Terrafirma: a Pan-European Terrain motion hazard information service

www.terrafirma.eu.com

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Introduction to Terrafirma

- Terrafirma is one of a number of services being run by the European Space Agency under the GMES Service Element Program as part of the Global Monitoring for Environment and Security initiative of the European Union. Terrafirma started in 2003 and ESA funding will continue until 2012. Its continuation beyond 2012 depends on users.

- The technology underpinning Terrafirma services is SAR data analysis using Persistent Scatterer Interferometry (PSI). These data, in combination with geophysical expertise, are delivered to users to identify and mitigate risk.

- Terrain motion can be related to subsidence, landslides, tectonic activity, flooding, coastal erosion, unstable buildings and infrastructure, and even poor engineering standards.

- The socio-economic cost of terrain motion across Europe runs into tens of billions of Euros a year.
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Terrafirma Suppliers and Users

• Terrafirma services couple advanced satellite interferometry products with expert interpretation.

• Its services are delivered to civil protection agencies and disaster management, coastal, rail and motorway authorities to support the process of risk assessment and mitigation.

• Terrafirma has consolidated and standardised the supply of interferometry products from the European companies specialising in this type of processing.

• Terrafirma combination with this, the project has federated most of Europe’s national geological surveys, provided services to Civil Protection Agencies and enrolled high profile engineering companies.

• This federation not only forms a primary user-base, but also provides the best source of the interpretation and represents a single point of contact for information on terrain motion hazards in Europe.

Terrafirma services help to identify and mitigate risk.
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Terrafirma Stages

- Terrafirma in Stage 1 (2003-2006): Consolidation of service provision
- Terrafirma in Stage 3 (2009-2012): Achieve Sustainable service provision
  - Focus on thematic lines (flooding, tectonics and hydrogeology) to deliver service to meet specific user needs
    - facilitate introduction into users operations -> achieve sustainability
  - Deliver wide area synoptic product to serve regional/Europe-wide users

Terrafirma services help to identify and mitigate risk.
TerraFirma Team

A team of experts around Europe providing services and working together for a common objective since 2003
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Terrafirma Service Coverage 2009-2010

Expert interpreted service delivery Stage 3, first year

- Groundwater
- Flood
- Landslide
- Abandoned Mines
- Tectonics
The objective of this service is to deliver geo-information for hydrogeological hazards affecting urban areas, mountainous zones and infrastructures.

**Description of Services**

Terrafirma’s Hydrogeology Products have been conceived for application in many scenarios:
- Groundwater exploitation subsidence
- Abandoned and inactive mines
- Slope instability in mountainous area.

**Thematic leader: University of Florence**

*Users of the Hydrogeology Product include civil protection agencies, coastal, mining and landslide authorities.*
This service presents information on seismic hazards and that are oriented by the needs of the end user within two subcategories: crustal block boundaries and vulnerability maps.

**Description of Services**

Crustal block boundaries service provides users with information on terrain motion related to faults, earthquake cycles, and vertical deformation sources.

Vulnerability map service combining PSI data with in situ measurements to identify regions with vulnerability in the case of earthquake.

Thematic leader: INGV

Product Example: Istanbul, Turkey

*The Tectonics Products are used by civil protection agencies and urban planning entities, amongst others.*
Flood Products

The flood theme is comprised of a portfolio of services that assess flood risk in coastal lowland areas and flood-prone river basins.

Description of Services

Advanced subsidence mapping service combines PSI with levelling data and GPS to enable users to interpret subsidence maps within their geodetic reference systems.

The flood defence monitoring service focuses on flood protection systems such as dikes and dams.

Thematic leader: Geological Survey of the Netherlands

Users of the Flood Product include civil protection agencies, coastal, transportation, waterway and port authorities.
The wide area mapping product is offered by Terrafirma as of 2009 and offers a synoptic overview of terrain motion.

Description of Services

Terrafirma’s Wide Area Product complements the service by offering terrain motion studies that cover areas larger than 100 Km wide at a scale of 1:250 000.

This product is especially designed for users who need a synoptic ground deformation map in order to highlight critical areas for further investigation.

Thematic leader: German Space Agency (DLR)

**The Wide Area Product offers civil protection agencies and the civil engineering community an overall view of terrain motion.**
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Case Study: Amsterdam, The Netherlands - Flooding

Objective of the project

- Amsterdam is a typical urban area that was used as a test-site for Terrafirma Validation Project.

Analysis and results


- Amsterdam includes autonomous and spatially uncorrelated terrain-motion over the 9.5km route of the new N-S metro line currently under construction.

- PSI is a promising tool for large area analysis of ground related movement. It offers a quick and efficient way to obtain large data sets not possible with conventional leveling or GPS.

“Terrafirma is a very valuable service and will provide spin-offs for the assessing, modelling and monitoring of subsidence, settlement, ground collapse and dyke failure.” TNO.
**Objective of the project**

- Within the ESA Terrafirma project a ground displacement study about was conducted for Budapest.

**Analysis and results**

- The Terrafirma product highlighted a zone of known subsidence in the Zuglo district of Budapest.

- A previously unknown area of uplift was also visible at Köbanya. The explanation for this uplifted area was investigated in the Budapest Interpreted product.

- Information was collected from four monitoring wells for the period coinciding with the PSI result shows a clear rise in groundwater levels.

“*The usefulness of the PSI method is obviously proven by the Köbanya uplift phenomenon. There wasn't any indication or measurement of this kind of movement before we got the PSI dataset.*” FOMI, ELGI.
Objective of the project

- The Alto Gallego study was to update the 1994 landslide inventory for the valley using geomorphology data, orthoimagery, etc.
- The PSI data were compared with the existing landslide inventory and other data layers to delimit the boundaries of each landslide.

Analysis and results

- Period of study: 1995-2007
- Landslide detection by PSI at a regional scale would help to identify active slides and lead to a greater understanding of the dynamics involved and possible triggering factors.
- The results of the Terrafirma Landslide Inventory study can be used by local and civil protection authorities and could have a direct application in prevention and mitigation activities in the area.

“There is no other ground-based or remote sensing technique that can provide such a large number of measurements over wide areas at a low cost, providing a historical archive of data available since 1991”. IGME, Instituto Geológico y Minero de España.
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Case Study: Stoke-on-Trent, UK: Abandoned mine re-watering

Objective of the project

• Detection and mapping of areas affected by uplift and subsidence in the area surrounding Stoke-on-Trent.
• Locate and measure ground motion accurately in the study area and find the main cause of such movement.

Analysis and results

• Period of study: 1992-2001
• Area has experienced terrain-motion during extraction and when mine-water levels were allowed to return to normal after abandonment
• Uplift attributed to older undermining, likely due to elastic rebound from groundwater recharge
• Subsidence linked to recent undermining, areas of made-ground, compressible alluvial soils and areas underlain by salt

“The data from the Terrafirma project is giving us new insights into ground and building movement histories in urban Britain.” – British Geological Survey
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Case Study: Istanbul, Turkey - Tectonics

Objective of the project

- Within the ESA Terrafirma project an amplification of seismic ground motion study was conducted over Istanbul

Analysis and results

- Much of the destruction caused by the 1999 Izmit earthquake was concentrated to the west of the city. By contrast the eastern city is built mostly on solid rock and is generally stable, though critical zones are revealed by the PSI study.

- This is a clear sign of unconsolidated soft sediments that can severely amplify seismic ground motion.

- Terrafirma provided subsidence data with a detail that would have been nearly impossible to detect in most circumstances

“Terrafirma data indicates where we should focus on our efforts in earthquake preparation.” Kandilli Observatory and Earthquake Research Institute (KOERI).
Thank you for your attention

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