Grant Agreement No. 718679
SAFETY – Sentinel for geohazard
prevention and forecasting

Deliverable D.G1: Description of the functionality of the long term operative infrastructure

A deliverable of

Task G: Project Sustainability

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TN	Technical Note	X

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EXECUTIVE SUMMARY

SAFETY is a two years research project funded under the ECHO (European Commission's Humanitarian aid and Civil Protection department call “Prevention and preparedness projects in Civil Protection and marine pollution”), and it started 1st January 2016. The mission of the project is to improve the efforts in detecting and mapping geohazards (i.e. landslides and subsidence), by assessing their activity and evaluating their impact on built-up areas and infrastructures' networks. SAFETY will enhance ground deformation risk prevention and mitigation efforts in highly vulnerable geographic and geologic regions. The outcomes of the project will provide Civil Protection Authorities (CPA) with the capability of periodically evaluating and assessing the potential impact of geohazards on the selected sites.

The main objective of task G is to design the long term operative infrastructure to supply to the CPAs in order to continue with the SAFETY project. It will be integrated as a service reinforcing the capabilities of the services which public institutions provide to the community and in particular to the CPAs.

The present technical note D.G describes the design of the long term operative infrastructure developed at CNIG-IGN, UNIFI and IGME.

Responsible for implementing it: CNIG-IGN
Participants: CTTC, IGME, UNIFI

REFERENCE DOCUMENTS

N°	**Title**
DB1	User needs and requirements
DC1	Software tools
DC2	Periodically updated deformation activity maps
DF1	Definition of the validation procedures
DF2	Validation of software tools and products

CONTRIBUTORS

Contributor(s)	Company	Contributor(s)	Company
Elena González	IGN	Gerardo Herrera	IGME
Sergio Ligüérzana	CNIG		
Carmen López	IGN		
Silvia Bianchini	UNIFI		
Lorenzo Solari	UNIFI		
Roberto Sarro	IGME		

REVIEW: CORE TEAM

Reviewed by	Company	Date	Signature

1. INTRODUCTION

The project SAFETY aims to provide to the Civil Protection Authorities (CPA) the capability of periodically monitor and assess the impact of geohazards (landslides and subsidence, volcanos, earthquakes) on urban areas.

The main objective of task G is to design the long term operative infrastructure to supply to the CPAs in order to continue with the SAFETY project. It will be integrated as a service reinforcing the capabilities of the services which public institutions provide to the community and in particular to the CPAs.

This document is the report that includes the description of the functionality of the long term operative infrastructure. It is divided in three sections which describe sustainability of SAFETY project at UNIFI, IGME and IGN-CNIG. Finally, the last section contains conclusions and suggestions for future of SAFETY.

2. DESCRIPTION OF THE LONG TERM INFRASTRUCTURE

2.1 CNIG-IGN PROJECT SUSTAINABILITY

2.1.1. Administrative framework

In Spain, the management of the volcanic risk depends on the Local, Regional or National Civil Protections. Depending on increasing risk, different plans can be activated and different Authorities would be in charge of the management. In the case the National Civil Protection is designed, the Decision Maker is the Home Secretary. In the case of the Autonomic Region Civil Protection, the Decision Maker is the Regional Adviser or Authority. If Local, the Local Mayor.

There are 3 predefined alert levels that implies increasing risk, that include the following situations:

- **Normal (“Stability” and “Pre alert”) → Local Authorities**
- **Pre emergency (“Alert” situation) → Regional Authorities**
- **Emergency (includes 4 different situations: “Maximum Alert”, “Level 1”, “Level 2” → Regional Authorities, “Alarm” → National Authorities**

The alert level is always established and modified by the Ministry or by requirement from the National Government in the Region or from the Director of the Emergency Plan, National or Regional (PEVOLCA). It is within these Plans, specifically in its Scientific Committee, where IGN and the rest of institutions interpret and forecast the activity in case of volcanic unrest or alert. There are two Scientific Committees, one for each Plan for volcanic risk:

- **The Canarian Scientific Committee from PEVOLCA, composed by CSIC, IGN, AEMET, Civil Protection (National and Regional). The Director of the Plan designates scientists from local universities or from other Canarian institutions specialized in volcanology research**

- **The National scientific Committee, from the National Plan composed by IGN and CSIC as Scientific Advisors.**

2.1.2 IGN Volcano Monitoring and Alert (VMS)

IGN is the institution responsible in Spain of the Volcano monitoring. The IGN volcano monitoring system has been designed to be able to detect changes in evolution of the data recorded by surveillance networks (seismic, geodetic, geochemical, geophysical and thermal networks) and to interpret them in terms of possible changes in the eruptive process, establishing prognosis of future evolution including scenarios of different hazards.

Figure 1: VMS in Tenerife Island

As well, IGN has to communicate this information to the volcanic risk managers (Civil Protections), in the form of scientific alerts, reports and personal communication. These scientific alerts triggers the activation of the Civil Protection Emergency Plans.

In case of volcanic alert, IGN follows a protocol of action that increases the regularity of reports, processed data, interpretations and forecasts based on the level of scientific alert. This protocol was validated during the volcanic unrest and eruption lived in El Hierro Island during 2011-2012, and the following reactivations registered during 2012-2014.

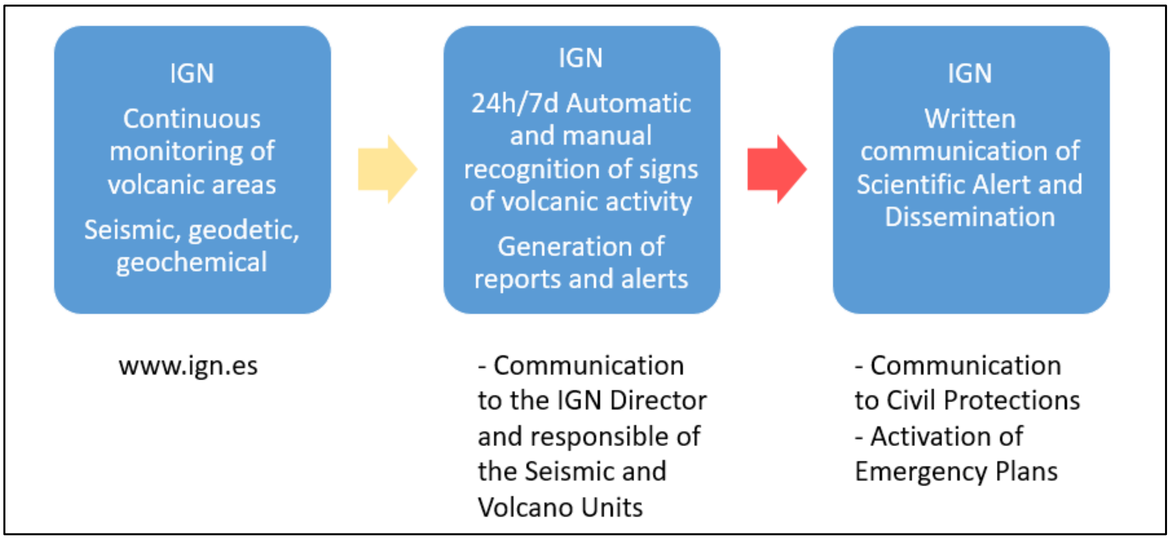
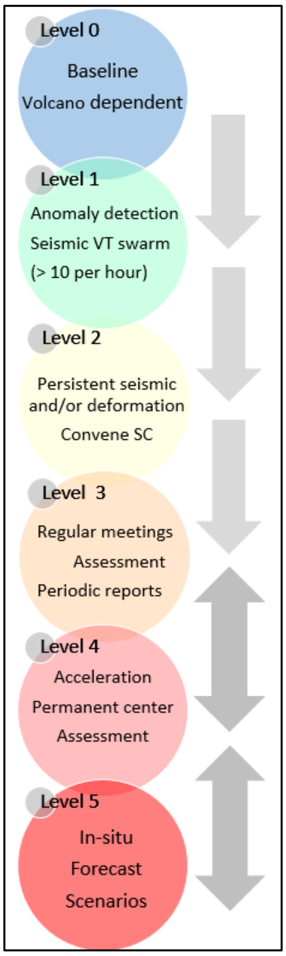


Figure 2: General view of protocol between IGN and CPA in case of volcanic unrest

2.1.3 IGN Scientific Alert: Levels

IGN uses five Scientific Levels to reflect the unrest state of the volcano and the manifestations of volcanic activity. Level ranges from 0 for the background or baseline behaviour to 5 when the behaviour of the activity is a cause for concern in the short-term because it might prelude an eruption.



Level 0. Volcano activity remains unchanged.

Level1. Anomaly Detection (seismic, deformations, volcanic gases)

Level 2. No anthropogenic or instrumental failures. 24-hour monitoring. Enhance surveillance network. Convene Scientific Committee (SC) for assessment.

Level 3. Confirmed that the signals are of volcanic origin and that the system has changed situation. Regular meetings of the Scientific Committee. Continuous assessment. Periodic reports.

Level 4. Acceleration of the activity. 24-hour monitoring. Permanent center of attention in the area. Decision-making. Recommend the activation of the Emergency Plan.

Level 5. Acceleration of the variation observed. Scientific Committee members should already be 24 hour available. Establishment of Forecasts and Scenarios. Implementation of the Emergency Plan.

Figure 3: Scientific alert levels

2.1.4 Protocol in case of volcanic unrest or alert

IGN Volcanic Monitoring System aims to identify the precursory volcanic activity in the active volcano areas and to communicate it to the Civil Protection with time enough for an effective volcanic risk mitigation. For this purpose, it studies the observable phenomena prior to eruptive activity, which reflects the accumulation of energy inside the volcano. The main techniques used are:

- **Seismicity**
- **Deformation**
- **Geochemistry**

The alert starts when IGN detects a change in the background level of the volcano activity. In most of cases (all of them until now) with the occurrence of a seismic swarm. If the activity last for more than one hour and there are more than 10 earthquakes located, the Seismic Network (24h/7d) prepare an alert report (mail + fax) to Civil Protection (National and Regional) after have communicated the event to IGN Director and the Responsible.

Once a volcanic unrest is detected, IGN reviews the rest of observables by means of a private web page, looking for anomalous signals in deformation or in gas emissions. The IGN prepare a volcano written report and send it to the Civil Protection. This report can be periodic (1 per week) during the first stages and daily or even more close to the eruption. When the Emergency plan is activated, IGN procedure of assessment includes the following tools:

a) **Real time, 24h continuous response in seismic and deformation**
    - **Activity assessment, diagnosis and prognosis of evolution**
    - **Volcano-seismic Signal recognition: tremor, VT, LP, hybrid**
    - **Event location, families identification-relocation**
    - **Hazard assessment**

b) **Characterization (Gutenberg-Richer b-value, Mogi/sill modelling, spectrogram)**

c) **Interpretation and Forecast: RSAM, SREM, SSEM,Mmax**

d) **Hazard assessment**
    - **Susceptibility maps (spatial probability of hosting a new vent)**
        - **Long/mid-term (dozens of years/years) based on location of vents and structural data.**
        - **Short term (months-days), based on Long term data + monitoring network data**
    - **Hazards maps (probability of being affected by the considered hazard during the time interval chosen for the map)**
        - **Long/mid-term, mainly based on the volcano's eruptive history.**

        - **Short term. UNREST + ERUPTION based on long term data + monitoring network data.**

e) **Scenarios (probability of being affected by the considered hazard during the time interval chosen for the map). Lava flow, pyroclastic density currents, ash fallout.**

  - **Long/mid-term, mainly based on the volcano's eruptive history.**
  - **Short term. UNREST + ERUPTION based on long term data + monitoring network data.**

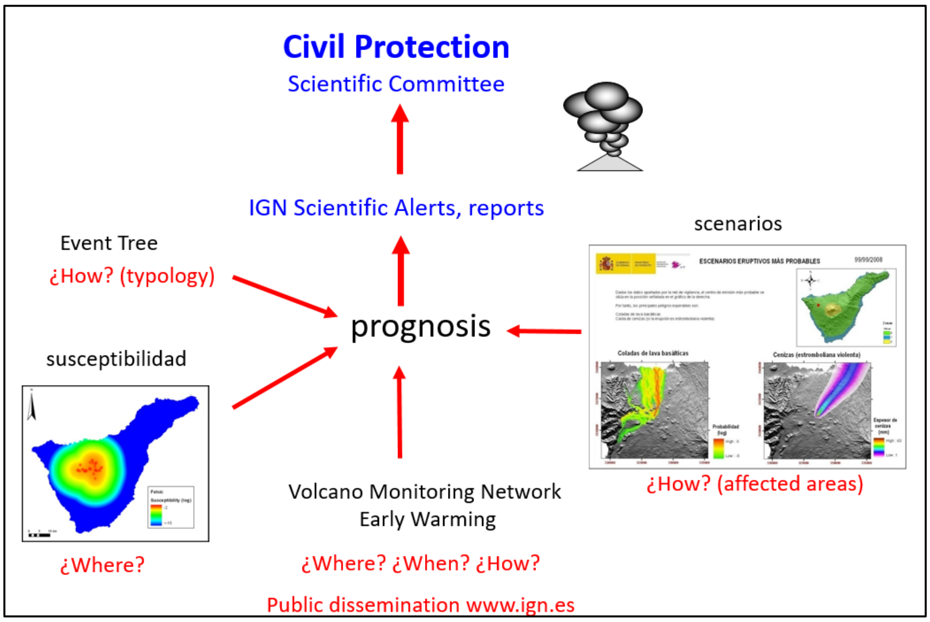


Figure 4: General view of procedure of assessment during activation of Emergency Plans

2.1.5 SAFETY in Volcano Monitoring System

We describe in this part the design of the InSAR volcanic monitoring system of IGN and how it is integrated into VMS procedures to provide useful information to CP authorities. It makes use of SAFETY tools mainly, modified and automated according to our specific needs and requirements. Products derived from InSAR processing reinforce deformation interpretation provided by VMS, strengthening our ability to create alarms.

Sentinel1, thanks to the constellation composed of Sentinel1A and Sentinel1B satellites, has a repeatability of six days over The Canary Islands. For every island there are at least two relative orbits available.

EL HIERRO	Relative Orbit Number S1A		Relative Orbit Number S1B		MAX Sensing Start
Asc	60		60		ene-17
Des	169		169		ene-17
LA PALMA	Sentinel 1A		Sentinel 1B		
Asc	60		60		ene-17
Des	169		169		ene-17
LA GOMERA	Sentinel 1A		Sentinel 1B		
asc	60		60		ene-17
des	96	169	96	169	nov-14
TENERIFE	Sentinel 1A		Sentinel 1B		
asc	60	162	60(2)	162	dic-15
des	96		96(21,22)		nov-14
GRAN CANARIA	Sentinel 1A		Sentinel 1B		
asc	162		162		dic-15
des	96		96		nov-14
FUERTEVENTURA	Sentinel 1A		Sentinel 1B		
asc	89	162	89	162	jul-15
des	23		23		may-15
LANZAROTE	Sentinel 1A		Sentinel 1B		
asc	89		89		jul-15
des	23		23		may-15

Table 1: Relative orbits (tracks) covering The Canary Islands for Sentinel 1A and Sentinel 1B satellites. Ascending and descending passes are specified. MAX Sensing Start indicates the earliest start acquisition date for every relative orbit.

Images, which are completely free and open, are downloaded automatically through the ESA Sentinel Data Hub. In the near future, images will be accessed directly from a mirror site of ESA stablished with IGN/CNIG and INTA as nodes for Spain. Efforts to achieve this aim are being developed currently.

For emergency purposes restituted orbits are used as they are available simultaneously to delivered images. So, within seven days we are able to obtain up to date results. This processing which make use of restituted orbits has been called “Fast Processing”. See Figure 5.

Once the precise orbits are available, in around 20 days, a re-processing is done to improve the precision. This processing which make use of precise orbits has been called “Precise Processing” See Figure 5.

For each processing, two complementary approaches have been implemented in order to obtain deformation signals. First, we generate Single Interferograms (IFGS), then we create Temporal Series of Deformation Velocities (TS). See Figure 5.

Images and products are stored and software is running automatically at IGN-CNIG headquarters taking advantage of the large and validated infrastructure created to distribute services to the general public.

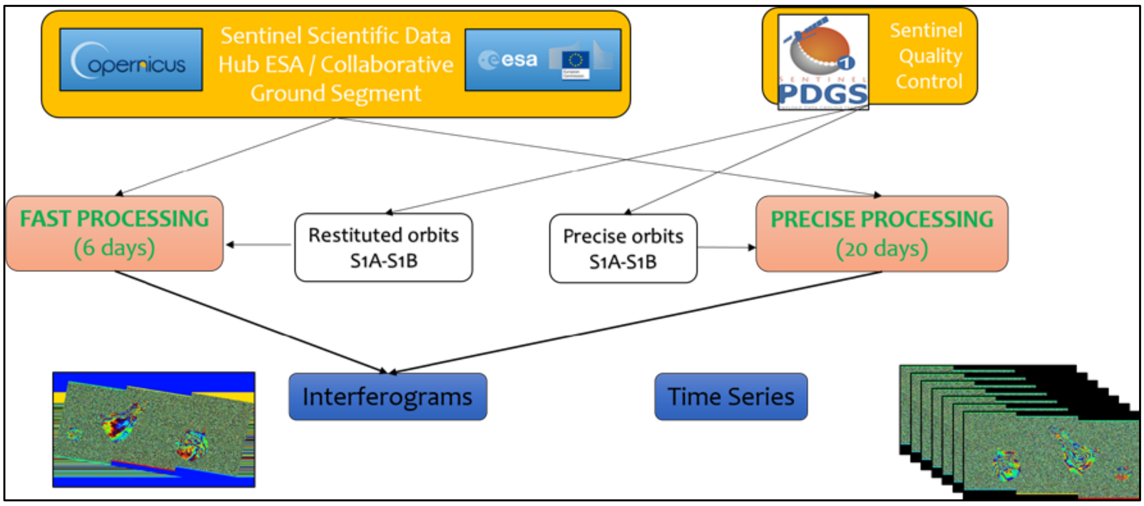


Figure 5: General view of Fast and Precise Processing and sub-processing IFGS and TS.

a. Single Interferogram Generation (IFGS)

To perform a reliable interpretation of possible deformations it is mandatory to know the historical deformation record so all tracks of interest will be processed since its start date of acquisition (Table 1). We generate all possible interferograms which keep a reliable signal to noise ratio. Methodology is described in detail in DC1.2.

This way, we will record possible deformations since the beginning of Sentinel mission over Canary Islands on a 6-days basis, when possible. Interferogramas are created automatically as long as images and orbits are available.

Single interferograms can detect linear and non-linear deformations above 2.8 cm in LOS. It is necessary to account for possible atmospheric effect in the interferograms at this stage so careful interpretation of interferograms must be done.

Taking this into account, we unwrap the interfograms to have absolute values of phase, relative to the location of selected GNSS stations of IGN. Then, we perform a suitable atmospheric correction to isolate deformation signal.

Errors are likely to appear when perform 2D-phase unwrapping. They will be reduced and masked as much as possible. However it is very important to have a fast result in spite of reducing precision, especially under emergency conditions. As we have external data (GNSS, inclinometers) to validate results unwrapping errors are not so critical in this case (see DF1 and DF2). As final step, phase deformation values will be transformed to displacements ones and georeferenced.

When possible, tracks over every island will be combined to obtain east-west and up-down displacements. See Figure 6 for work flow details.

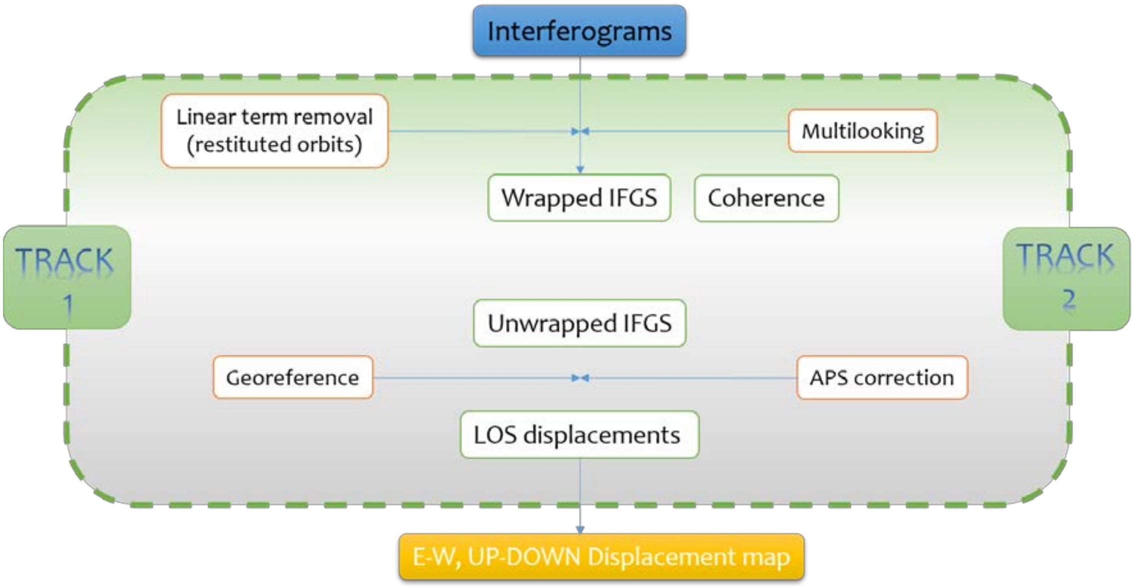


Figure 6: General view of Interferogram processing

b. Temporal Series of Deformation and Velocities (TS)

According to the methodology established in DC1 we will use generated interferograms to calculate linear velocities of PS. This approach reduce associated errors and improve precision reaching magnitudes of several mm/year in estimations. Topographic errors are estimated and atmospheric effect is removed.

First result of this processing is the Row Deformation Map (RDM) which is then filtered using suitable criterions to obtain the Deformation Activity Map (DAM). Afterwards, conditions based on time series analyses will be applied to focus on active deformation areas. Also, spatial conditions are taken into account in order to avoid selection of isolated pixels. Final product is the Active Deformation Areas (ADA). For more details see Barra et al, 2017 and Figure 7.

Due to radiometric characteristics temporal windows of one year and a half will be used with overlapping periods of six months.

When possible, tracks over every island will be combined to obtain east-west and up deformation and velocities.

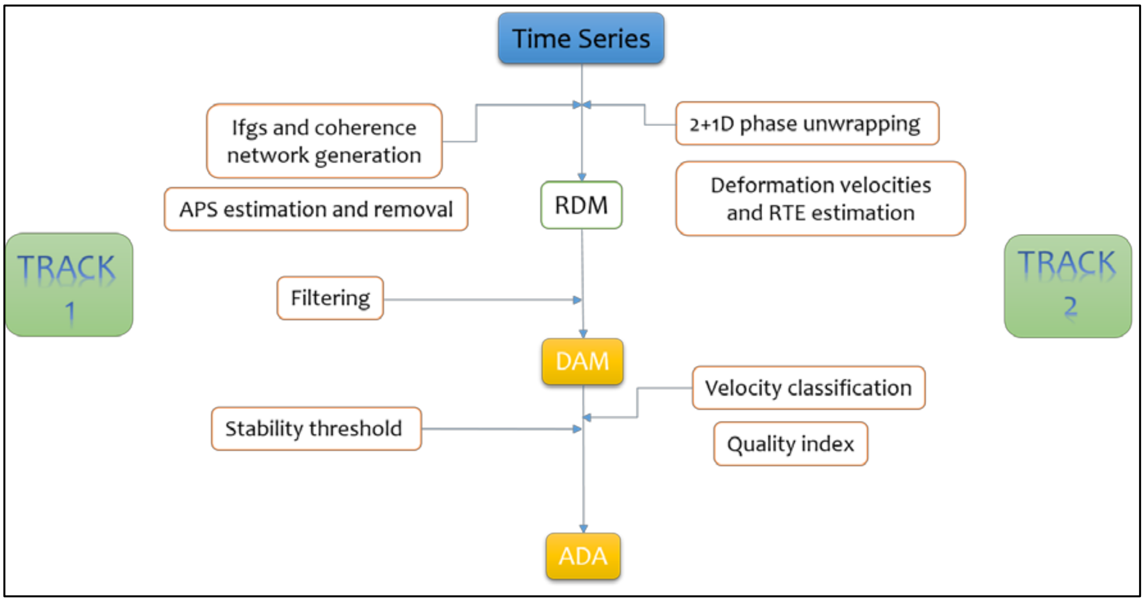


Figure 7: General view of Time Series processing

2.1.6 CNIG-IGN products and SAFETY INTEGRATION

Once IGN identifies the beginning of an unrest, the Protocol in case of volcanic unrest or alert produces the following real-time products for Volcano Monitoring and early warning:

- **Near real-time seismic location Catalogue: latitude, longitude, depth, Magnitude, Intensity**
- **Near real-time Seismic source characterization: focal mechanism, Mw, seismic energy**
- **Near real-time Swarm characterization: histograms, b-value, spectrograms**
- **Forecasting: RSAM, 1/RSAM**
- **Daily and sub-daily GPS time series and distances series**
- **Daily vertical and horizontal vectors of deformation**
- **Daily deformation source (position and volume) inversion of GPS data (point, sphere, sill and spheroid)**
- **Regular deformation source (position and volume) inversion GPS**
- **Near real-time Inclinometers, gravity and magnetograms time series**
- **Near real-time CO_2, radon, T° and other geochemical time series**
- **Near real-time Meteorological data**

SAFETY add to this list:

- **Spatially distributed 3D deformation (weekly)**
- **Regular deformation source (position and value) inversion InSAR data (+ GPS data)**

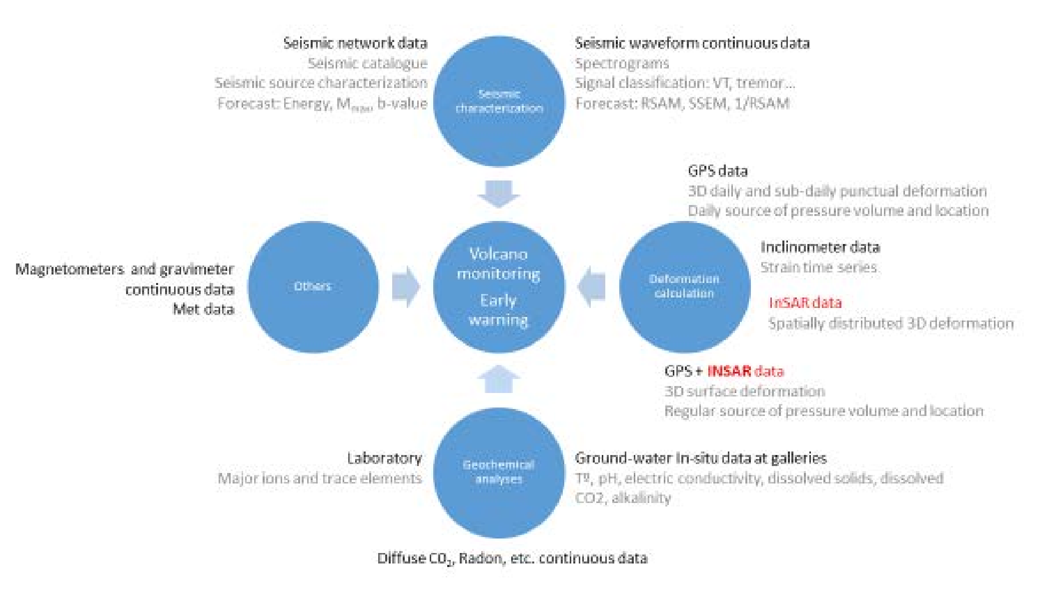


Figure 8: IGN Early warning products including InSAR data derived from SAFETY tools

SAFETY results will be validated with GPS results according to methodology described in deliverable F1 and F2.

Integration will be done in GIS systems. Then, deformation signal is interpreted in a general geophysical context using also seismic, gravimetric and geochemical data.

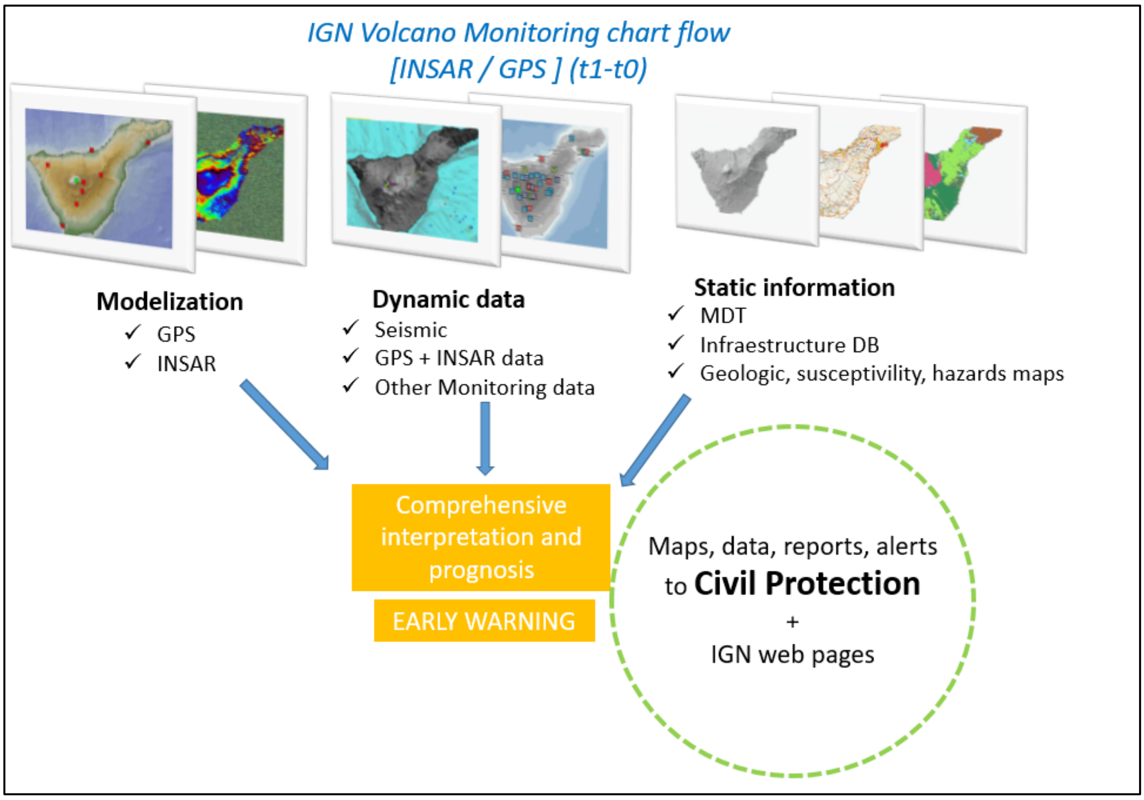


Figure 9: Integration of IGN Early warning products (deformation) at GIS platform.

SAFETY-based products will be delivered to CP authorities following INSPIRE guidelines.

2.1.7 SAFETY added value for VMS

SAFETY has allowed to establish a semi-automatic methodology whose products have a high value to detect deformations and therefore improve the ability to create alarms to CPA.

Compared to GNSS spatial coverage, SAFETY products will allow to limit spatially the extension of possible deformations as well as to define minimum and maximun gradients which will be useful to define hazard areas.

SAFETY products will allow to record possible deformation signals since 2014 which is meaningful taking into account some other geodetic techniques were installed later. So, Sentinel catalogue would allow to recover deformation that, otherwise would be lost.

Thanks to SAFETY methodology Active Deformation Areas (ADA) have been defined. It will be up to date routinely and represent an important contribution to both the short and long term hazard assessment.

Sentinel1 images are free and open to everyone. Moreover InSAR techniques do not need in-situ instalation either communication. Both questions reduce associated costs.

2.2 UNIFI - PROJECT SUSTAINABILITY

As SAFETY project sustainability the main goal of UNIFI is focused on to keep on contribution of satellite SAR-derived displacement measurements in landslide risk management practices. In particular, SAFETY outputs are thought to be suitably implemented in strategies of risk prevention and prevision for italian Civil Protection purposes, at both local and regional scales.

To this aim, UNIFI is carrying out an agreement named “PS continuous streaming for landslide monitoring and mapping on Tuscany Region (Italy)” with Italian Civil Protection and Regional Authority (Tuscany region). As a consequence, SAFETY procedures would be potentially implemented within this framework for Civil Protection agency and Local authorities in charge of environmental management.

The main objective of this agreement is to perform the transition from historical analysis of radar satellite image archives to real time monitoring of ground deformation at regional scale using radar satellite scenes. To accomplish this objective the short revisiting time and regularity of acquisitions of Sentinel-1 constellation of SAR (Synthetic Aperture Radar) satellite sensors will be exploited (Fig .1) .

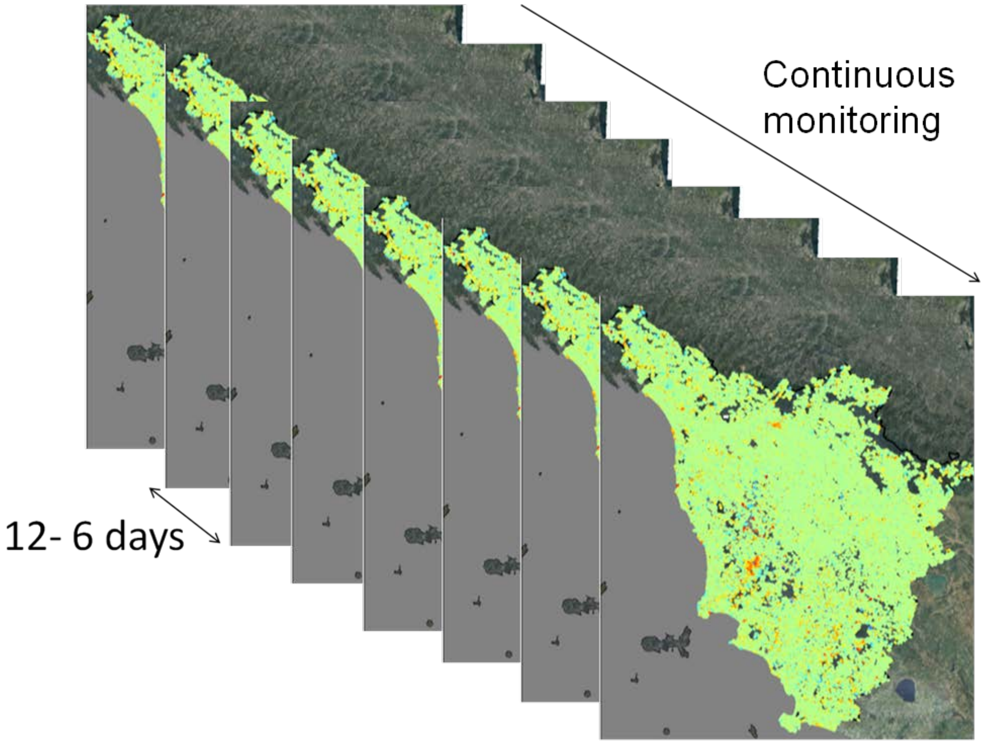


Figure 10 – Concept of “PS continuous streaming for landslide monitoring and mapping on Tuscany Region (Italy)”, exploiting SENTINEL-1 SAR data with revisit time of 6-12 days.

The study area will be the Tuscany Region (Central Italy), specifically selected due to its peculiar geological setting prone to ground instability phenomena. Its territory, mainly hilly (66.5%) with mountainous areas (25.1%) and few plains (8.4%) results to be a very landslide-prone area

For the initial implementation of the continuous monitoring of the Tuscan Region, the existing archives of the Sentinel-1A are acquired and processed by means of a multi-interferometric (MT-InSAR) approach, specifically designed to analyse long series of SAR scenes. For both ascending and descending geometries, reference ground deformation maps are thus generated, providing a synoptic, retrospective view of the main areas affected by ground motion. To accomplish the transition from historical analysis to near-real time monitoring program at regional scale based on Sentinel-1 images, a processing plan for both ascending and descending geometry is set. Once a new Sentinel-1 image is available, it is automatically downloaded and added to the existing archive. The new data stack is then entirely reprocessed to generate new ground deformation maps and updated displacement time series (TS). A series of subsequent updating is created every 6 days using Sentinel-1A and Sentinel-1B images. Following the creation of updated ground deformation maps, displacement TS (Time Series) of each measurement point for both ascending and descending geometry are systematically and automatically analysed to identify, in the last part of the TS (i.e., in a defined temporal window) any change in the deformation pattern. When this change occurred a breaking point is identified and defined. The average deformation rates before and after the breaking point are recalculated; when their difference |ΔV| is higher than a defined velocity threshold (in mm/yr) the points are highlighted as “anomalous points”. Changes in the deformation pattern are analysed and interpreted, update by update, assigning them a driving triggering factor

Analysis and interpretation of results derived from continuous elaboration of Sentinel-1 images-include the "radar-interpretation" activity, devoted to assign a geomorphological meaning to the scattered point-wise ground displacements measurements and to obtain an accurate analysis of the phenomenon (i.e. typology, spatial extension, causes). Due to the intrinsic characteristics of multi-interferometric techniques (e.g., the possibility to measure only the LOS component of ground movement and the scattered distribution of measurement points etc), the interpretation of PSI data and TS changes (i.e., anomalous points) requires a proper strategy of analysis based on traditional geomorphological thematic information (i.e. topographic, geomorphologic, geological and land use maps), optical images (both aerial and satellite data) and in situ data investigations. Furthermore, the potential impact of ground movements on the elements at risk of the territory are also taken into account.

In particular, the agreement includes two different kinds of activity:

- *PS mapping* activity in deferred time with archive data
- *PS monitoring* in near-real time with continuous streaming

On one hand, the *PS mapping* deals with highlighting the most critical areas characterized by the highest ground motion rates with PSI data, where the attention must be paid at a defined deferred time. On the other hand, *PS monitoring* is based on the analysis of trend variation that means the analysis and interpretation of Time Series of PSI “anomalous points” with detected trend changes in their temporal deformation series.

The SAFETY procedures would be implemented within the *PS mapping* activity, which implies hotspot analysis that would include the ADA extraction.

In particular, within this activity firstly the whole Sentinel.1 data stack is sub-set by sampling only PS data with a Velocity higher than a defined stability threshold. On this subset of PSI data a Hotspot generation is performed and it would be carried out by exploiting the ADA extraction: it consists in VLOS Buffer within each PS and buffer aggregation for obtaining clusters as active deformation areas (ie. ADA) (Fig. 2).

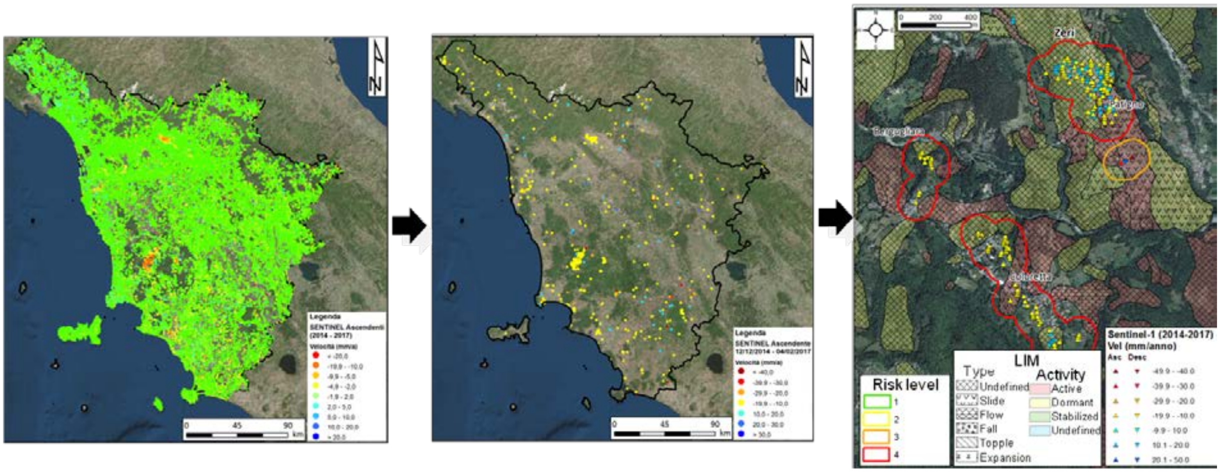
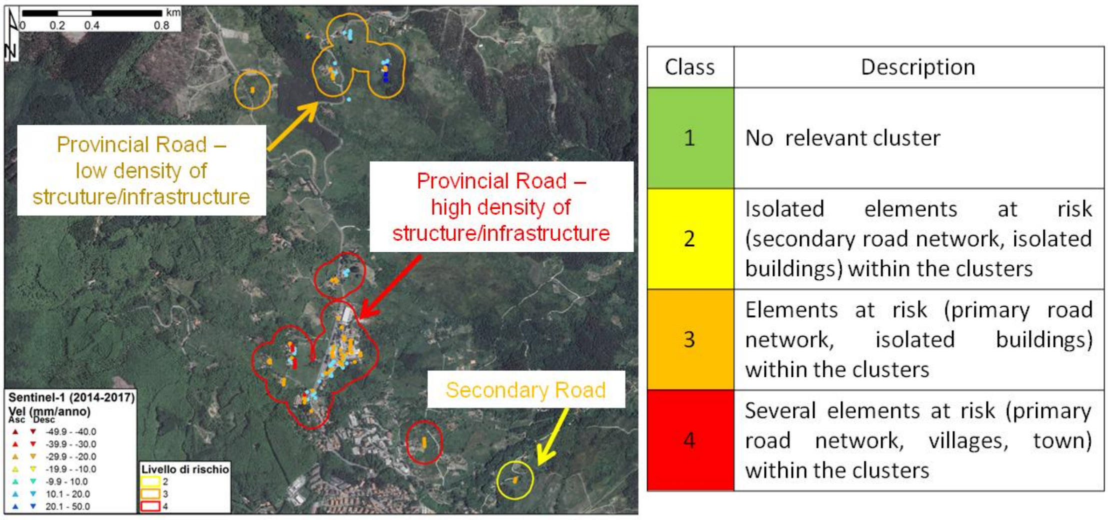


Figure 11 – Sketch of the procedure for PS mapping activity: hotspot analysis and SAFETY ADA extraction

Moreover, the hotspot clusters can be intersected with different types of the elements at risk of the territory and so classified accordingly. Thus, this classification is composed of 4 classes: 1- red colour: No relevant cluster; 2 – yellow colour: Isolated elements at risk (secondary road network, isolated buildings) within the clusters; 3 – orange colour: Elements at risk (primary road network, isolated buildings) within the clusters; 4 – green colour: Several elements at risk (primary road network, villages, town) within the clusters (fig. 3).



Class	Description
1	No relevant cluster
2	Isolated elements at risk (secondary road network, isolated buildings) within the clusters
3	Elements at risk (primary road network, isolated buildings) within the clusters
4	Several elements at risk (primary road network, villages, town) within the clusters

Figure 12 – Criteria for Hotspot clustering and classification.

Finally, every municipality of the Tuscany Region can be classified according to the presence of the classified clusters: ie. a municipality is classified as yellow if at least one yellow cluster is present within its boundary; a municipality is classified as orange if at least one orange cluster is present within its boundary and so on.

As a result, the final aim of this activity is the Classification for quick qualitative risk map of each municipality in Tuscany Region, as shown in Figure 4.

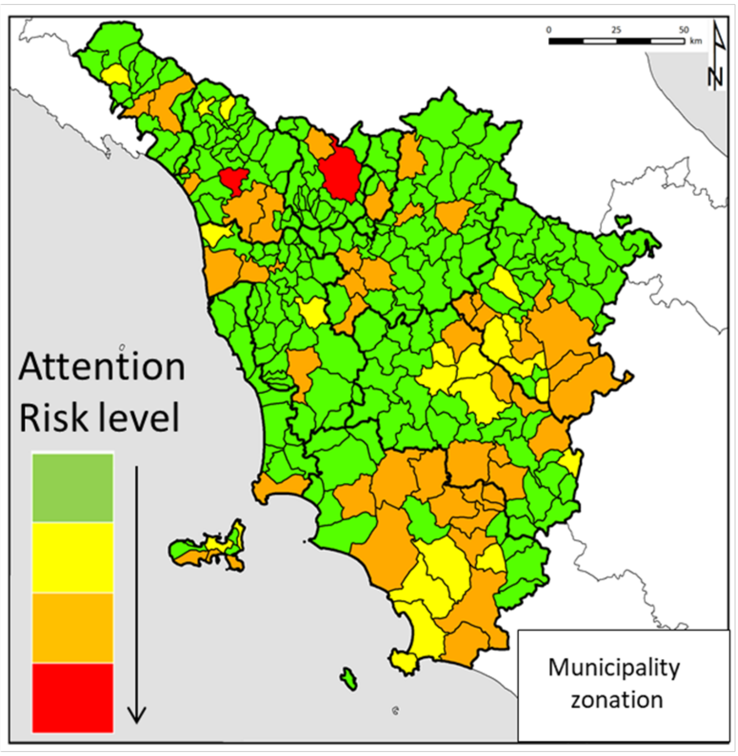


Figure 13 - Classification for rapid Risk map of each municipality in Tuscany region

This municipality classification on the basis of the rapid qualitative Risk level according to PSI data and elements at risk can be exploited by authorities in charge of civil protection and environmental management purposes. In fact, the main end user of the agreement is the Tuscany Region. Potential beneficiaries include Civil Protection Authorities, River basin Authorities, local authorities and any other entities in charge of management of risk posed by hydrogeological hazards, e.g. landslides.

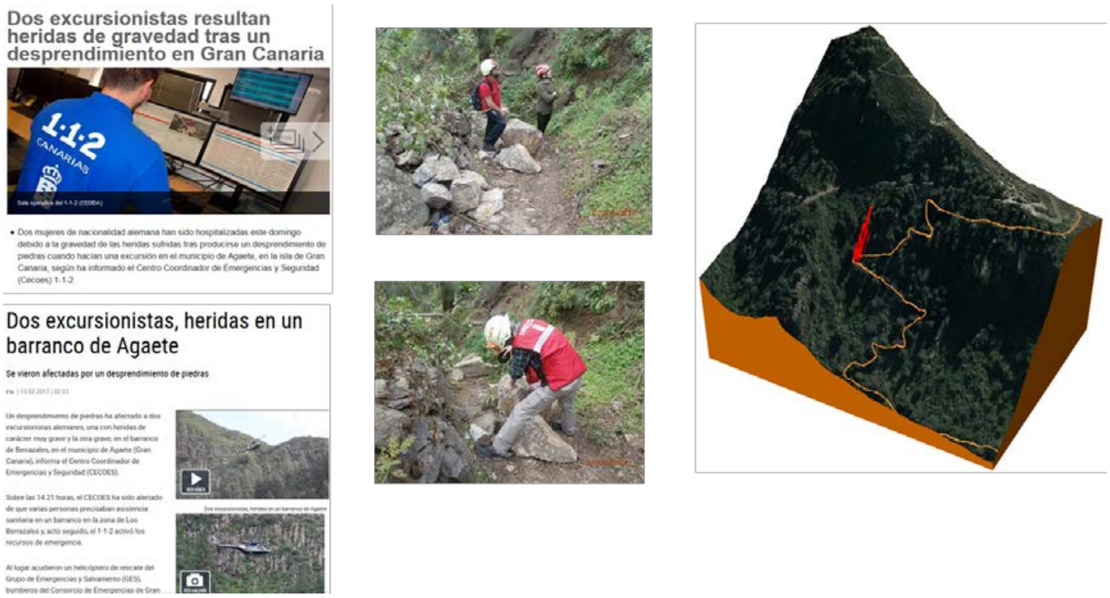
2.3 IGME - PROJECT SUSTAINABILITY

2.3.1 Operative structure Spanish Geological Survey and the Canary Island Civil Protection

Protocol to assess rockfall hazard

One of the main outcome of the project is to provide an operable methodology, a protocol, which can be integrated into Civil Protection prevention activities, and providing the capability of evaluating and assessing rockfall hazard. This methodology is based on rockfall simulations, and involves three main phases: (1) inventory, (2) simulation, and (3) validation.

We have exploited STONE, a GIS based rockfall simulation software which computes 2D and 3D rockfall trajectories starting from the identification of the sources areas, an accurate digital terrain model (DTM) and maps of the dynamic rolling friction coefficient and of the normal and tangential energy restitution coefficients.



Dos excursionistas resultan heridas de gravedad tras un desprendimiento en Gran Canaria

- Dos mujeres de nacionalidad alemana han sido hospitalizadas este domingo debido a la gravedad de las heridas sufridas tras producirse un desprendimiento de piedras cuando hacían una excursión en el municipio de Agaete, en la isla de Gran Canaria, según ha informado el Centro Coordinador de Emergencias y Seguridad (Cecoes) 1-1-2

Dos excursionistas, heridas en un barranco de Agaete

Se vieron afectadas por un desprendimiento de piedras

Un desprendimiento de piedras ha afectado a dos excursionistas alemanes, una con heridas de carácter muy grave y la otra grave, en el barranco de Berrazales, en el municipio de Agaete (Gran Canaria), informa el Centro Coordinador de Emergencias y Seguridad (CECOES).

Sobre las 14.21 horas, el CECOES ha sido alertado de que varias personas precisaban asistencia sanitaria en un barranco en la zona de Los Berrazales y, acto seguido, el 1-1-2 activó los recursos de emergencia.

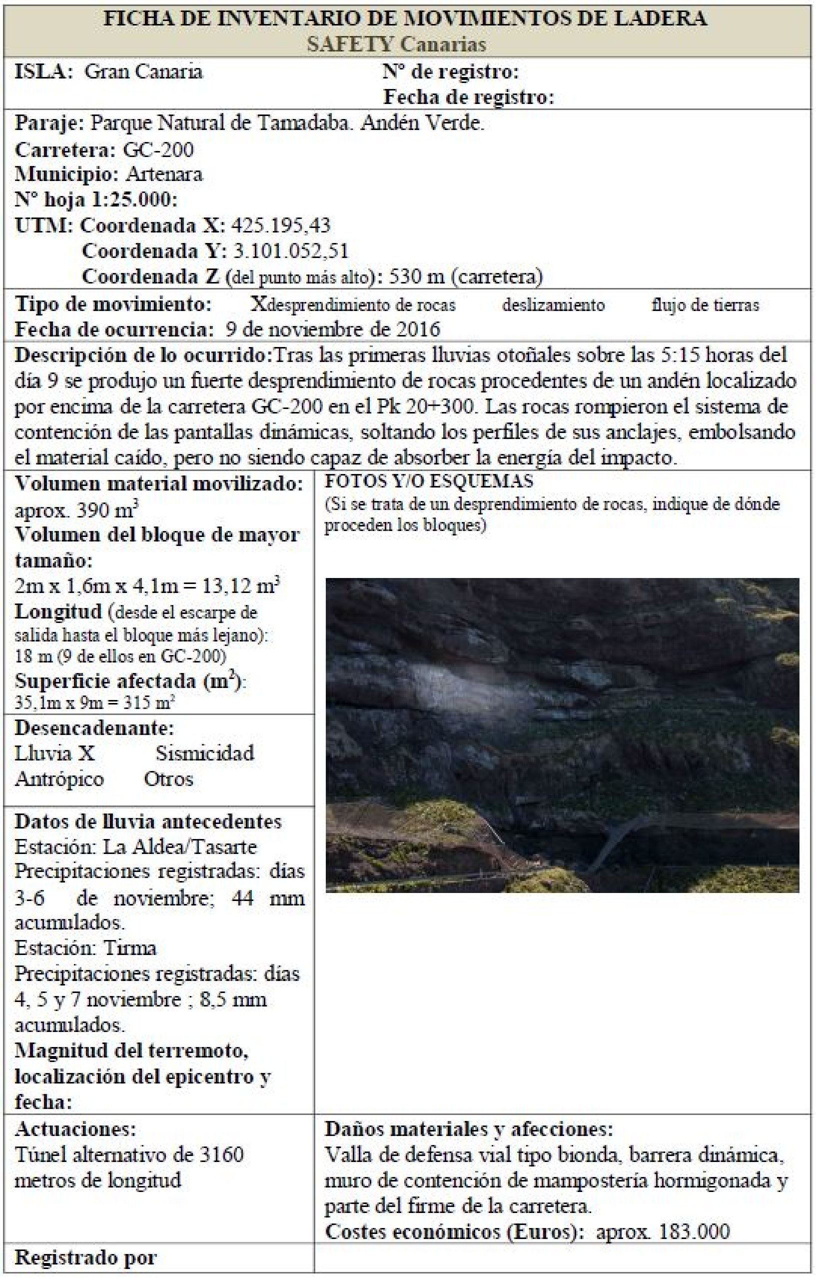
Al lugar acudieron un helicóptero de rescate del Grupo de Emergencias y Salvamento (GES), bomberos del Consorcio de Emergencias de Gran

Figure 14: Back-analysis of well-known rockfall event to assess rockfall hazard. Collaboration between Civil Protection and IGME.

Protocol to collect rockfall events data

In the SAFETY project is to carry out an updated rockfall inventory in the GC-200 road and to define accurately the location of each impact on the road by means of the orthophotos available in the region. In a first stage, we have used the information and observations carried out by the Canarian CPAs. The information for each event includes the following data: (1) kilometer point (PK), (2) Number of events, (3) Date, (4) boulder size: big, medium, small and gravel.

In case of future event a new data form designed in the frame of SAFETY project will be used by CPA to collect future rockfall events data.



FICHA DE INVENTARIO DE MOVIMIENTOS DE LADERA
SAFETY Canarias

ISLA: Gran Canaria
N° de registro:
Fecha de registro:

Paraje: Parque Natural de Tamadaba. Andén Verde.
Carretera: GC-200
Municipio: Artenara
N° hoja 1:25.000:
UTM: Coordenada X: 425.195,43
Coordenada Y: 3.101.052,51
Coordenada Z (del punto más alto)**:** 530 m (carretera)

Tipo de movimiento: Xdesprendimiento de rocas deslizamiento flujo de tierras
Fecha de ocurrencia: 9 de noviembre de 2016

Descripción de lo ocurrido: Tras las primeras lluvias otoñales sobre las 5:15 horas del día 9 se produjo un fuerte desprendimiento de rocas procedentes de un andén localizado por encima de la carretera GC-200 en el Pk 20+300. Las rocas rompieron el sistema de contención de las pantallas dinámicas, soltando los perfiles de sus anclajes, embolsando el material caído, pero no siendo capaz de absorber la energía del impacto.

Volumen material movilizado: aprox. 390 m^3
Volumen del bloque de mayor tamaño: 2m x 1,6m x 4,1m = 13,12 m^3
Longitud (desde el escarpe de salida hasta el bloque más lejano): 18 m (9 de ellos en GC-200)
Superficie afectada (m^2): 35,1m x 9m = 315 m^2

FOTOS Y/O ESQUEMAS
(Si se trata de un desprendimiento de rocas, indique de dónde proceden los bloques)

Desencadenante:
Lluvia X Sismicidad
Antrópico Otros

Datos de lluvia antecedentes
Estación: La Aldea/Tasarte
Precipitaciones registradas: días 3-6 de noviembre; 44 mm acumulados.
Estación: Tirma
Precipitaciones registradas: días 4, 5 y 7 noviembre ; 8,5 mm acumulados.
Magnitud del terremoto, localización del epicentro y fecha:

Actuaciones:
Túnel alternativo de 3160 metros de longitud

Daños materiales y afecciones:
Valla de defensa vial tipo bionda, barrera dinámica, muro de contención de mampostería hormigonada y parte del firme de la carretera.
Costes económicos (Euros): aprox. 183.000

Registrado por

Figure 15: Example of data form designed in the frame of SAFETY project.

Virtual platform for the management of rockfall hazard

Results allow the design of systems for the management of risks related to rockfall events in the Canary Islands by CP. In this sense, the methodology results will be able to place in the GIS of the General Directorate of Civil Protection and will be integrated in geographic information systems managed by public company GRAFCAN.

3.2.2 Transfer of knowledge to Geological Surveys of Africa and Latin America

In Africa, the main known geohazards are earthquakes and volcanic activity; mass movements; flooding; gully and coast erosion and various geoenvironmental (anthropogenic) hazards. With more than 40% of the population living below the poverty line, Sub-Saharan Africa is also the least-equipped and prepared continent to cope with the impacts of these events.

Majority of the African geological surveys are involved in geohazards activities and are interested in cooperation. However, information sources on geohazards analysis are different in each survey. On the basis of analysis of information sources on geohazards, it is almost obvious that systematized data portals or data bases are not available. Most of the respondent surveys indicated very different needs and expectations in the field of geohazards analysis.

In this sense, the aim of this training was to raise level of knowledge of African staff in scope of recognition of geohazards. Methods of identification of different types of geohazards and its monitoring works based on SAFETY project as well as research and prevention was an important element of the training.

Figure 16: PanAfGeo Trainings. IGME present results of SAFETY project.

On other hand, IGME will be to strengthen the interaction with Asociación de Servicios de Geología y Minería Iberoamericana (ASGMI) in order to improve the evaluation of the impact of geohazards with a focus on recent damaging events affecting urban structures and infrastructures.

3. SAFETY IN THE FUTURE

SAFETY products provide valuable information on deformation process which can be precursor of volcanic process. This information is essential to early warning assessment to CPA.

CNIG-IGN has developed a design based on SAFETY tools suited to its particular needs. SAFETY products cover a wide range of these necessities, however some efforts are necessary to lead with emergency and improve the short-term hazard assessment.

To this end, exploitability of the 6-day repeatability of Sentinel1 is mandatory. Use of not precise orbits is essential to manage the emergency too. On the other hand, volcanic processes generate non-linear deformations. So it is important to exploit single interferograms information which forces to improve atmospheric correction methodologies.

Most of these questions are targets of U-Geohaz project. The U-Geohaz project will be focused on monitoring geohazard-associated ground movements, a key prevention action that will be specifically addressed to urban areas and critical infrastructures. The project will propose a procedure to produce maps to assess continuously the potential impact of geohazard activity. These maps will provide essential inputs to support early warning, giving information on the stability of the monitored areas and to evaluate the expected damage. The goal of the project will be achieved by fully exploiting the results obtained in SAFETY project.

4. REFERENCES

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- Barra A. et al 2017, “A Methodology to Detect and Update Active Deformation Areas based on Sentinel-1 SAR Images”, Remote Sens 2017, 9(10), 1002; doi: 10.3390/rs9101002