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RAPID ANALYSIS AND SPATIALISATION OF RISK

RASOR Final Report

RASOR

RAPID ANALYSIS AND SPATIALISATION OF RISK

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2 Final publishable summary report

3 Abstract

RASOR services to specific user segments and geographic areas. In essence, RASOR will improve risk assessment by serving as an information integrator for satellite and in-situ data at local, national and international levels. It will provide a robust backbone for multi- hazard, end-to-end, full-cycle disaster and risk management. RASOR acts on each element of the risk equation, offering regularly updated hazard information, up-to-date and complete exposure data and dynamic vulnerability evaluation. Within this context the first fifteen months of the project served to develop all algorithms and the first alpha version of the Platform to be used at the End User Workshop.

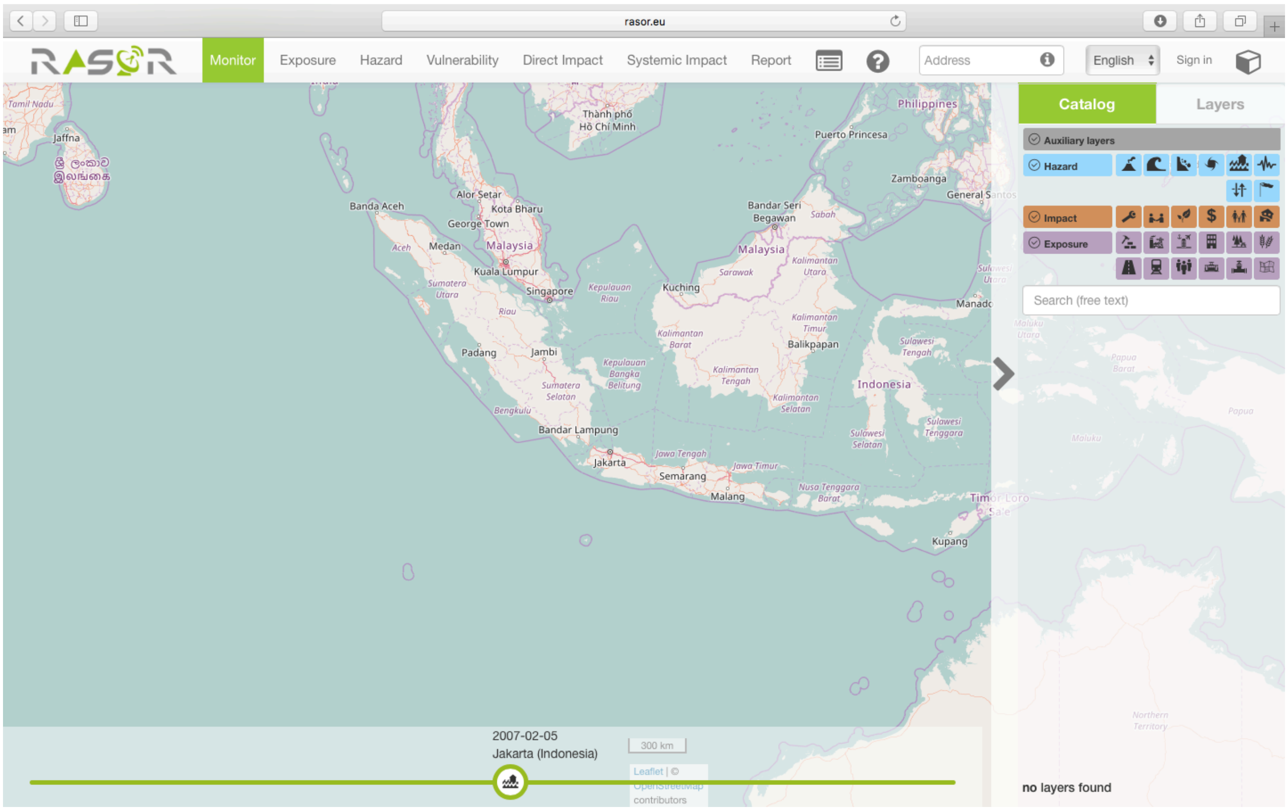

Figure 1 The RASOR platform

4 Summary description of the project

Over recent decades, there has been a dramatic rise in disasters, and their impact on human populations. Rapid climate change has brought changing weather patterns, making risks increasingly difficult to understand and changing the ways in which hazards interact with each other. Growing populations, particularly in coastal areas, have increased vulnerability. According to UNISDR, from 2000-2012, disasters killed 1.2 million people, affected another 2.9 billion people and caused damages of US$1.7tr (~€1.2tr).

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RAPID ANALYSIS AND SPATIALISATION OF RISK

Europe's Copernicus programme is implementing a number of services related to climate change and to emergency management. In this last arena, Copernicus now offers both rapid and risk & recovery operational mapping products for authorised users on a global basis. There is to date however no tool to integrate these diverse products and existing background data in a single work environment. RASOR supports comprehensive risk
assessment, before disasters occur, and the generation of new risk information during and immediately after disasters.
Over the past decade, considerable progress has been made in the application of satellite data to disaster management. The advent of the International Charter Space and Major Disasters in particular has led to a much wider availability of data and related products during the response phase of the disaster cycle. European initiatives such as the Copernicus Emergency Management Services are introducing new standards for how
satellite data can be quickly brought to bear to save lives and assess damages. RASOR augments these data with complementary archived and near real-time high resolution
optical and radar satellite EO data.

The Rapid Analysis and Spatialisation Of Risk (RASOR) project has developed a multi-hazard risk analysis platform to support the full cycle of disaster management. RASOR provides up-to-date hazard information across floods and geohazards, up-to-date exposure data from known sources and newly-generated EO-based data, and information on vulnerabilities. RASOR also adapts the newly-developed 12m resolution global TanDEM-X Digital Elevation Model (DEM) to risk management applications, using it as a base layer to interrogate data sets and develop specific disaster scenarios.
RASOR overlays archived and near real-time very high resolution optical and radar satellite data, combined with in situ data for both global and local applications. A scenario-driven query system allows users to project situations into the future and model multi-
hazard risk both before and during an event. Managers can determine the extent of flooding in a given area and calculate, for example, the risk pending on critical infrastructure systems in terms of their residual functionality. Public authorities can
determine the impact of coastal subsidence on flood defences over several years, given several sea surge scenarios and based on actual, accurate subsidence information. RASOR allows managers to use real historical scenarios when determining new mitigation or prevention measures, and integrate new, real-time data into their operational system when organising response activities.
The RASOR consortium currently offers three tracks of services based on adding value through customised exploitation of the RASOR tool for risk management and insurance markets: a global risk assessment service, and SME-led national and local services
through innovative partnering arrangements in each national marketplace. These tracks have been validated in five different geographic locations (Haiti, Indonesia, Italy, Netherlands and Greece) with end users and practitioners, as well as with
international organisations (World Bank/GFDRR, UNOSAT and Munich Re). For each of these tracks, RASOR offers tools adapted to both expert users and policy and decision makers.
The services offered by RASOR tools can produce detailed and accurate risk information very rapidly, in hours and days for updates to risk assessments, rather than weeks and months. RASOR also offers either standalone remotely-sourced analysis, or the merging of satellite EO and detailed in situ data sets, according to the needs of the client or end user. This is achieved by investing in the convergence of the latest generation of satellite data and related technology. Technologies able to reach higher levels of accuracy than ever before have become available, but have yet to be applied in a comprehensive manner to address risk assessment.

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RASOR combines a number of global data sources with tailored or targeted data sets and new technologies. For instance, one of the challenges to applying Digital Terrain Models (DTM) to real flooding scenarios has been the unavailability of a standard DTM at a sufficient level of resolution. Low resolution options such as the STRM 90m DEM are globally available free of charge, but offer limited use for flood modellers in many geographic areas, either because of the errors in water flow or the inability to distinguish
critical urban infrastructure.
With the advent of commercially available DEMs at higher resolution such as the TanDEM-X DEM at 12m resolution, significant progress in risk assessment becomes possible.
TanDEM-X provides a global and homogenous data set and greatly improved spatial and vertical resolution. Recent analysis comparing DTMs ranging from 1m to 90m resolution have shown that DTMs offering around 10m resolution are very useful for flood modelling, with 50m and 90m models being too coarse and 1m models requiring too much computation time for only marginally better results.

RASOR innovates by:
- Tailoring the 12mTanDEM-X DEM to risk management applications;
- Integrating SAR and optical high resolution imagery from archives and in near real-time, to generate standardised hazard and exposure products;
- Using scenario-based modelling to identify systemic risk and model potential structural measures; and
- Integrating previously disparate tools and products into a highly accurate and flexible decision making support tool.

5 Description of the main S & T results/foregrounds.

5.1.1 The Need for RASOR

Space-based assets have a compelling role to play in the development of services to meet global challenges. It is increasingly evident that risk and disaster management rank as one of the chief challenges facing global decision makers. Rapid climate change has brought increased uncertainty into weather and water cycle patterns, just as growing populations and rapid land use change have strained an already challenged global infrastructure. The result is a dramatic rise in the number and impact of large-scale disasters.
In 2010, disaster events caused the death of almost 300,000 people, affected another 220 million and resulted in more than $120 billion in economic damages. Impacts of disaster events on economic and human lives are increasing every year due to growing urbanisation and an increase in the number and severity of weather-extreme events; by 2050, the number of people exposed to storms and earthquakes in large cities could double and by 2100, damages from weather-related hazards may triple. While 2011 saw a drop in fatalities (29,782), the damages tripled to over $366 billion (cf. Figure 2, below). The Japanese earthquake and tsunami of March 2011 accounted for over half these damages on its own. Some 206 million people were affected by disasters in 2011, including 106 million by flooding and 60 million by drought, mainly in the Horn of Africa. 2012 gave rise to another series of disasters, including the Brahmaputra floods in India, floods in Nigeria and southern Russia, earthquakes in northern Iran and Italy and most recently hurricane Sandy on the US East Coast.

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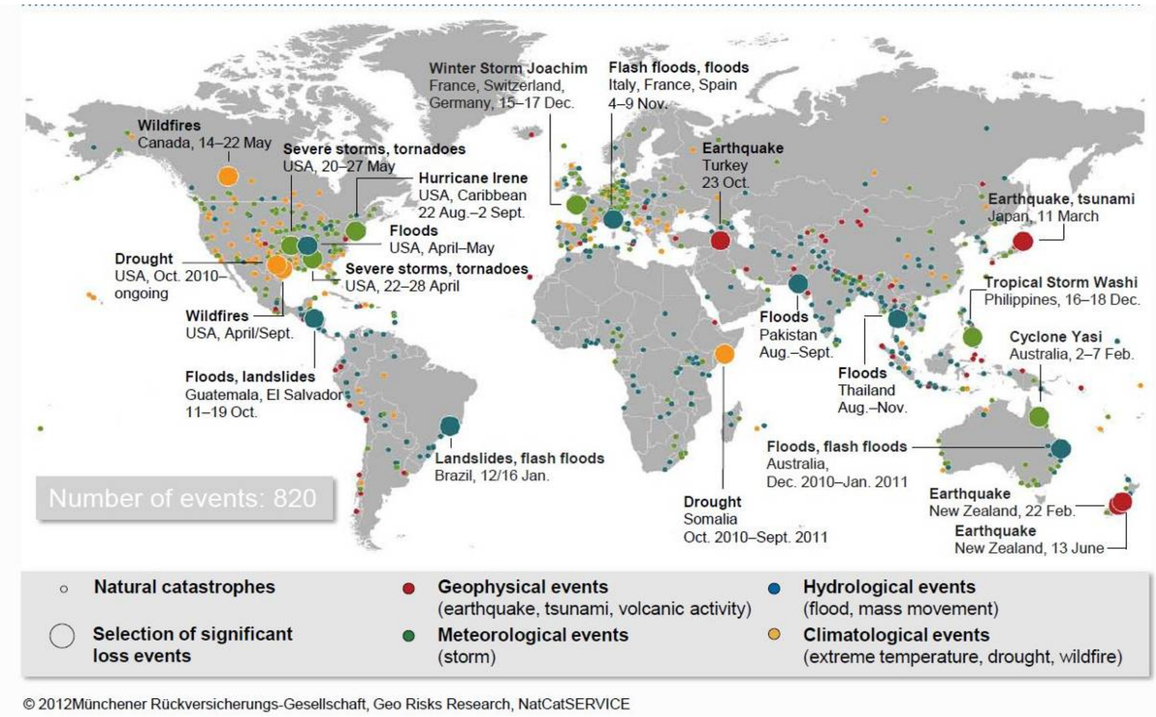

Figure 2 Disasters caused by Natural Hazards – Global Distribution 2010-2012

There is little doubt that improved risk and disaster management offer socio-economic benefits to governments. What is less developed is the growing realisation that this also represents a huge commercial opportunity for those that can bring real solutions to the emerging marketplace. Potential clients for such services include national and regional governments (civil protection agencies, the European Commission), international organisations concerned with development and risk management (the World Bank, UNDP, UNISDR) and a growing number of private sector organisations (including the global insurance and re-insurance sector and their suppliers such as global modelling companies (e.g. RMS)).

As the world faces strong challenges through the need to adapt to climate change and its many impacts, satellite-based Earth observations offer scope and coverage unparalleled by other technologies. It is however in their integration with existing systems and the combined use of space-based technologies and in-situ data that some of the greatest challenges are to be met. Currently, the use of satellite-EO is applied on an ad hoc basis to risk assessment, and rapid damage mapping. The full capability of new data sets such as high-resolution DEMs are not enough exploited, and require research and development efforts to adapt the DEMs to these applications. The different tools available are not used in conjunction as no organisation has made the necessary investment to bring these technologies together, harnessing them in a single platform that integrates space and in-situ data to support multi-hazard risk management.

A number of well-planned services are going forward under COPERNICUS/GMES, relating to the marine environment, the atmosphere, climate change and security. These services have clear outputs that are relevant to RASOR and have been integrated in the RASOR model.

The RASOR product and its associated services offer a critical innovation to the existing global disaster management marketplace for real clients such as the insurance industry and national disaster management agencies: they present an integrated offering with tailored information products and services rather than isolated data sets and DEMs. Interviews conducted during the RASOR development process confirm that specific data sets such as new DEMs cannot be integrated directly into existing risk management systems. DEMs must be married with other data sets for

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information extraction and analysis either in a new system or as an export layer integrated into existing systems. RASOR is designed to provide both of these. RASOR can be queried along thematic lines (by hazard), along scenario lines (e.g. effects on critical functionalities), along geographic lines (e.g. multi-hazard analysis in a given town, region or country) or any combination thereof.

5.1.2 Progress beyond the state-of-the-art

The objective of RASOR, i.e. to deliver tools for calculating and visualising multi-hazard risk, is not new. Several methods and techniques have been developed in the last two decades for evaluation of current risks. RASOR however benefits from technological elements now ready to support operational services with regard to full-cycle disaster monitoring. RASOR invested in the integration of key new elements that make EO data much more valuable than before to end users, especially: 1) a globally available high resolution DEM adapted to risk management applications; 2) leading edge simulation techniques to forecast effects based on real observations and advanced modelling; 3) rapid computation techniques to perform real-time and near-real time analysis using large volumes of data; and 4) a wide range of COPERNICUS/GMES-funded sector specific products that are integrated as information layers in the RASOR platform.
RASOR developed a quantitative risk assessment methodology mainly focussed onto risk identification and analysis as a support for risk evaluation done by the End Users. RASOR starts from the basic terms of the risk equation Hazard, Exposure and Vulnerability and combines them into a specifically designed platform, that enables an easy way of building risk scenarios referring to multiple hazards (e.g., floods and Earthquakes), focusing on specific exposure characteristics (e.g., Population, Environment, Economy) and on specific phases of DRR (e.g., Prevention, Recovery).
Although the major innovation has been achieved by the combination of the different factors and from the exploitation of the new possibilities offered by the new generation of global DEMs, each of the component has been produced by cutting edge methodologies that make the best out of models and Satellite sensors available at present and in the near future (with particular focus on the Sentinel Constellation and high-resolution commercial satellite systems).

5.1.3 Global DEM: a key factor for improved risk analysis

An improved Tandem-X DEM adapted to risk assessment applications in a multi-hazard concept represents one of the main achievements of the project.
Global topography is mainly derived from space borne imagery either by stereo matching or by SAR interferometry. Well-known missions are the Shuttle Radar Topography Mission (SRTM) using SAR interferometry, ASTER and CARTOSAT (stereo matching of optical imagery). The most recent and sophisticated SAR interferometry mission, TanDEM-X is already making available elevation data at high spatial and vertical resolution globally.
Common to all these global missions is that they mainly provide surface information – relief and land cover. High resolution laser scanning e.g. enables a separation of terrain surface and land cover as when first and last pulse information is recorded. But such data sets are only available on local to regional scale. While DTMs provide the best possible background for risk assessment, high resolution DEMs can accurately serve as a substitute in most cases.
The focus of this project has been the post-processing of the un-edited TanDEM-X DEM in order to correct for distortion effects. Different editing levels have been developed, demonstrated and evaluated in order to identify the best cost-benefit ratio for the purpose of risk assessment and disaster preparedness.

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The existing post-processing functions have been adapted and further developed to consider the characteristics of the TanDEM-X high-resolution large area covering data set. In particular, this include the consideration of water flow and improved outlier testing (pit removal) and DEM filtering (break line preservation). The TanDEM-X Water Indication Mask contains for each pixel the results of the coherence and radar backscatter analyses of every data set that covered the corresponding area. This data set have been analysed in order to extract a reliable indicator for water surfaces to support an automated water flattening process.

5.1.4 Hazard: the challenge of a multi-hazard approach

Hazards have historically received the highest attention in the research world. Hazard mapping is mature and provides a solid basis for risk assessment studies.
RASOR has mainly focused on floods with different declinations (i.e. riverine floods, coastal floods, tsunamis and storm surges) and on geo-related hazard (i.e. volcanoes, earthquakes and subsidence); it has tested and demonstrated the multi-risk validity of the methodology developed.
Flood hazard encompasses both riverine floods, coastal flooding and tsunamis, this last one representing the natural link and transition to seismic hazard. For floods, the project has used the highest standards possible of modelling. RASOR allows the possibility of developing hazard scenarios as well as the reproduction of historical events; this constitutes a major improvement in the prevention phase where the possibility of evaluating mitigating solutions is needed as well as the need to take into account effects of climate change. In that respect, coastal flooding risk is exacerbated by two slow-onset treats: subsidence and climate change; the first increasing assets exposure and the second increasing the flooding hazard. RASOR has demonstrated the importance of mixing subsidence monitoring with costal flood modelling in Jakarta where the platform allows to consider different historical and future conditions of coastal elevation.
In the case of earthquakes, hazard is a geological fact: Horizontal Peak Ground Acceleration (PGA), the main hazard parameter, can be estimated on a long temporal scale, but little can be done to reduce the hazard. RASOR enables the possibility of reproducing shake maps of historic events and of possible future scenarios and also the assessment of variation in the evolution of the seismic hazard conditions during long the aftershock sequences period, considering earthquake triggering phenomena. This theme received much attention after recent events (e.g., the 2011 Christchurch and the 2012 Emilia-Romagna earthquake) and generate important information for both for institutional and private players, especially for the recovery phase.
RASOR makes the most out of the combination of satellite and in-situ data for the assessment of indirect seismic hazards, as co-seismic ground deformation, seismically induced gravitational mass movements, ground breakage and surface faulting, and soil liquefaction. These products evaluate the total risk level caused by the simultaneous presence of more than one such hazards, and also non-seismic hazards as subsidence and coastal flooding.
The novelty of the RASOR approach is however in the combination of different hazard models. A good example is offered by the Italian case study where the influence on hazard and risk conditions with regards to floods have been evaluated after the Earthquake of 2012 that damaged part of the complex flood protection system of the Po river.

5.1.5 Exposure: a fundamental link to the multi-risk dimension

Characterisation of assets have developed with emerging observation techniques from space-borne sensors, however its use for further vulnerability assessment is often hampered by lack of completeness and in many fields (such as insurance applications) assets correct geolocation remains a challenge.

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RASOR has worked in the direction of overcoming two major limitations:
• exposed elements must be properly geolocated, identified and stratified with reference to their vulnerability to the respective hazard, taking into account the different facets of vulnerability (holistic approach);
• vulnerability characterisation must take place in a multi-hazard context.

Many times, only one hazard is taken into consideration when exposed elements are mapped, while a minor incremental effort would greatly increase the utility of the tool. A clear example of that is seismic risk, where major attention has been given to asset mapping, but rarely in a multi-risk framework despite the fact that some of the seismic exposure information is also relevant to other types of hazards, such as presence, location, and height of buildings, that can be used in both seismic and flood risk computation.
RASOR defined a standard taxonomy that started from the GEM taxonomy for earthquake expanding this to other perils.
In addition, RASOR merged approaches to extract exposure and risk information from a common source (i.e. Very High Resolution satellite images/radar reflectivity maps, ancillary data such as a high-density DEM, aid and combination with VHR optical satellite imagery) and the ability of collecting information with mobile devices in the field. All this is made possible at different scale: from the building scale to different level of administrative boundaries.

5.1.6 Vulnerability as the basis for effective risk scenario development

Vulnerability assessment is considered as one of the major contributions achieved in the RASOR project. A poor vulnerability characterisation hampers the development of long-term policies and non-structural finance-based mitigation frameworks (e.g. insurance products). As a result, DRR policies are ineffective.
Vulnerability assessment is often lacking of completeness in more than one direction:

- Many times only one hazard is taken into consideration (already elaborated for exposure);
- Direct damage is often the only variable taken into account, although in many cases (such as for floods) indirect damage is by far dominant;
- In order to develop risk management plans in the prevention/preparedness phase, the interaction of the specific hazard with the social texture needs to be described and the concept of social vulnerability taken forward;
- Vulnerability almost never considers the “residual functionality” of the different assets which in normal and emergency conditions provide services to the urban/social system.

RASOR elaborates on all of the above-mentioned points, but focuses on the last.

RASOR supports a complete classification which accounts for different subsystems: historical and artistic heritage (churches, museums, monuments, etc.), public buildings, the school system, health care, industrial plants, road and rail networks, lifelines and pipelines (water, electricity, sewer, gas, petroleum and telecommunications), environmental issues, etc.
The physical vulnerability of these exposed elements in relation to extreme events is described by families of curves, which provide the percentage of loss depending on specific parameters (e.g. for floods, the hydraulic depth). However, these curves provide a value of physical impairment that does not necessary match functional loss. RASOR also methodologically supports the use of

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functionality curves where each element has an intrinsic functionality that may depend on external physical damage or on damages to the content. This is clear if we consider a hospital, where damage to medical equipment results in a loss of functionality. When preparing a prevention plan, during emergency and post-event management, it is necessary to know not only where the elements in critical condition are located, but also if those elements are more or less important. This information is also used to define a hierarchy in recovery activities. RASOR grades the "importance" of the element depending on its economical, social, cultural or environmental value. This can be used to analyse critical nodes with respect to different objectives (e.g., saving lives / Emergency Plans, reducing economic losses / Risk reduction plans).

5.1.7 Interoperability: a cornerstone of the RASOR Platform

Interoperability is a mandatory requirement when developing new tools, algorithms and methodologies, especially when they need to be combined into a platform to be fully exploited. RASOR has Interoperability and interconnection of the data processing and delivery systems at the heart of its development and took into account harmonisation policies, directives such as INSPIRE, and standardisation initiatives (e.g., OGC, or guidelines from GEO and GEOSS).
Interoperability in RASOR guarantees:

- improved accessibility to long-term data archives, implementation of meta-data standards,
- actions to facilitate information retrieval and dissemination;
- improved accessibility to satellite and in-situ systems;
- adoption of open standards for data documentation, data models and services;
- integration of tools and services allowing anybody to query, view access and trade the information held by distributed public and private bodies.

More specifically, RASOR interoperates with COPERNICUS/GMES services (specifically all EMS services like the rapid mapping and risk & recovery services). Full compatibility with previously EU financed ICT research infrastructure (e.g. DRIHM – www.drihm.eu). RASOR integrated in full with other established initiatives in the DRR field (e.g. Geonode).

5.1.8 Scenario building to characterise risk

Scenarios are the key information that enables Risk Identification and Analysis, guides prevention actions and improved reconstruction in the aftermath of a disaster. RASOR extends the concept of scenarios going beyond pure damage assessment introducing the concept of targeted scenarios for the identification of critical nodes and links in the system, giving indication of social vulnerability and coping capacity. However, scenarios are not the ultimate goal of RASOR. RASOR enables the use of impact scenarios on prevention plans and reconstruction prioritisation as well as investment planning. RASOR, differently to other projects dealing with multi risk approaches, will not addressing multi-risk just by layering on top of one another multiple hazard layers and exposure; RASOR integrates hazards deriving from different perils to produce new integrated hazard maps (e.g. mixing coastal flooding models and subsidence or seismic damage on defences and flood modelling) and ultimately assesses vulnerability in a holistic fashion.

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5.1.9 The heart of the system – the RASOR Platform

RASOR is a web-based platform used to analyse risk. The platform is the most evident achievement of the project and represent the technological tool that gathers the RASOR Community of Practice. Users can examine hazard information, exposure information and vulnerability information, and simulate actual events to determine possible impacts, in terms of both direct damage and other impacts: cultural/social, environmental or systemic. Users also have access to historical records showing past events, which can be used to simulate the current impact of the same event or as a basis for new simulations. This rapid analysis can be performed in minutes and updated several times over several hours. It's the ability to change key parameters and quickly re-run simulations that enables RASOR users to model the specific impact of dedicated risk reduction measures. In this way, RASOR users can prioritise government or private sector investment in risk reduction. Previously run scenarios can also be accessed in real time during an event to better estimate damage and plan response efforts. RASOR users can also work offline in QGIS to change information layers or use a RASOR mobile app to update exposure information or track the extent of a flood, and upload historical flood delineations. The RASOR mobile app could also be used to track near real-time information during an event and can be shared with other users once uploaded to the platform. RASOR overlays archived and near real-time, very high resolution optical and radar satellite data, combined with in situ data for both global and local applications. As a global base layer the RASOR platform uses the Global DEM (digital elevation model) provided by Airbus Defence and Space, a 12m horizontal/1m vertical resolution DEM that allows users to work from up-to-date and well-resolved topography globally. Managers can, for example, determine the extent of flooding in a given area and assess risk to critical infrastructure systems in terms of the residual functionality of a given system (e.g. energy, transport, health). Public authorities can determine the potential impact of sea surge scenarios and their effects on flood defence infrastructure. RASOR allows managers to use real scenarios when determining new mitigation or prevention measures, and integrate new, real-time data into their operational systems during response activities. For example, users can access a database of historical hurricane tracks in the Caribbean to simulate past events or model new ones using a simple drag and drop system.
Initially, RASOR was available over six case study areas in Haiti, Western Java, Malawi, Italy, Greece and Holland. The RASOR Consortium is working to broaden the functionality over these areas and increase the geographic coverage. The platform can also be made available over other areas; however, users must bring their own datasets to enable platform functionality. This work is being co-ordinated through the RASOR Global Community of Practice. Ultimately, the RASOR Consortium will offer global services to support in-depth risk assessment and full cycle risk management.

6 Potential impact, main dissemination activities and exploitation of results

RASOR has both a strong impact on the European market and on the efficiency of final user decisions.
The SME-driven approach adopted by RASOR has brought world-leading organisations together around a single platform where the best of their knowledge is used to integrate previously successful more narrowly focussed products. Apart from the SME participating already as partners to the realisation of the Platform, RASOR successfully attracted other SMEs as partners for the commercial phase (e.g. TRE that now is joined with Altamira and Geoville) and of big industries such as Airbus DS. In addition, more than 80 organizations participate to the RASOR Community of Practice and have an account onto the RASOR Platform. The integration of products coming from different sources opens new markets, such as the insurance market, which cannot ingest products currently coming out of the COPERNICUS/GMES programme, but rather requires the translation of

these products into information layers within their proprietary systems. The RASOR Consortium understands the specific needs of the risk management marketplace and has geared the flexible RASOR services towards these ends.
DLR's contribution, the adaptation of the TanDEM-X DEM to risk management applications, provides a critical new development by making risk management tools more accurate and more relevant for end users. This is one of the main reason that attracted Airbus DS as an associate partner in the commercial phase of RASOR. Combined with high resolution imagery and the possibility of user friendly scenario-based queries, RASOR offers a leap forward, bringing satellite solutions to bear for national and local end users as well as international organisations.

The Table below summarizes the contribution that RASOR offers to the Innovation Union Flagship initiative by highlighting key successes enabled through the project.

Table 2.1 RASOR Impact on Innovation Objectives

Innovation Union Objective	RASOR
Stimulate competition	Stimulate competition: Working through EARSC, RASOR has set up a European network of SMEs that understand RASOR opportunities in national and local markets. This allows for the emergence of a series of European experts in the application of space assets to full-cycle disaster management.
Create jobs	The SME-driven approach adopted by RASOR will result in more jobs located in diverse geographic regions, closer to end users and well distributed across the European area.
Drive sustainable growth	RASOR's key strength is to bring world-leading organisations together around a single platform where the best of their knowledge will be used to integrate previously successful more narrowly focussed products. Their integration opens new markets, such as the insurance market, which cannot ingest products currently coming out of the COPERNICUS/GMES programme, but rather requires the translation of these products into information layers within their proprietary systems. The RASOR Consortium understands the specific needs of the risk management marketplace and has geared the flexible RASOR services towards these ends.
Enable Social Progress	The adaptation of the TanDEM-X DEM to risk management applications, provides a critical new development by making risk management tools more accurate and more relevant for end users.

One of the distinguishing factors of the RASOR Project is the unique position played by end user organisations and intermediary users such as UNOSAT, who play a bridging role with the entire UN family of agencies and organisations, or the World Bank, linking RASOR to Bank projects around the world.
In particular, UNOSAT has begun to effectively use RASOR for capacity development courses in developing countries on Disaster Risk Assessment concepts and practice. At the time of writing already two courses have been held, one in Nairobi (Kenya) for the IGAD participating countries and ICPAC, the second in Myanmar for institutional stakeholders.

The following table provides high-level impact for the RASOR product and each service track.

Table 2.2 RASOR impact on operations and capacities of users

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RASOR Product or Service	Impact on operations and Capacities of Target User Communities
RASOR tool	Ability for international users to rapidly (in minutes and hours) assess risk without prior data sets; Ability to export data layers into proprietary systems (e.g. exploit RASOR without changing operating systems).
Track 1 – international service	international service: Ability for international users to tailor RASOR to specific needs and use it during actual crises, for more accurate and more in-depth analysis (e.g. insurance sector – rapid damage assessment, integration of sector specific data sets such as insured assets as opposed to exposed assets); Ability to refer to objective and internationally comparable (homogenous) data for determination of donor funding to support risk mitigation or relief; Ability to track long-term risk (e.g. subsidence) in conjunction with other parameters (e.g. wave height, sea level rise) to perform risk scenarios in present climate or climate driven scenarios for long-term risk.
Track 2 national service	Ability to integrate multiple hazards in single projection with far higher accuracy; Ability to easily integrate 'classified' data sets not available to users outside national governments, and use them for integrated analysis with international data sets; Integration of satellite and in-situ data sets in a single system geared towards scenario driven queries instead of simple mapping outputs.
Track 3 local service	Ability to "tunnel" into detailed data sets and project them against international standards, and model in areas where high resolution DEMs were not previously available; Access to world-class standard tool that has flexibility to integrate local parameters and display them for analysis.

It is clear from the current use of satellite by disaster managers that more can be achieved by focussing on the full cycle of disaster management, rather than merely on response. While great progress has been made in the area of rapid mapping, some of the key limitations on progress are institutional.

There is a need for greater collaboration between solution providers and disaster management agencies between disasters. In particular, more emphasis needs to be placed on tools that support the disaster manager in the risk analysis tasks that feed into proper planning and mitigation activities, and more tools are required that can display risk across several phases of risk management, and integrate changes in near-real time. RASOR goes exactly in this direction filling a gap in current exploitation of earth observation data.
Experience demonstrates that Disaster Risk Reduction activities are most effective when integrated into the full cycle of disaster response. Humanitarian aid should include the application of the "build back better" principle. The impact of disaster relief is longer lasting when humanitarian actions take into account hazards, vulnerabilities and risk analysis. RASOR offers an efficient means of rapidly spatialising these elements and performing summary trade-offs to evaluate the impact of decisions. Critical to effective mitigation of risk, such an approach also reinforces the usefulness of actions throughout the disaster cycle. For this reason, the RASOR tool, while focussed on mitigation, is designed to support multi-risk analysis for the full disaster cycle: mitigation, warning, response and recovery.

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In fact, the World Bank and several regional or national end users consulted on the Project (CIMH, RCWC, the CEOS pilot partners, Namibia Department of Water Affairs) indicated that the RASOR approach builds strongly on existing initiatives and is the next logical step for the application of technology to their risk mitigation activities. The Global Facility for Disaster Risk Reduction and Recovery Labs (GFDRRRL) used the RASOR technology with great benefit to several on-going Bank projects in Africa producing country level risk profiles.
Other international organisations concerned with disasters such as the UNISDR and the Group on Earth Observations (GEO) concur.

RASOR offers the GEO community an impressive tool to address these priorities. In particular, RASOR:

- provides a cost-effective means of improving risk assessment for multiple risks over "data poor" areas;
- serves as an information integrator, ensuring that space-based data are married with other data and together produce products that are disseminated at the local, national and international levels;
- provides a robust backbone for multi-hazard, end-to-end management addressing the full cycle of disasters;
- documents risk analysis and present a compelling "spatialised" view that informs mitigation decisions taken by policy makers;
- facilitates the application of space technologies to the priorities enumerated in the HFA.

One of the strengths of RASOR is the recognition of the critical role local and national actors play, even when international risk reduction is concerned.
These organisations, while not international players per se, have valuable and often overlooked insight into how risk management tools can and should be applied in their regional and national context. Moreover, the support of organisations like these is critical to achieving uptake of future tools and investment by these organisations in their successful deployment. By integrating end user organisations in the development team, RASOR bridges the relational gap between institutions that is one of the most common reasons for failed application of technology solutions in the disaster community. RASOR cannot stop disasters. However, tools such as RASOR can breed a culture of disaster risk reduction that will dramatically reduce the impact of certain disasters.

In a European context, a number of EU-wide initiatives are making headway in creating a European area in which disaster management is increasingly reliant on satellite technology. Technologically, the ability to integrate different elements from a broad range of applicable technologies and bring them to bear provides a showcase for European technology providers and stimulates further technology development. Furthermore, the design of European standards can incorporate other European technologies to ensure for instance that standard data sets for the RASOR tool are provided by the COPERNICUS Sentinels whenever possible, and by other European missions when they are available. This cross-fertilisation will lead both to further technology development and increased economic output. Indeed, from an economic point of view, it is clear that European companies have much to gain from the dissemination of European developed technologies and are ideally positioned in the long run to translate the technology investments into concrete products and services offered to the international development community.

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6.1 Public website address and relevant contact details

RASOR web-site: www.rasor-project.eu
RASOR Platform link: www.rasor.eu
RASOR Help Link: http://www.rasor.eu/wiki/index.php/Main_Page
RASOR Coordination Contact: Roberto Rudari - roberto.rudari@cimafoundation.org
RASOR Project Manager: Andrew Eddy - andrew.eddy@athenaglobal.com

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RAPID ANALYSIS AND SPATIALISATION OF RISK

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HTTP://WWW.RASOR-PROJECT.EU