SSEP	Jordi Farrés	SuperSites Exploitation Platform (SSEP) is a cloud-based geohazards research platform that allows researchers to access geodata for natural hazards in geologically active regions, including information from Synthetic Aperture Radar (SAR), GPS crustal deformation measurements, and earthquakes. "SuperSites" consists of seven observatories collecting data from all geologically active regions of the world.
TEP-QuickWin	Sveinung Loekken	The Thematic Exploitation Platform (TEP) QuickWin is the first project to build the geohazards TEP to address the goals: deploy a complete and consistent collaborative platform; serve the QuickWin objectives of hosting data, applications and services on scalable Cloud resources; allow closer links with users to ease access to data; foster the use of Earth observations (EO) and reinforce the user needs gathering for enhanced satellite EO programs to better address the communities objectives

Main Projects

G-POD: Grid Processing on-Demand (G-POD), an ESA infrastructure available since mid-2006, provides a “user-segment” putting EO data and processors closer together. The G-POD is a hybrid Grid/Cloud based high-performance and high through-put computing infrastructure promoting the access to Earth Observation data, offering on-line access to products with attached computing infrastructure and tools to generation of scientific added value products. Terradue is responsible for the maintenance and evolution of the system and manages the integration of the ESA EO routine production processors and Principal Investigators scientific applications

ngEO: the ngEO project (Next Generation User Services for Earth Observation) of the European Space Agency (ESA) is a set of generic services: product metadata catalogue, browsing images, data access, shop-cart management, dataset/authorization/data access service management, etc for all the GMES/COPERNICUS and past Earth Observation Mission. Terradue is responsible for development of ngEO Web Server that acts as the GMES/COPERNICUS data discovery and access main decision point.

SENSYF: a FP7 project kicked-off in January 2013, and will last until the end of 2015. The project provides a specialised Sandbox Service with tools and development/validation platforms where developers are allowed to develop and test of new processing chains and methods for Sentinel and Copernicus/GMES contributing mission data on a continuous basis, and the delivery of higher-level products and services complementing the information provided by the operational services. Terradue’s responsibilities are the service integration, deployment, operations and support of the SensyF infrastructure. The backbone of the SenSyF project is provided by Terradue’s cloud platform based in the company’s experience in Earth observation data processing and applications development.

E-CEO: this on-going ESA project will allow the set-up of on-line contests and will offer an appealing way of conducting research, with scientists tackling new research problems in a “parallel and collaborative way”. It delivers a collaborative platform that trough data challenges contests will improve the adoption and outreach of new applications and methods to processes EO data. Terradue manages and develops the ESA e-Collaboration for Earth Observation platform

GENESI-DEC: the EC FP7 GENESI-DEC was a FP7 project that provided data discovery, access, processing and visualization mechanisms to several Digital Earth Communities with a strong accent on distributed infrastructures security, semantics, ontology and advanced workflow management. Terradue had a major role in the infrastructure architecture and services (data discovery, catalogue, access and processing) and performed research activities targeting the fast data access and computing resources virtualization

GEOWOW: the EC FP7 GEOWOW project addressed the challenge to evolve the GEO Global Earth Observation System of Systems (GEOSS) in general and the GEOSS Common Infrastructure (GCI) in particular in terms of interoperability, standardization and functionality, to the final purpose of providing users with improved discovery, access and usability of Earth Observation data and services. Terradue made contributions to the GEOSS architecture with special emphasis on data discovery, access and processing using the Developer Cloud Sandboxes.

MELODIES: the MELODIES project (Maximizing the Exploitation of Linked Open Data In Enterprise and Science) is a European Union (FP7) project about using diverse sources of Open Data to develop new applications and technologies that benefit society in a variety of ways. Terradue Cloud Platform applies the latest technologies in cloud computing and data-handling to exploit these data to their best advantage. Terradue’s responsibilities are the service integration, deployment, operations and support of the MELODIES infrastructure.

SSEP: the SuperSites Exploitation Platform (SSEP) The SSEP project brought together existing software components and EO data allowing geo-hazard scientists to apply their algorithms and tools to analyse the data. It represented ESA contribution to the GEO Supersites initiative. The developments contributed by Terradue comprised an instance of an exploitation platform for radar imagery in the context of geo-hazards, for the sharing of SAR data and the exploitation of interferometry processing on those data.

OWS-10: the Open Geospatial Consortium's (OGC) Interoperability Testbed (OWS-10) focused on the Performance of OGC Services in the Cloud. The activity conducted by Terradue, in collaboration with CNR-IREA (SBAS processing chain) and with grant program from Amazon Web Services Education & Government Solutions demonstrated the performance enhancements for a Cloud deployment of the processing application with the use of WPS and OpenSearch OGC Web Services for the production of On-demand Ground Deformation Maps. The deployment exploited resources from Terradue (Cloud Controller), AWS (public Cloud), Interoute (public Cloud), and the GEO Supersites Virtual Archive (Cloud Storage of massive ESA SAR data).

German Aerospace Center (DLR) - Microwaves and Radar Institute (HR)

DLR (acronym for Deutsches Zentrum für Luft- und Raumfahrt in German) is a public research organisation in Germany working in the aerospace field. The HR Institute has more than 80 years of experience in radio frequency technology and has for more than 25 years been active in microwave remote sensing. It holds leading expertise in SAR system design, operation, data processing, air- and space-borne SAR interferometry and polarimetry, innovative SAR operation modes, processing and inversion algorithms.

In 2000 the HR Institute participated in the SRTM mission with the leadership for the X-SAR project. One year later the SAR-Lupe project started consisting of a constellation of five high resolution SAR satellites operating at X-band. The HR Institute supports this project with technical consultancy in a number of system aspects, like mission planning, sensor performance estimation and simulation. A few months later the approval for the realisation of the TerraSAR-X satellite was obtained. TerraSAR-X is the first German radar satellite realized under a Public Private Partnership between DLR and EADS Astrium GmbH and launched in June 2007. Within the TerraSAR-X project the HR Institute is delivering system engineering support, holding the mission manager position and developing the Instrument Operations and Calibration System.

Building on the experience gained in more than 25 years with the successful participation in NASA's Shuttle Radar Programme and the TerraSAR-X mission, the HR Institute submitted in November 2003 the TanDEM-X mission proposal that was finally accepted in March 2006 following a successful demonstration of its feasibility during the phase A study. TanDEM-X has the objective to generate a consistent, global Digital Elevation Model with an unprecedented accuracy. This goal will be achieved by means of a second slightly modified TerraSAR-X satellite flying in a close orbit formation with TerraSAR-X. TanDEM-X was launched in June 2010, which, together with TerraSAR-X, represents the first spaceborne bistatic radar system and the first operational close formation flying system in space. In addition to across-track interferometry and bistatic SAR imaging, TanDEM-X has allowed the demonstration of several new techniques and modes like TOPS imaging, digital beamforming, super resolution, single-pass polarimetric SAR interferometry or bi-directional SAR, among others.

Background experience and reference projects

The HR Institute has participated in the last years in several ESA projects and has developed a close cooperation with the German space industry. It contributes actively to several current satellite programmes such as Sentinel-1, SMOS, BIOMASS, COREH2O, and TANDEM-L.

DLR-HR was the first to demonstrate the TOPS mode in space under a contract with the Agency. The flexibility of the phased array antenna of TerraSAR-X concerning the operational commanding allowed an efficient implementation of the TOPS mode even though this mode was not foreseen when designing the system. A first TOPS data take took place on 9th July 2007, less than a month after the start of the satellite. A second project with the Agency followed in the period 2009-2011, where several investigations in the frame of the TOPS mode were performed: verification of the TOPS prototype processor of Sentinel-1, investigations concerning the quantization of the data with a flexible dynamic block adaptive quantizer (FD-BAQ), the TOPS scalloping reduction, the high azimuth steering angles, as well as the coregistration of TOPS image pairs and TOPS interferometry. A third TOPS study with the Agency is still on-going, where more application–oriented aspects are analysed, like the coregistration in the presence of non-stationary scenes or the exploitation of image stacks for PSI applications. Similarly, the HR Institute is also involved in the commissioning phase of Sentinel-1 for its calibration and interferometric validation. All these investigations have delivered/are currently delivering very valuable inputs to the Sentinel-1 mission.

Istituto Nazionale di Geofisica e Vulcanolgia (INGV)

INGV was founded in September 1999 by merging the former Istituto Nazionale di Geofisica, the Osservatorio Vesuviano, the Istituto Internazionale di Vulcanologia, the Istituto di Geochimica dei Fluidi and the Istituto di Ricerca sul Rischio Sismico. INGV was meant to gather all scientific and technical institutions operating in Geophysics and Volcanology and to create a permanent scientific forum in the Earth Sciences. The current INGV mission focuses mainly on the observation, monitoring and understanding of geophysical phenomena in both the fluid and solid components of our planet. INGV is in charge of the surveillance of the seismicity and volcanic activity of the entire Italian country through state-of-the-art instrumental networks covering the national territory or concentrated on the active volcanoes. The monitoring systems feed a significant scientific production (over 450 in 2011) based on research teams that hold an indisputable worldwide leadership in the scientific areas of reference. Along with its own expertise on the assessment of natural hazards, INGV gives fundamental support to programs for risk mitigation at national, European and global scale. Within such a framework, INGV operates in close collaboration with the Ministry of Instruction, University and Research (MIUR) and has priority agreements with the Civil Protection Department (DPC) and with other authorities in charge of managing the emergencies, both on a national scale and on a local scale. INGV also collaborates with the Ministry of Environment, of Defence and of Foreign Affairs in the framework of national and international strategic projects.

Background experience and reference projects

APhoRISM - Advanced PRocedures for volcanIc and Seismic Monitoring: it is financed by the European Commission under the 7th Framework Programme, SPACE, Remote Sensing Methods.

MIA-VITA - MItigate and Assess risk from Volcaninc Impact on Terrain and human Activities: the project aims at developing tools and integrated cost effective methods to mitigate risks from various hazards on active volcanoes (prevention, crisis management and recovering). MIA-VITA is financed by the European Commission under the 7th Framework Programme for Research and Technological Development, Area “Environment”, Activity 6.1 “Climate Change, Pollution and Risks. 2008-2012

TERRAFIRMA ESA Extension phase: it is a Pan-European ground motion information service in support of policies aimed at protecting citizen against natural and anthropogenic ground motion hazards”. GMES Service Element, funded by European Space Agency (ESA), 2009–2012.

SAFER, Service and Application For Emergency Response: the objective of the project has been to reinforce the European capacity to respond to emergency situations such as Meteorological-driven hazards, Geophysical hazards, man-made disasters and humanitarian disasters. It was funded in the 7th Framework Programme under the Theme Space to implement the Emergency Response Core Service for GMES. 2007-2012.

SIGRIS, Integrated System for Seismic Risk Management: the project aimed at using satellite data to develop tools able to provide a contribution to the analysis of the seismic risk and its mitigation. It is funded by the Italian Space agency. 2007-2011.

PREVIEW, PREVention Information and Early Warning: the project addressed the development of Value Added information services to support the decision making process of risk management. It has been based on best results from thematic research projects, information services to be ingested in the systems of operators and users. PREVIEW was funded under the 6th Frame Program (FP6) and has represented the first Project which addressed the GMES requirements. 2005-2008.

MED-SUV project proposes the development and implementation of a state-of-the-art infrastructure for the volcanic risk management life-cycle, from the observation to people preparedness, in southern Italy. The infrastructure will rely upon the improvements of the understanding of geophysical processes underlying the volcanic systems of Vesuvius / Campi Flegrei and Mt. Etna. It will also achieve the integration of existing components, such as monitoring systems and data bases, novel sensors for the measurements of volcanic parameters, and tools for data analysis and process modeling. MED-SUV is funded under the call FP7 ENV.2012.6.4-2: Long-term monitoring experiment in geologically active regions of Europe prone to natural hazards : the Supersite concept.

National and Kapodistrian University of Athens (NKUA)

The roots of the Department of Geophysics and Geothermics date back to the late 19th century when the Chair of Seismology was established as one of the founding chairs of the University of Athens. The Department of Geophysics & Geothermics is situated at the Geology Faculty Building in Panepistimiopolis. Ever since, its major axes of contribution have been the education of students, as well as the monitoring of seismicity of the area of Greece, in cooperation with the Geodynamic Institute of the National Observatory of Athens. The large number of scientific publications in international and Greek scientific journals, the participation in conferences, the organization of international conferences, seminars and lectures and the Greek and EU research contracts, exhibit the competitive status of the Laboratory, not only on Greek, but also on an international basis.

During the last 60 years the Department of Geophysics & Geothermics has greatly contributed to the scientific advances in the field of Seismology and Applied Geophysics in Greece. In the course of its activities over the years, a better understanding of the seismicity, seismic hazard and seismic risk of the area of Greece was accomplished. Several local seismic networks were deployed, together with remeasurements of local GPS Networks, monitoring the ground deformation and seismicity and determining the seismotectonic regime of certain very active seismogenic areas.

The Department of Geophysics & Geothermics includes the Seismological Laboratory and the Geophysical Laboratory. The Seismological Laboratory is the only seismological institution in Greece certified according to the requirements of the EN ISO9002: 1994 quality system. The Geophysical Laboratory is assigned to the Department of Geophysics and Geothermics, and was established in the Faculty of Geology of the University of Athens in 1999. Its purpose is to serve and promote the educational and research needs and activities of the various faculties of the University of Athens.

The imperative need for the implementation and use of the recent applications of Space Technology in Applied Geophysics and other fields of Geosciences led to the establishment of the "Space Applications Research Unit in Geosciences", a research unit assigned within the activities of the Geophysics Laboratory and in close association to the Remote Sensing Laboratory.

The scientific expertise of the Department centers upon the following major areas: Space Application Techniques in Geosciences; Applied Geophysics; Seismology; Geothermal Exploration and Palaeomagnetism.

Background experience and reference projects

- European Plate Observing System (EPOS) Research Infrastructure and E-Science for Data and Observatories on Earthquakes, Volcanoes, Surface Dynamics and Tectonics (EU) (http://www.epos-eu.org/)
- Seismic Hazard Harmonization in Europe (SHARE), Seventh Framework programme (EU), (http://www.share-eu.org/)
- 2010-2013. TERRAFIRMA - 3: Pan-European Ground Motion Hazard Information Service. Global Monitoring for Environment & Security (GMES), European Space Agency (ESA) & EU (2010-2013).
- 2010. Ground Deformation Studies in the Central Ionian Islands (Greece) using Time Series Interferometry. European Space Agency (ESA), Type: Category 1 Project - C1P.6831 (2010)
- 2005-2008. Investigations of seismic and volcanic activity in the Lithosphere-Troposphere-Ionosphere System based on Satellite and Ground Surface Measurements, Bilateral Co-operation Greece-Russia, General Secretariat of Research and Technology (GSRT), Athens.
- 2004-2008. TERRAFIRMA: Pan-European Ground Motions Risk Assessment Service in Support of Policies Aimed at Protecting the Citizens against Natural & Anthropogenic Ground Motion Hazards. Global Monitoring for Environment & Security. European Space Agency (ESA) & EU
- 2003-2005. Crustal Deformation and Volcanic Hazard Assessment along the Hellenic Volcanic Arc (HVA), Announcement for Opportunities for Greece ESA (European Space Agency) project, (Id: AO GR 1497)

The Institute of Geology and Mineral Exploration (IGME)

The Institute of Geology and Mineral Exploration (IGME) is the national geological survey of Greece, originally founded in 1976. Its activity started in 1952 as IGSR and continued as ETHIGME (1972-1976). It is a public corporate body of private law, supervised by the Ministry of Environment, Energy and Climate Change, and is the official geoscientific adviser of the State on geo- science, minerals and energy raw materials of the Greek landmass and its adjacent continental shelf.

The IGME is the national supplier of geoscience solutions and holds the country’s geoscientific information databases. It provides objective and up-to-date geoscientific information, advice and professional services, which meet the requirements of customers in the governmental, municipal, industrial, scientific and public communities of Greece. It consists of scientists including geologists, structural geologists, economic geologists, engineering geologists, hydrogeologists, hydrologists, geochemists, geophysicists, remote-sensing experts, mining engineers, metallurgists, palaeontologists, mineralogists, petrographers, chemists, mathematicians, computer and information scientists.

The activities of Engineering Geology Department that will be involved in the program can be listed as follows:

- Natural Hazards studies (landslides, earthquakes, soil subsidence, floods, etc)
- Seismogeological and macroseismic studies in earthquake affected areas.
- Generation of thematic maps (Geotechnical, Seismotectonic, Seismic zonation)
- Geotechnical studies for urban planning, and industrial development projects.
- Geotechnical investigations and studies for civil engineering projects (road network, dams, tunnels, large buildings, pipelines, etc)

The technical facilities of IGME include a fully equipped Aggregate, Soil and Rock Mechanics Laboratory as well as drilling machine equipment. In addition, of special interest for the project will be its Computer Processing facilities which include data bases of geological and mining data, computer-based support for decision making, Geographical Information Systems and automated cartography, image analysis processing of satellite products, mathematical geological models, statistical and geostatistical procedures on related fields.

Background experience and reference projects

Project Title: Integration of remote sensing and geophysical techniques for the analysis of natural and artificial causes of reservoir induced earthquakes in the Kremasta and Marathona lakes, Sponsor: Greek Secretariat of Research & Technology – Ministry o Development, Project Co-ordinator: G Memou IGME, Project Participants: IGME, China Institute of Water Resources and Hydropwer Research, (I.W.H.R.), Duration: 1995-1997

Project Title: Study of subsurface water systems of Ionian islands., Project Co-ordinator: A. Morfis, Project Participants: IGME Second EU Structural funding BKPS Project Code 4.2.13 9561959, Duration: 1996 - 2001

Project Title: Hydrological- Hydrogeological study of Kastoria lake – Proposals for the water quantitative enrichment of the lake, Project Co-ordinator: A Stamos Sponsor: Kastoria Perfecture, Project Participants: IGME Peripheral unit of West Macedonia, Duration: 2000-2002

Project Title: URAMIS – Urban and Mining Subsidence Geo-Information Market Drivers, Sponsor: ESA, Project Co-ordinator: Solétanche Bachy (France), Project Participants: EO techniques providers: Spot Image (France), Gamma (Switzerland) and Altamira Information. Users: IGME (Institute of Geology & Mineral Exploration, Greece), BRGM (France), Geobid (Poland), Soldata (France), Solétanche Bachy (France), Budget: ESRIN Contract No 16695/02/ I-LG, Duration: Nov-30-2002 to 2003

Project Title: Landslide management along water-supply pipelines using remote sensing and GIS techniques, Sponsor: Greek Secretariat of Research & Technology – Ministry o Development, Project Co-ordinator: M Stefouli, Prof. J. Tarney, Project Participants: IGME, University of Leicester, EYDAP S.A – Water supply and water sewage / drainage of Athens, Joint Research and Technology projects Britain-Greece, Duration: 2001 – 2003

Project Title: Natural Environment & anthropogenic Impact on internal waters: Integrated surveillance methods for pollution measurement and risk assessment., Sponsor: Greek Secretariat of Research & Technology – Ministry o Development, Project Co-ordinator: E Charou, Project Participants: Demokritos Institute, DEI, Water Resources Management Research and Application Center (SUMER), Docuz Eylul University Turkey, IGME, NTUA, Duration: 03/2003 – 09/2006

Project Title: Recording and evaluation of hydrogeologic characteristics of underground waters and water bearing systems of the country (7.3.2.1) Sub-project 8: Evaluation and exploitation of subsurface waters of Ionian islands., Project Co-ordinator: X. Kouris, X. Smirniotis, Community Support Framework 2000-2006, Project Participants: IGME.

Project Title: Influence of seismic activity and rainfall to landslides. An investigation using information techniques, Informal Particiapation on the Project Co-ordinated by prof. M Sakelariou – NTUA Duration: 1-1-2005 to 31-12-2006

3. FINANCIAL PART

3.1. PRICE QUOTATION FOR THE CONTEMPLATED CONTRACT:

The total price of the proposal is 299,691.05€ (two hundred ninety-nine thousand six hundred ninety-one euro and five cents). The price is hereby defined as a Firm Fixed Price and as such, it shall not be subject to any adjustment or revision by reason of the actual costs incurred by the Contractor in the performance of this Contract.

The price is stated as being “Delivery Duty Paid” (DDP) for all deliverables, exclusive of import duties and VAT in accordance with the Incoterms 2010.

3.2. SUBCONTRACTING PLAN

Company name	Country	Prime/ Subcontractor	WP’s	Total Budget (€)	% total budget
ALTAMIRA	SPAIN	Prime	3000, 4000, 5000, 6000	118,270.43	39,46%
CNR	ITALY	Subcontractor	1000, 4110	60,210.39	20,09%
TERRADUE	ITALY	Subcontractor	2000	44,996.88	15,02%
INGV	ITALY	Subcontractor	4120	30,131.95	10,05%
DLR	GERMANY	Subcontractor	5400	30,073.60	10,04%
NKUA	GREECE	Subcontractor	4220	8,007.60	2,67%
IGME	GREECE	Subcontractor	4210	8,000.20	2,67%
TOTAL				**299,691.05**	**100.00%**

3.3. DETAILED PRICE BREAKDOWN

3.3.1. PSS costing forms

The following PSS forms are included for prime and each subcontractor in Appendix B.

- PSS A2 (Breakdown of total price per participating company or institute)
- PSS A1
- PSS A8

The profit does not exceed eight percent (8%) of the total cost.

3.3.2. Milestone Payment Plan

Table 7 etails the Milestone Payment Plan proposed based on the achievement of the defined scheduled milestones which provide landmarks for progress in the work performed:

Table 7. Milestones payment plan.

Milestone (MS) Description	Schedule Date	Payments from ESA to Prime Contractor	For Information: Payment amount to Contractor and	
			Contractor	SubContractors
Progress (MS 1): Upon successful completion of D1.1 & D.2.1	T0+6 months	89,908.75 €	35,481.13 €	54,427.62 €
Progress (MS 2): Upon successful completion of D4.1, D5.1, D5.2 & D5.3	T0+12 months	104,893.55 €	41,394.65 €	63,498.90 €
Final Settlement (MS 3): Upon the Agency's acceptance of all deliverable items due under the Contract and the Contractor's fulfilment of all other contractual obligations including submission of the Contract Closure Documentation	T0+18 months	104,888.75 €	41,394.65 €	63,494.10 €
TOTAL		299,691.05 €	118,270.43 €	181,420.62 €

Advance Payment

Prime (P)	Vendor Code	Advance Payment Euro	Offset against	Offset by Euro	Condition (if applicable)
ALTAMIRA	1000003175	Max 15%	MS 1	444,954.38	Upon signature of the Contract by both Parties

3.3.3. Travel and subsistence plan

Table 8 shows the meetings and travels planned within the project.
Detailed information of the subsistence plan for each partner can be found in the PSS A2 forms included in Appendix B.

Table 8. Meeting and travels planned within the project.

Time	Meeting	Location	Participants	Travel duration (days)
T0	KO	Frascati/ESRIN	8	1
T0+2	Progress Meeting (PM1)	Frascati/ESRIN	8	1

T0+4	User Consultation Workshop (USW)	Frascati/ESRIN	15	1
T0+6	PM2	Teleconf	10	1
T0+12	Review Meeting (RV1)	Barcelona/ALTAMIRA	10	1
T0+18	RV2 and Final Meeting (FM)	Frascati/ESRIN	12	1

4. CONTRACT CONDITIONS PART

4.1. BACKGROUND INTELLECTUAL PROPERTY RIGHTS

The following table details the intellectual property rights (IPR) applicable for items indicated in the technical part (section 1.4).

Name	Type	Source	Use	Access conditions	Use conditions	Status
SAR images	Raster		Motion Mapping	Available for processing within project	Project aims	Space Agency/ Company
Polarimetric SAR images	Raster		Classification Mapping	Available for processing within project	Project aims	Space Agency/ Company
Digital Elevation Model	Tiff		Motion and Classification Mapping	Available for processing within project	Project aims	NASA-NGA consortium
DIAPASON	Software		Motion and Classification Mapping	Available on Cloud for processing within the project	Available for running the trial cases. Software will not be distributed	Altamira-Information property.
SPN + Offset Tracking	Software		Motion Mapping	Available on Cloud for processing within the project	Available for running the trial cases. Software will not be distributed	Altamira-Information property
POLSARpro	Software		Classification Mapping	No restriction	No restriction	ESA property (open source)
Multi-temporal LIM	Shape	Collazzone (Italy)	Hazard modelling		Available on demand IRPI-CNR	IRPI-CNR property

Multi-temporal LIM	Shape	Montecastello di Vibio and Fratta Todina (Italy)	Hazard modelling		Available on demand IRPI-CNR	IRPI-CNR property
Geological map	Shape	Collazzone, Montecastello di Vibio and Fratta Todina (Italy)	Hazard modelling		IRPI CNR will use but not share	IRPI-CNR property
Landuse	Shape	Collazzone, Montecastello di Vibio and Fratta Todina (Italy)	Hazard modelling		IRPI CNR will use but not share	IRPI-CNR property
DEM	Grid	Collazzone (Italy)	Hazard modelling		IRPI CNR will use but not share	IRPI-CNR property
Structural domain map	Shape	Collazzone, Montecastello di Vibio and Fratta Todina (Italy)	Hazard modelling		IRPI CNR will use but not share	IRPI-CNR property
Geomorphological LIM	Shape	Collazzone, Montecastello di Vibio and Fratta Todina (Italy)	Hazard modelling		IRPI CNR will use but not share	IRPI-CNR property
Stereo satellite images	Tiff	Collazzone (Italy)	LIM production		IRPI CNR will use but not share	IRPI-CNR property
Stereo aerial photograph	Print copy	Collazzone, Montecastello di Vibio and Fratta Todina (Italy)	LIM production		IRPI CNR will use but not share	IRPI-CNR property
GPS	Time series and velocity	INGV	InSAR validation	Project consortium	Project aims	INGV property

Seismicity	Text files	INGV	Background data	Project consortium	Project aims	INGV property
Fault map	Shape	INGV	Base maps	Project consortium	Project aims	INGV property
Geological map	Shape	INGV	Base maps	Project consortium	Project aims	INGV property
GPS Deformation & velocity vectors deduced from local GPS networks.	Vectors	NKUA Geophysics and Geothermics Dept.	Trial Case 2, Exploration Site	Open access and shared with ALTAMIRA partner	Open use to the partners (internal), but not for publication.	Property of Department of Geophysics and Geothermics, NKUA
Accurately Relocated epicentres and associated focal mechanisms of the seismic activity in the broader area of the exploration site.	Table	NKUA Geophysics and Geothermic Dept.	Trial Case 2, Exploration Site	Open access and shared with ALTAMIRA partner	Open use to the partners (internal), but not for publication.	Property of Department of Geophysics and Geothermics, NKUA
Landslides Geodatabase		IGME	Trial Case 1, Exploration Site		Project aims	IGME property
Reports Archive		IGME	Trial Case 1, Exploration Site		Project aims	IGME property
Geological Maps Archive		IGME	Trial Case 1, Exploration Site		Project aims	IGME property
ArcGIS 10		ESRI	Mapping and Calculations			ESRI property
Measurements (GPS and Inclinometers)		Engineering Geology Laboratory –University of Patras	Trial Case 1, Exploration Site		Project aims	Engineering Geology Laboratory–University of Patras property
Measurements (GPS and Inclinometers)		Vinci	Trial Case 1, Exploration Site		Project aims	Vinci property

4.2. OTHER REMARKS ON THE DRAFT CONTRACT

We hereby state that we have read and understood all the terms and conditions of the draft contract included in the subject RFP/ITT and that we accept the said terms and conditions without any reservations.

4.3. MANAGEMENT AND ADMINISTRATIVE COMPLIANCE

Note that the requirements stated in the compliance matrix hereafter have the following code:

- MXX: Management requirement number XX.
- CXX: Contractual requirement number XX.

  FXX: Financial requirement number XX.

REQUIREMENT	COMPLIANT	REMARKS
M01 The Project Manager will be the final responsible for the efficient and successful execution of the project (SoW section 4.1.1)	Y	
M02 The Project Manager will coordinate the consortium work (SoW section 4.1.1)	Y	
M03 The communications to the Agency will be addressed to the Agency's representatives nominated in the Contract (SoW section 4.1.2)	Y	
M04 The Agency will have access to consortium internal documentation relevant to the management of the project (SoW section 4.2)	Y	
M05 The Contractor will produce and distribute the Minutes of Meeting for all the meeting held during the Contract (SoW section 4.3.1)	Y	
M06 The Contractor will maintain the bar-chart for tracking the work carried out (SoW 4.3.2)	Y	
M07 The Contractor will provide monthly reports to the Agency describing the project progress status (SoW 4.3.3)	Y	
M08 The Contractor will notify the Agency of any issue affecting the schedule and/or scope of work to be performed (SoW section 4.3.4)	Y	
M09 Technical documentation will be punctually submitted to Agency once available (SoW section 4.3.5)	Y	
M10 The Contractor undertakes to fulfil the Project Meeting Plan as described in section ¡Error! No se encuentra el origen de la referencia. (SoW section 4.4)	Y	
M11 The Contractor undertakes to be compliant with the Deliverables Plan described in section ¡Error! No se encuentra el origen de la referencia. (SoW	Y	
C01 The duration of the project activities will be 18 months from KO date (SoW section 5.1)	Y	
C02 The work activities will feature the Milestones defined in section ¡Error! No se encuentra el origen de la referencia. (SoW section 5.2)	Y	
C03 The contractor has submitted the proposal documentation required by the Agency: Cover Letter and Detailed Proposal (Request for Proposal document pg 2)	Y	
F01 Total price of the project proposal presented by the Contractor remains within the 300 k€ limit (Request for Proposal document pg 3)	Y	

4.4. CONTRACT COMMUNICATIONS

This section provides information of the persons who would responsible on the Contractor's side for all communications concerning the technical and contractual management in case of contract award.

For technical matters to:

Dr. Javier Duro

Tel: +34 93 183 57 50

Fax: +34 93 183 57 59

E-mail: javier.duro@altamira-information.com

with copy to: Ms. Maite Garcia

E-mail: maite.garcia@altamira-information.com

For contractual and administrative matters to:

Dr. Alain Arnaud

Tel: +34 93 183 57 50

Fax: +34 93 183 57 59

E-mail: alain.arnaud@altamira-information.com

with copy to: Ms. Maite Garcia

E-mail: maite.garcia@altamira-information.com

APPENDICES

Appendix A: Letters of authorisation

Appendix B: PSS forms

Appendix C: List of Figures

Appendix D: List of Tables

APPENDIX A – LETTERS OF AUTHORISATION

National Research Council
RESEARCH INSTITUTE FOR GEO-HYDROLOGICAL PROTECTION

IRPI - CNR - IRPI	
it: . Cl:	F:
N. 0003232	12/12/2014

To Altamira Information

Att: Alain Arnaud
Chief Executive Officer
Còrsega 381-387
08037 Barcelona
Spain

Perugia, 10 December 2014

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+)

Dear Mr. Arnaud,

I, the undersigned, Mr Fausto Guzzetti acting as legal representative of Istituto di Ricerca per la Protezione Idrogeologica (IRPI) del Cosiglio Nazionale delle RIcerche (CNR) hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Sincerely,

Dr. Fausto Guzzetti
IL DIRETTORE
Dott. Fausto Guzzetti

FAUSTO GUZZETTI • CNR IRPI • VIA MADONNA ALTA 126 • 06128 PERUGIA • ITALY
TEL. +39 075.5014429• FAX. +39 075.5014429• HTTP://WWW.IRPI.CNR.IT/ • EMAIL DIRETTORE@IRPI.CNR.IT

To Altamira Information

Att: Alain Arnaud
Chief Executive Officer
Còrsega 381-387
08037 Barcelona
Spain

Rome, December 11th 2014

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+)

Dear Mr. Arnaud,

I, the undersigned, Mr. Fabrice Brito acting as legal representative of Terradue Srl hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Sincerely,

Fabrice Brito

Contract Administration Oberpfaffenhofen /
Earth Observation and Aeronautics

DLR **Deutsches Zentrum für Luft- und Raumfahrt**
German Aerospace Center

DLR e. V. Project Administration and Project Controlling
Oberpfaffenhofen, Postfach 11 16, 82230 Wessling, Germany

To Altamira Information
Att: Alain Arnaud
Chief Executive Officer
Còrsega 381-387
08037 Barcelona
Spain

Your reference AO/1-8130/14/F/MOS
Your letter
Our reference 3 012 060
Your correspondent Katja Sachs
Telephone +49 8153 28- 2695
Telefax +49 8153 28- 1972
E-mail katja.sachs@dlr.de

09th December 2014

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+)

Dear Mr. Arnaud,

we, the undersigneds, Mr. Helmut Süß and Mrs. Katja Sachs acting as legal representative of DLR - German Aerospace Center hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Yours sincerely,

i.V. Helmut Süß

i.V. Prof. Dr. H. Süß
(Head of Department Reconnaissance And Security)

K. Sachs

i.A. K. Sachs
(Contract Administration Oberpfaffenhofen)

I - 00143 ROMA
Via di Vigna Murata, 605
e-mail: presidente@ingv.it
Tel.: (39)-06-51860465
Telefax: (39)-06-5041287

Il Presidente

Istituto Nazionale di Geofisica e Vulcanologia

Istituto Nazionale di Geofisica e Vulcanologia
AOO INGV
Protocollo Generale - U
N. 0022274
del 09/12/2014

Dott. Alain Arnaud
Chief Executive Officer
ALTAMIRA INFORMATION
Còrsega 381-387
08037 Barcelona
Spain – E -

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+).

Dear Mr. Arnaud,

I, the undersigned, Prof. Stefano Gresta acting as legal representative of Istituto Nazionale di Geofisica e Vulcanologia, INGV, hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Sincerely,

Rome, - 9 DIC. 2014

IL PRESIDENTE
Prof. Stefano Gresta (... GRESTA)

NATIONAL CENTER OF SUSTAINABLE DEVELOPMENT (N.C.S.D.)

Legal Entity of Private Law under the auspices of the Ministry of Environment, Energy and Climate Change (CMD 25200/2011)

1, Sp. LOUIS St., OLYMPIC VILLAGE, ACHARNAE, P.C. 13677 TEL.: +(30)213 1337000-2, FAX: +(30)213 1337015

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION

1, Sp. LOUIS St., OLYMPIC VILLAGE, ACHARNAE, P.C. 13677 TEL.: +(30)213 1337000-2, FAX: +(30)213 1337015

To Altamira Information

Att: Alain Arnaud
Chief Executive Officer
Còrsega 381-387
08037 Barcelona
Spain

A.Π. 6021
Athens, 08/12/2014

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+)

Dear Mr. Arnaud,

I, the undersigned, Mr Nikolaos Nikolaou acting as legal representative of Institute of Geology and Mineral Exploration (IGME) hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Sincerely, On the behalf

Dr. G. Economou
Director of [illegible]

Nikolaos Nikolaou

NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS
FACULTY OF GEOLOGY & GEOENVIRONMENT

Panepistimiopolis - Ilissia
Athens 157 84, Greece
Tel. : +30 210 727 4424, 210 727 4368
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To Altamira Information

Att: Alain Arnaud
Chief Executive Officer
Còrsega 381-387
08037 Barcelona
Spain

December 14, 2014

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+)

Dear Mr. Arnaud,

I, the undersigned, Professor Nikolaos Voulgaris, Head of Faculty of Geology and Geoenvironment, acting as legal representative of National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Sincerely,

Professor Nikolaos Voulgaris
Head of Faculty of Geology and Geoenvironment

HELLENIC REPUBLIC

National and Kapodistrian University of Athens

SPECIAL ACCOUNT FOR RESEARCH GRANTS
SECRETARIAT OF THE RESEARCH COMMITTEE

Address	: 6 Christou Lada str., 10561, Athens, Greece
Information	: P.Papagianni
Tel.	: + 30 210 369379
Fax	: + 30 210 3689008
Email	: rc@elke.uoa.gr

Athens, 04/12/2014

To : Altamira Information

Att: Alain Arnaud
Chief Executive Officer
Còrsega 381-387
08037 Barcelona
Spain

Subject: Authorization to submit the proposal MEMpHIS "Multi scalE and Multi Hazard mappIng Space based solutions" under the call AO/1-8130/14/F/MOS "Disaster Risk Reduction using innovative data exploitation methods and space assets" for the category ESA EXPRESS PROCUREMENT (EXPRO+)

Dear Mr. Arnaud,

I, the undersigned, Prof. Theodore P. Fortsakis, Rector, acting as legal representative of National and Kapodistrian University of Athens hereby declare that:

We are interested in participating in MEMpHIS project and submit together with Altamira Information the proposal related to "Multi scalE and Multi Hazard mappIng Space based solutions".

We accept that this proposal is submitted on our behalf by Altamira Information.

If the proposal is successful, we agree to enter into a Consortium Agreement according to the project plans and conditions stated in the proposal, to comply with the terms and conditions of the Contract and to ensure the proper execution of our respective share of the Services.

Sincerely,

Theodore P. Fortsakis

APPENDIX B – PSS FORMS

APPENDIX C – LIST OF FIGURES

APPENDIX D – LIST OF TABLES