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**Safety – Sentinel for geohazard**  
prevention and forecasting

**Deliverable DD.2: Geodatabase description of the  
selected test sites**

**A deliverable of**

**Task D: Test sites characterization and geodatabases**

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# ***Table of Content***

<b><i>EXECUTIVE SUMMARY</i></b> .....	<b>3</b>
<b><i>REFERENCE DOCUMENTS</i></b> .....	<b>4</b>
<b>INTRODUCTION</b> .....	<b>6</b>
<b>1. DESCRIPTION OF THE TEST SITES</b> .....	<b>6</b>
1.1 Volterra geodatabase .....	7
1.1.1 Basic layers .....	7
1.1.2 Output product maps .....	11
1.2 Canary Island geodatabase .....	12
1.2.1 Basic Layers .....	12
1.2.2 Output product maps .....	15

## ***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 1 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.

D.D2 "Geodatabase description of the selected test sites" is the last of the two deliverables of Task D "Test sites characterization and geodatabases". This deliverable provides the description of the geodatabase and of its elements, giving a brief characterization of the different levels that constitute the geodatabase.


## **REFERENCE DOCUMENTS**

<b>N°</b>	<b>Title</b>
RD1	DoW Part B
RD2	D5.1: Test site selection
RD3	D2.1: User Requirements

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# INTRODUCTION

SAFETY project will be tested in two test areas in Europe (in Italy and Spain). The selected study areas were chosen on the presence and relevance of known phenomena that threaten the urban fabric and population, and on the availability of significant thematic and environmental data, as well as on a specific interest of Civil Protection authorities.

## 1. DESCRIPTION OF THE TEST SITES

The two selected test sites are:

- Volterra site in Tuscany region (Italy)
- Canary Islands (Spain)

The structure of the geodatabase and the description of the single layers and output product-maps that constitute the geodatabase are hereafter explained (Fig. 1).

Both SAFETY test sites share the same geodatabase structure, including basic layers and product maps. The basic layers are thematic data of different nature, i.e. vectorial (polyline, point-like or polygonal units) or raster data. These input layers are needed to deliver the product-maps as outputs of the SAFETY project. These product-maps are the Deformation map, the Hazard map, the Susceptibility map, the Geo-Hazard Activity Map and the Impact Assessment map (Fig. 1-1).

In Figure 1-1, the data type and the reciprocal relationships and data requirements are graphically shown in a logic Flowchart using different colours needed for each product.

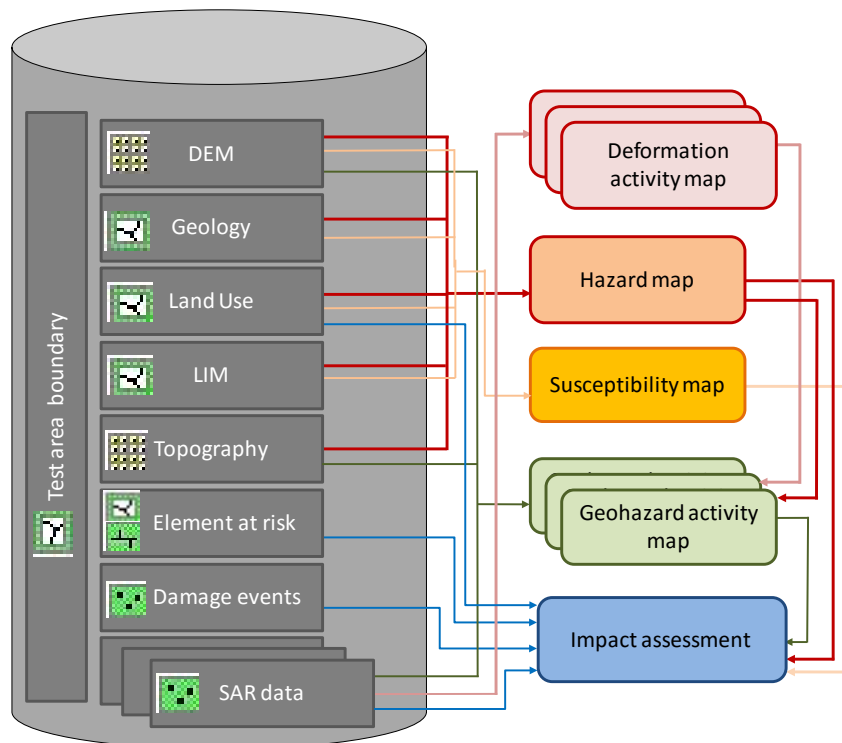


Figure 1-1 Flowchart of the Geodatabase structure.

## 1.1 Volterra geodatabase

### 1.1.1 Basic layers

In detail, the basic layers composing the geodatabase are:

- Volterra municipality boundary in shapefile format (.shp);
- digital elevation model (DEM) in grid format (.grd);
- geological map in shapefile format (.shp);
- land use map in shapefile format (.shp);
- landslide inventory map (LIM) in shapefile format (.shp);
- topographic map at 1:10000 nominal scale in geotiff format (.tif);
- element at risk catalogue in shapefile format (.shp);
- damage events database in shapefile format (.shp);
- SAR SENTINEL deformation activity map (.shp).

#### 1.1.1.1 Digital Elevation Model

The raster DEM that covers the test site area of Volterra is a 10 m cell resolution Digital Elevation Model (Fig.1-2) provided by the cartographic database (TINITALY/01, TARQUINI et alii, 2007, 2012) of the National Institute of Geophysics and Volcanology (INGV).

#### 1.1.1.2 Geological and Land Use maps

The geological map of the Volterra municipality is digitalized in a polygonal shape format starting from the geological map of the Volterra municipality (Bianchini et al., 2016) (Fig. 1-3A). Each polygon represents a lithological class, defined on the basis of similar lithological and geotechnical characteristics between the original various geological formations of the original map. For example, the class named Clays represent the union of different clayey lithotypes referred to different geological formations but with similar geotechnical behaviour.

The Land Use map is obtained from the CORINE Land Cover map of year 2006 (CLC, 2007) and its polygons represent the Level 2 data of the CORINE system (Fig. 1-3B).

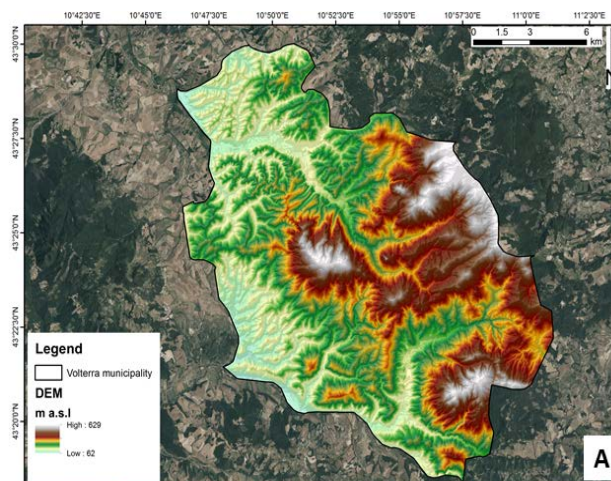


Figure 1-2 Digital Elevation Model (DEM) of the Volterra municipality.

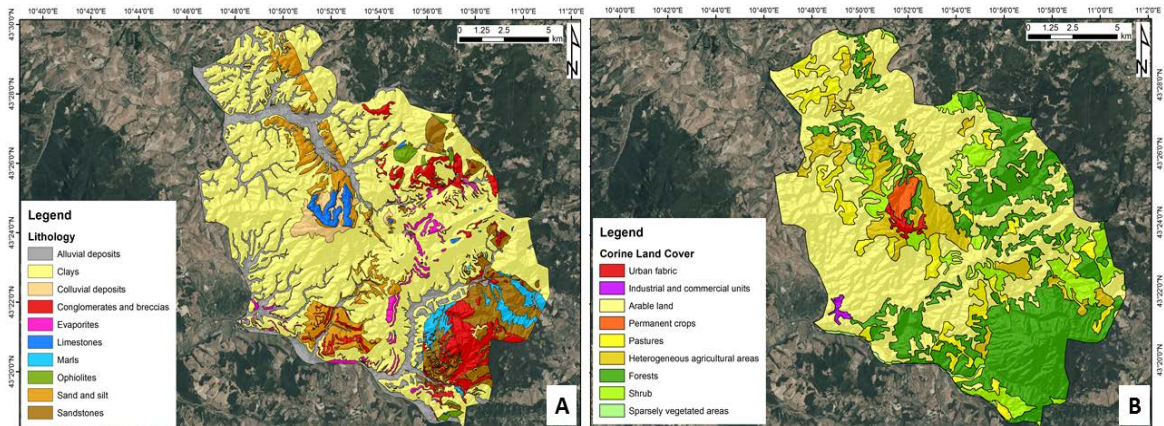


Figure 1-3 Geological (A) and Land Use (B) maps of the Volterra municipality.

### 1.1.1.3 Landslide Inventory Map

The Landslide Inventory Map (LIM) layer is composed of 1040 landslides that have been mapped relying on two landslide inventories provided by the Tuscan region and by the GEOPROGETTI company (Fig.1-4). The first geodatabase is recorded at a regional scale and represent an evolution of the previous IFFI (Inventario dei Fenomeni Franosi in Italia) database, improved with ERS 1/2 an Envisat PSInSAR information (DIANA project, Dati Interferometrici per l'ANalisi Ambientale). The second one is referred to a detailed survey performed only in the 20 km<sup>2</sup> covered by the Volterra city (GEOPROGETTI, 2010). The results of the two inventories were merged in order to provide a database which shows the extension of the phenomena and their state of activity.

### 1.1.1.4 Topographic map

The topographic base implemented in the geodatabase is a 1998 CTR (CARTA TECNICA REGIONALE) map at 1:10000 nominal scale provided by the cartographic web service of the Tuscany Region (<http://www502.regione.toscana.it/geoscopio/cartoteca.html>) (Fig.1-5).

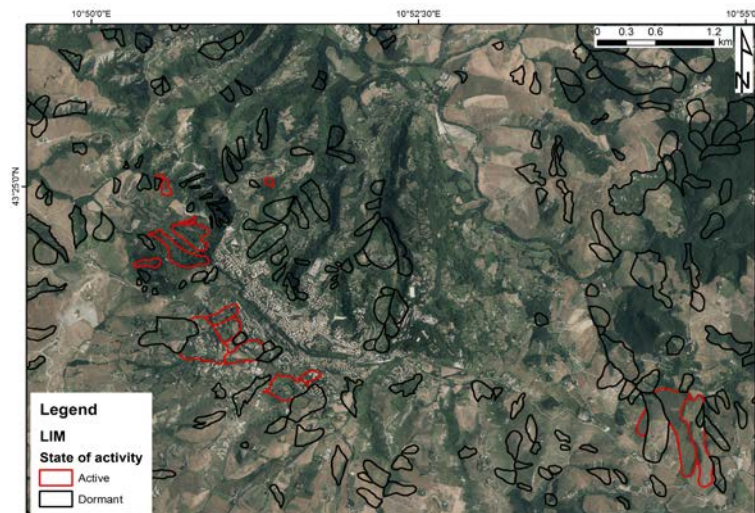


Figure 1-4 Landslide Inventory Map (LIM) around the city of Volterra.



Figure 1-5 Zoom of the topographic map at 1:10000 scale in the city of Volterra.

#### 1.1.1.5 Element at risk

The element at risk catalogue is composed of a polygonal shapefile containing all the buildings in the Volterra municipality and a linear shapefile containing roads and railroads of the area of interest. Both shapefiles are classified on the basis of their typology, and a Code is assigned (Table 1-1 and 1-2) (Catani et al., 2005).

For each structure Code, a vulnerability value  $V$  is also assigned for landslides of various intensity ( $I$ ), in order to derive the Vulnerability map, useful for producing the Impact assessment map (See section 2.1.2).

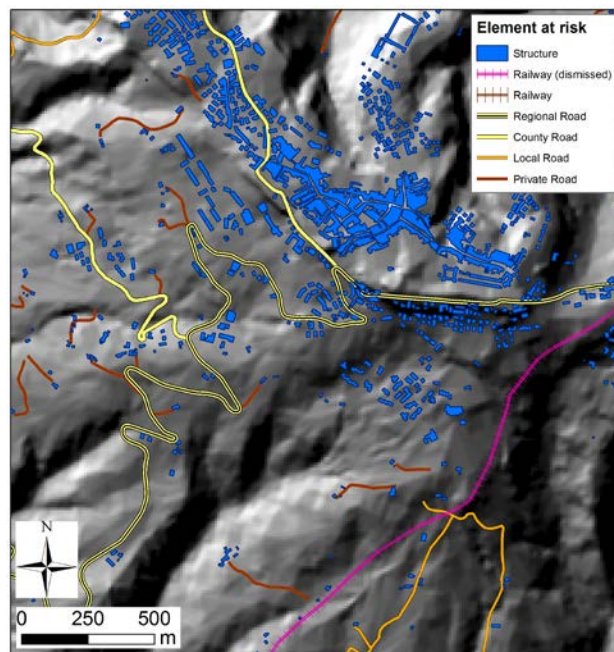


Figure 1-6 Elements at risk of the Volterra test area.

Code	Description	Vulnerability				
		V(I=I0)	V(I=I1)	V(I=I2)	V(I=I3)	V(I=I4)
201	Public/Social/Administrative Building	0	5	10	30	60
202	Industrial/Commercial/Building-Factory	0	5	10	20	50
204	Building under construction	0	5	15	30	40
205	Abandoned/Ruined Building	0	5	20	50	60
212	Power station/Power substation/Power shed	0	5	10	20	50
216	Stable/Barn/Breeding farm	0	5	15	40	60
226	Religious building complex, Church	0	5	15	30	60
229	Campground/resort/Tourism Structure	0	5	20	50	80
220	Building (Not Residential)	0	5	20	50	80

Table 1-1 Element at risk: Structures.

Code	Description	Vulnerability				
		V(I=I0)	V(I=I1)	V(I=I2)	V(I=I3)	V(I=I4)
602	State Highway/Regional Road	0	5	40	60	100
603	Provincial Road	0	5	50	80	100
604	Local Road	0	5	60	80	100
605	Private Road	0	5	70	80	100

Table 1-2 Element at risk: Road network.

#### 1.1.1.6 Damage events

The damage database includes point-like data in a shapefile (points), specifying the damage event related to ground movements and landslide phenomena. For each point, the following information are recorded: the damage type (i.e. if damage is to structure or to the road network), the localization (the more detailed available description; e.g. the mileage indication of the road), the date of occurrence (whose precision depends on the quality of the information, e.g. in some cases, only year or period indication is possible, in other cases the precise day/month/year is highlighted).

FID	Shape*	Type	Location	Year
1	Point	Road	Road Via della Frana - Loc. Le Balze	06-2014
2	Point	Road	Road SP15 – km 8.5	13-05-2010
3	Point	Structure	Loc. Le Colombaie	2014
4	Point	Structure	Lungomura Pratini, Volterra town	31-01-2014
...	...	...	....	...

Table 1-3 Extract example of the Table of attributes of the Damage events shapefile.

#### 1.1.1.7 SAR data

The SAR data consist of the first output of the Sentinel-1 interferometric products processing. Three elaborations are expected during SAFETY project that lead to the creation of updated deformation activity maps.

Data are point-wise targets in a shapefile (points) with fields shown in Table 1-4, according to Task C and related Deliverables. As a result, this basic layer will be updated tree times after each processing step.

Field	Description	Unit
ID	Name of the point	-
Row	Radar image line	-
Col	Radar image column	-
Fi	WGS84 Geographic Latitude	(°)
Lambda	WGS84 Geographic Longitude	(°)
E	UTM East	(m)
N	UTM North	(m)
H	SRTM Height	(m)
Velocity	Point Mean yearly velocity	(mm/year)
S0	Sigma zero of the velocity	(mm)
aaaa/mm/dd	Displacement value at date aaaa/mm/dd	(mm)

Table 1-4 Description of the Table of attributes of Sentinel-1 SAR data.

In figure 7, the spatial distribution of the six-month velocity map of the first delivered Sentinel deformation activity map is shown.

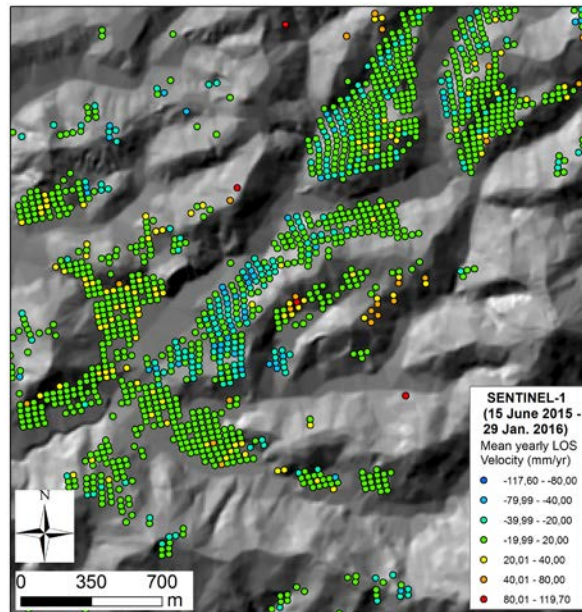


Figure 1-7 Sentinel-1 deformation activity map, first delivery (spanning time June 2015 – January 2016).

### 1.1.2 Output product maps

The geodatabase of the Volterra test site will include the output product-maps of SAFETY project. The Deformation activity map will be the output of SAR data. It is a multi-level map that contains different level of information related to the different level of activity of each map cell for the three SAR data processing.

The Hazard map will be a vectorial/raster map that receives input from DEM, geological and land use maps, topography and LIM (Landslide Inventory map) basic layers, for revealing the probability of landslide occurrence. It will be classified in a number of classes according to the hazard likelihood.

The Susceptibility map will be a raster map elaborated from DEM, geology, land use map, and LIM (Landslide Inventory map) layers.

The Geo-Hazard Activity Map will be a multi-level map and it will be based on local information (DEM and topography layers) and on SAR data and related Deformation activity maps and hazard map.

The Impact Assessment map will show the evaluation of the impact of detected geohazards on vulnerable structures and infrastructures (i.e. buildings, roads). It will be compared with the other product-maps. It will receive input from the Land use coverage and Elements at risk catalogue and from the damage events database, as well as from SAR data, because it is based on a Vulnerability map, which is function of the type of affected elements (the Code described in section 2.1.1.5) and of the intensity of the phenomenon (to be assumed as ground motion velocity from satellite radar measurements).

## 1.2 Canary Island geodatabase

### 1.2.1 Basic Layers

In detail, the basic layers composing the geodatabase are:

- Canary island municipal boundaries (level 4) in shapefile format (.shp);
- digital elevation model (DEM) in grid format (.grd);
- geological map in shapefile format (.shp);
- land use map in shapefile format (.shp);
- rockfall inventory map (LIM) in shapefile format (.shp) – in elaboration
- topographic map at 1:25000 nominal scale in shapefile format (.shp);
- element at risk catalogue in shapefile format (.shp); - under request
- damage events database in shapefile format (.shp) – in elaboration
- SAR SENTINEL deformation activity map (.shp)

#### 1.2.1.1 Geotematic layers

Geological map: shapefile. This product derives from national geological continuous map (GEODE) in Spain at a 1:50.000 scale ([www.igme.es](http://www.igme.es)).

Land use map: shapefile and raster. This product derives from the Spanish Information System on Land Cover (SIOSE) referred to 2014 (<http://www.ign.es/ign/main/index.do>).

Topographic map: shapefile. This product derives from the national topographic map at a 1:25.000 scale from IGN (<http://www.ign.es/ign/main/index.do>).

Digital Elevation Model: raster layer. Digital Elevation Model (DEM) with 5x5 m cellsize resolution elaborated by IGN under the Spanish National Plan of Aerial Orthophotography and LiDAR. (<http://www.ign.es/ign/main/index.do>). Derived datasets: aspect and slope maps are also available.

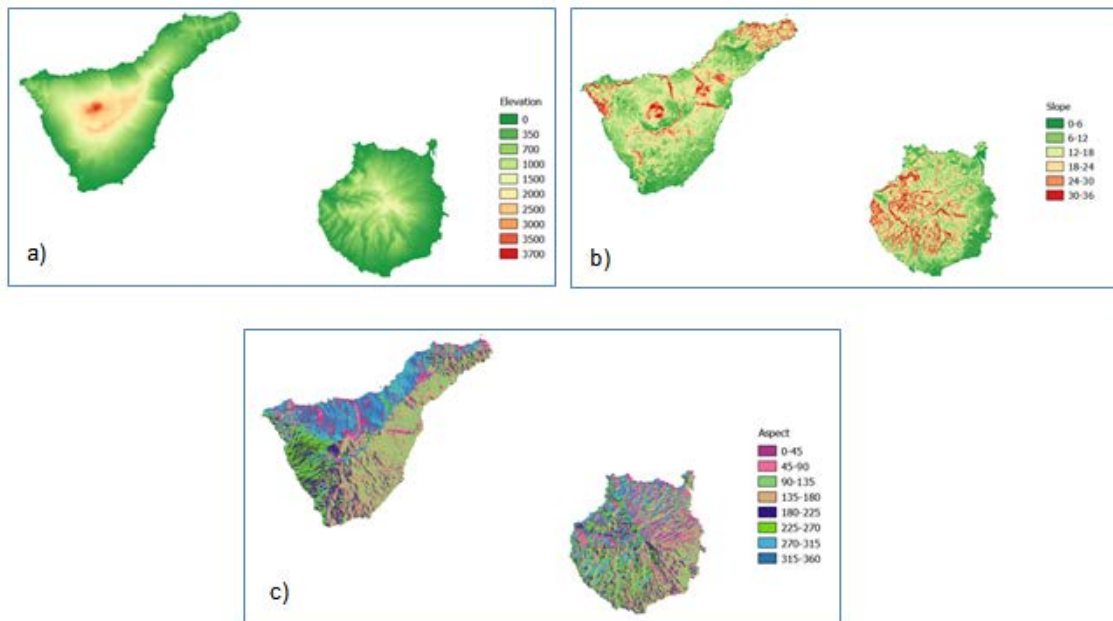


Figure 1-8 Digital Elevation Model (DEM) and derived products of the Canary islands

### 1.2.1.2 Seismic and volcanic monitoring networks

We offer also dynamic real time and updated thematic maps and data as a result of the IGN monitoring seismic and volcanic networks, offering:

- IGN Real time seismic Catalogue  
<http://www.ign.es/ign/layoutIn/volcaFormularioCatalogo.do> : it includes the information related to all seismic events localized in the entire Canary Archipelago as date, time, latitude, longitude, depth, intensity, magnitude of earthquakes, etc.
- IGN Real time seismic waveform and spectrograms of different stations located in the Canaries (one in Tenerife): <http://www.ign.es/ign/layoutIn/volcaSenalesAnteriores.do>
- IGN Accelerogram Catalogue  
<http://www.ign.es/ign/layoutIn/sismoFormularioAcelerogramas.do>

There are two stations located in Tenerife and Gran Canaria Islands that continuously record the maximum acceleration of the ground.

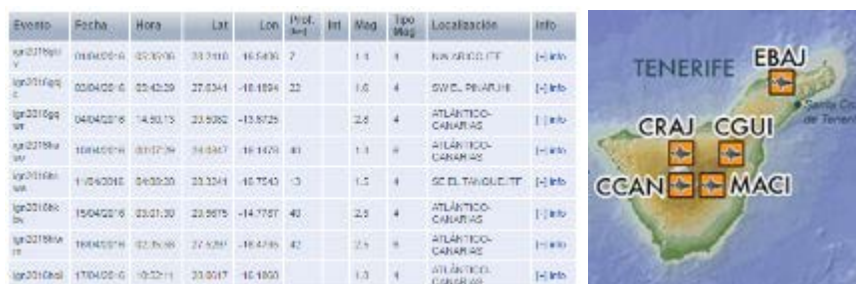


Figure 1-9. Real time seismic catalogue and seismic stations located in Tenerife Island.

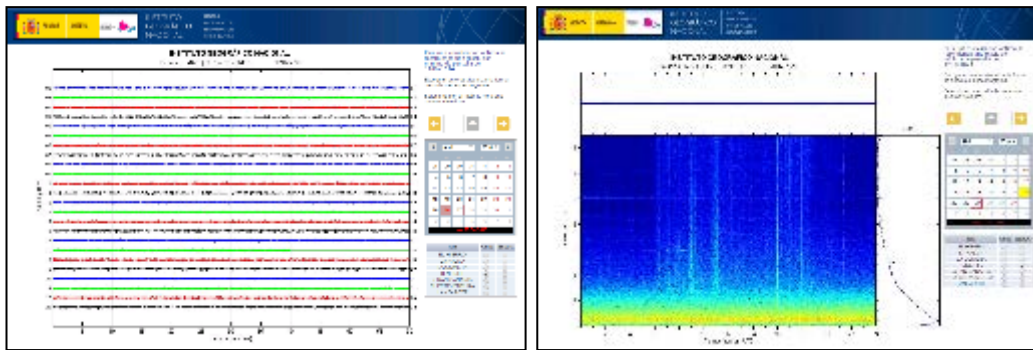


Figure 1-10. Example of seismic wave form and spectrogram from MACI seismic station in Tenerife.



Figure 1-11: Location of accelerographs in Tenerife and Gran Canaria Islands.

- IGN GNSS data server download:

<http://www.ign.es/ign/layoutIn/geodesiaDatosGNSS.do>  
[RINEX files of GNSS Stations Network \(ERGNSS\) are available for several stations in the Canary Islands, 4 stations in Tenerife.](#)

- IGN mareograph data series:

<http://www.ign.es/ign/hwide/redMareografica.do>

There are several stations in the Canary Islands, (three stations in Tenerife) continuously measuring sea surface levels.

#### 1.2.1.3 Rockfall inventory (LIM)

Rockfall events recorded in the GC-200 road from La Aldea to El Risco (Great Canary Island) from 2010 to 2016 are being geocoded and stored into a geodatabase in shapefile format.

Rockfall events recorded in Anaga test site (Tenerife island) in the past 6 by the road maintenance service is available in shapefile and is being adapted to Safety format.

#### 1.2.1.4 Element at risk

The element at risk catalogue has been requested to Regional Civil Protection Service. The aim is to retrieve a polygonal shapefile containing all the buildings and a linear shapefile containing roads and railroads of the Canary islands.

### 1.2.1.5 SAR data

The SAR data consist of the first output of the Sentinel-1 interferometric products processing. Three elaborations are expected during SAFETY project that lead to the creation of updated deformation activity maps. Data are point-wise targets in a shapefile (points) with fields shown in deliverable C2.1. As a result, this basic layer will be updated three times after each processing step. In Figure 1-12, the spatial distribution of the one year velocity map of the first delivered Sentinel deformation activity map is shown.

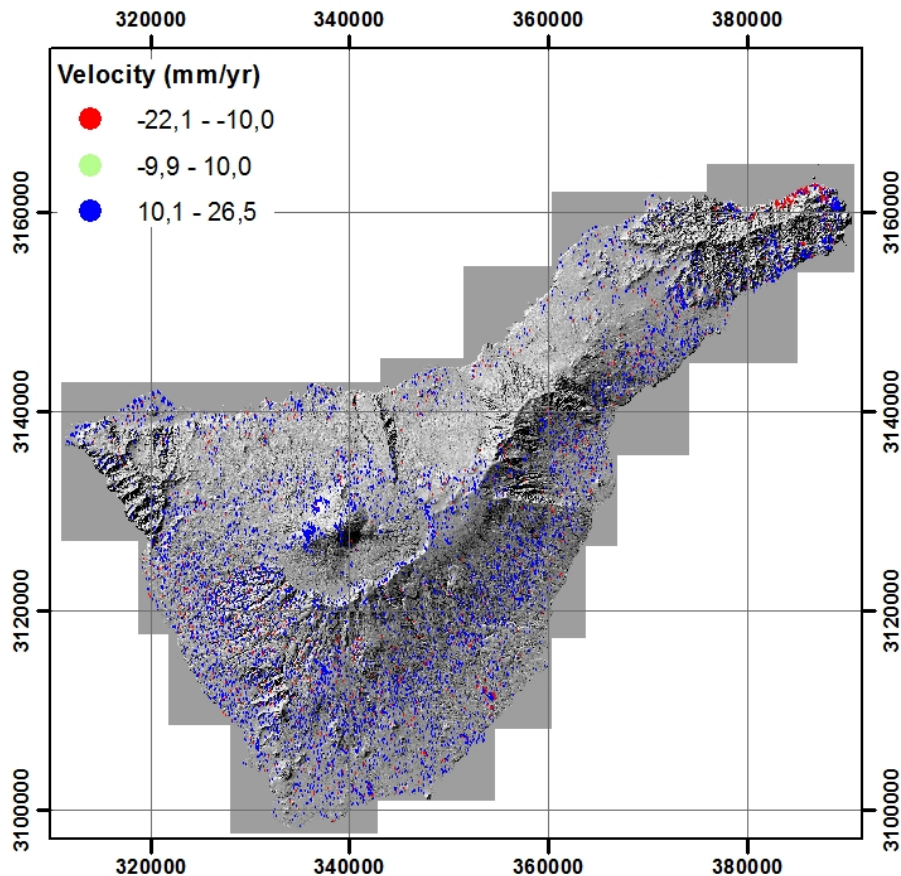


Figure 1-12 Sentinel-1 deformation activity map in Tenerife island, first delivery (spanning time June 2015 – January 2016). Only active points are represented.

### 1.2.2 Output product maps

The geodatabase of the Canary Islands test site will include the output product-maps of SAFETY project.

The Deformation activity map will be the output of SAR data. It is a multi-level map that contains different level of information related to the different level of activity of each map cell for the three SAR data processing.

The Hazard map will be a vectorial/raster map that receives input from DEM, geological and land use maps, topography and LIM (Landslide Inventory map) basic layers, for revealing the probability of rockfall occurrence. It will be classified in a number of classes according to the hazard likelihood.

The Susceptibility map will be a raster map elaborated from DEM, geology, land use map, and LIM (Rockfall Inventory map) layers.

The Geo-Hazard Activity Map will be a multi-level map and it will be based on local information (DEM and topography layers) and on SAR data and related Deformation activity maps and hazard map.

The Impact Assessment map will show the evaluation of the impact of detected geohazards on vulnerable structures and infrastructures (i.e. buildings, roads). It will be compared with the other product-maps. It will receive input from the Land use coverage and Elements at risk catalogue and from the damage events database, as well as from SAR data, because it is based on a Vulnerability map, which is function of the type of affected elements (the Code described in section 2.1.1.5) and of the intensity of the phenomenon (to be assumed as ground motion velocity from satellite radar measurements).

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