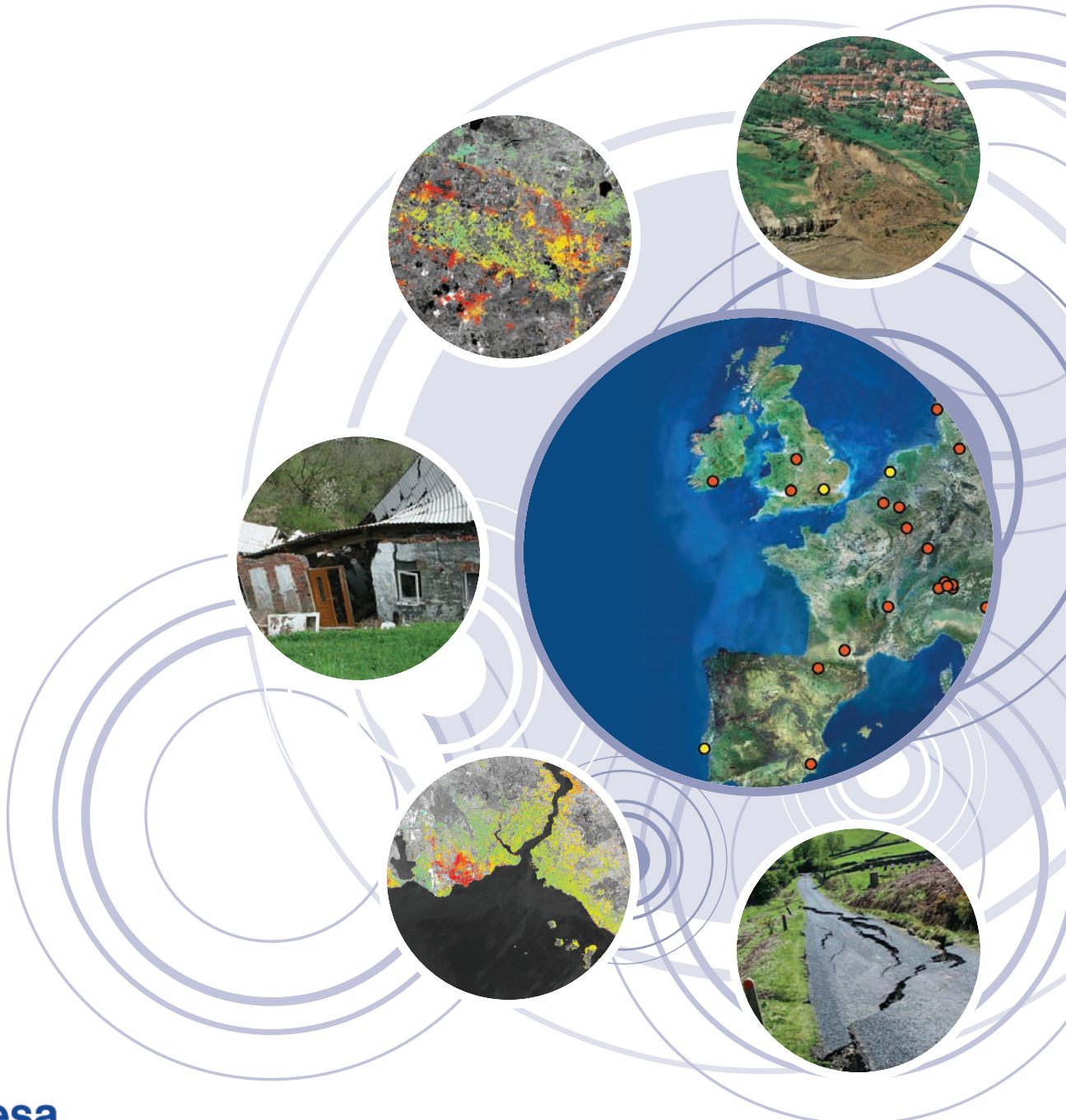
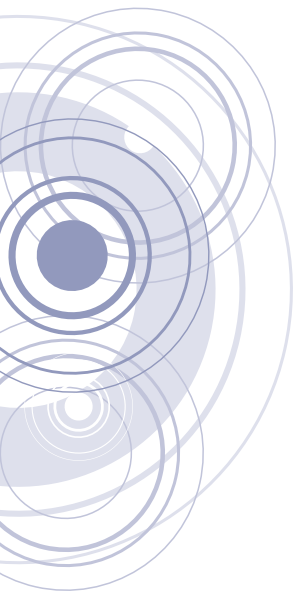


TERRAFIRMA



TERRAIN MOTION INFORMATION SERVICE FOR EUROPE

TO SAVE LIVES, IMPROVE SAFETY & REDUCE ECONOMIC LOSS



What is 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 will end in 2008 when it is planned that services will be adopted by the European Commission as part of their GMES strategy.
- Terrafirma harnesses the unique power of satellite radar interferometry to detect and measure Earth-surface terrain motion. These data, in combination with geophysical expertise, are used to save lives, improve safety and reduce economic loss.
- Terrain motion can be related to subsidence, landslides, earthquake activity, flooding, coastal erosion, volcanoes, unstable buildings and infrastructure, and even poor engineering standards. Many of these phenomena and their associated hazards are made worse by the effects of rapid climate change.
- The socio-economic cost of terrain motion across Europe runs into tens of billions of euros a year, and is becoming higher as populations increase, cities become larger, resources become scarcer and the climate becomes more unstable.

[FLOODING]

14% of the EU27 population live in coastal regions and the majority of tomorrow's mega-cities will be built on or near a shoreline. There are major geodetic issues in de-correlating small variations in land level from climate-induced sea-level rise. Recent work for DEFRA (UK) comparing PSI results with GPS, tide gauge and absolute gravity measurements have shown that PSI data can be valuable, not only in correcting the inherent uncertainty of past and present GPS measurements and filling in the gaps between stations, but also in optimising GPS station placement for ongoing monitoring. Equally, natural subsidence within floodplains may be affecting flood defences or increasing vulnerability locally.



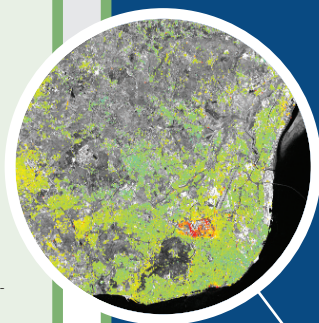
Suppliers and Users

- Terrafirma has consolidated and standardised the supply of interferometry products from the European companies specialising in this type of processing. In combination with this, the project has federated most of Europe's national geological surveys, provided services to Europe's 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 value-adding skills necessary to maximise the products' utility. Terrafirma, therefore, represents a single point of contact for information on terrain motion hazards in Europe.
- Terrafirma is delivering products for at least one major site in each country of Europe, plus 17 landslide products for Italy, Greece, Spain and Switzerland. By 2008, nearly 60 Terrafirma products will have been made, interpreted and utilised.

[URBAN STABILITY]

Recent statistics show that 50% of the world's population already live in cities, and 'mega-cities' of over 10 million people are now commonplace. As the trend toward urbanisation continues and pressure on space grows in both vertical and horizontal domains, ground stability becomes an increasingly critical concern.

Issues such as metro tunnelling, historical and contemporaneous mining, compressible substrates, oil and gas production and water-table change can all have adverse effects to property and people. Furthermore, many mega-cities already lie on vulnerable flood plains, in coastal lowlands or in earthquake-prone zones. In the past, these kinds of hazards have been monitored in a purely reactive manner. For the first time, Terrafirma offers a wide-area synoptic overview of terrain motions, allowing for proactive remediation and planning.



● ● : sites processed

Image: Copyright ESA

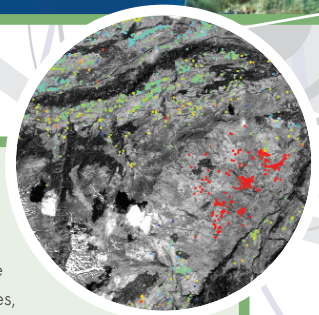
Products

The technology underpinning Terrafirma uses data collected by European radar satellites in a process called Persistent Scatterer Interferometry, or PSI for short. The synoptic view of the satellite covers whole cities and regions, and because an archive exists of repeat satellite coverage dating back to 1991, PSI is unique in being able to look back at past terrain motion with millimetric precision. Products are being used by national civil protection agencies and the civil engineering community, as well as being offered by national geological surveys who are integrating pre-existing and in-situ data to provide 'interpreted', 'causal' and 'modelled' information services.

[LANDSLIDES]

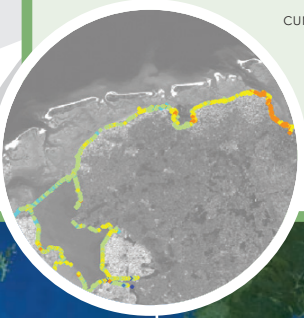
Landslides account for a significant number of deaths and damage to economies in many mountainous parts of Europe.

Terrafirma products have been successfully used to both identify unstable slopes and monitor known slides. One village in Italy was even relocated based upon the direct evidence provided by Terrafirma partners using this technology. For landslides, Terrafirma also provides a 'rapid mapping service' where results can be provided to civil protection authorities within hours of request. The result for Lumnez, Switzerland, shown here, identified two unstable sectors which are currently home to several villages. This information is being used by the Federal Office for the Environment who have responsibility for landslide risk in Switzerland.



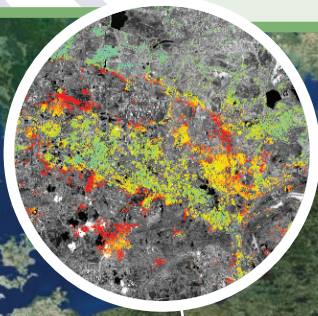
[DYKE STABILITY]

For major regions in the world, water defence systems such as dykes, dams and levees form the only protection against flood risk. Inspection of the structural stability of dykes relies on visual surveys, often rather infrequent as levee-failures in New Orleans demonstrated. A PSI-based method for monitoring of dyke stability has been developed by the TerraFirma partner at TU Delft, and is currently applied to the dykes of the Netherlands.



[MINING]

Subsidence caused by mining is a major concern across many parts of Europe. The effects of active mining are perhaps better controlled, though the many private companies responsible are sometimes reticent to proactively monitor and publicise results for liability reasons. This is one good reason for an independent synoptic overview of the type that TerraFirma can provide. On the other hand, Europe is honeycombed with older, historical mines, some of which are mapped, but many of which are unknown until some collapse occurs. This represents a real power of TerraFirma products - being able to provide a synoptic view over whole regions that can reveal these kind of deformation trends, allowing a more proactive approach to remediation.



[EARTHQUAKES]

Understanding fault mechanisms is critical to earthquake forecasting, and large amounts are spent in the US and Japan in monitoring crustal deformation using satellite positioning. GPS, however, can only be deployed in relatively sparse networks and is typically less accurate in the horizontal plane, whereas PSI provides high vertical accuracy and integrations between the two techniques can help de-correlate motion vectors as well as highlight localised motions which might be biasing GPS results. In Turkey, PSI results have been useful in detecting zones of old sediment which have the potential to liquefy and amplify the effects of earthquakes. This product led to a re-evaluation of risk zonation within the city. In other cities, for example Lisbon, PSI has revealed deep basement geology and improved tectonic modelling. TerraFirma know-how and products have the capability to create 'virtual GPS networks' with a historical time-series reaching back 15 years for all earthquake-prone cities of Europe.

PARTICIPATING ORGANISATIONS

Country	Site	Organisation
Belgium	Brussels Liege	Royal Belgium Institute of Natural Sciences
Bulgaria	Sofia	St. Ivan Rilski Mining and Geology University Bulgarian Academy of Sciences (BAS)
Cyprus	Lefkosia	Cyprus Geological Survey
Czech Republic	Prague	Czech Institute of Rock Structure and Mechanics (IRSM)
Denmark	Esbjerg	Danish National Space Centre (DNASC)
Estonia	Parnu	Geological Survey of Estonia (EGK)
Finland	Vaasa	PÖYRY, Soil and Water Ltd
France	Lyon Toulouse	Bureau de recherches géologiques et minières (BRGM)
Germany	Hamburg Stassfurt Berlin	Federal Institute for Geosciences and Natural Resources (BGR)
Greece	Athens Larissa	National Kapodistrian University of Athens (NKUA) Harkopeio University, Earthquake Planning and Protection Organisation (EPPO)
Hungary	Budapest	Eotvos Lorand Geophysical Institute of Hungary (ELGI) Institute of Geodesy and Remote Sensing (FOMI)
Ireland	Cork	Geological Survey of Ireland (GSI)
Israel	Haifa	Geological Survey of Israel The Geophysical Institute of Israel (GII)
Italy	Rome Calabrian Basin Gorgolone Frazzanò Palermo	Municipal Civil Protection Agency of Rome National Civil Protection Agency The Agency for Environmental Protection and Technical Services (APAT) CESI Ricerca National Civil Protection Agency CESI Ricerca
Latvia	Riga	Latvian Environment, Geology, and Meteorology Agency (LEGMA)
Lithuania	Vilnius	Geological Survey of Lithuania
Luxembourg	Luxembourg	Geological Survey of Luxembourg (SGL)
Poland	Rybnik-Ostrava Sosnowiec	Polish Geological Institute (PGI)
Portugal	Lisbon	Institute of Engineering and Structures (ICIST)
Russia	Moscow St Petersburg	Geophysical Survey of Russian Academy of Sciences
Slovenia	Ljubljana	Slovenia Geological Survey (GeoZs) Geological Agency of the Slovenian Republic (ARSO)
Spain	Murcia Alto Gallego	Institute of Geology and Mineralogy of Spain (IGME) Institute Geologic de Catalunya The Government of Aragon Environmental Department
Switzerland	Central Swiss Alps Canton Graubunden Val Lumnez Kloster-Cumbel Bernina Braunwald	Federal Office for the Environment (FOEN)
The Netherlands	Alkmaar - Amsterdam	Netherlands Institute of Applied Geoscience (TNO)
Turkey	Istanbul	Bogazici University Kandilli Observatory and Earthquake Research Institute (KOERI)
UK	Stoke on Trent Bristol / Bath	British Geological Survey (BGS) ARUP

TERRAFIRMA FULL PARTNERS



"The Terrafirma products not only describe the ground subsidence in detail but also provides a time window of the past in any region where in situ measurements started later."

TerraMentor, Greece.

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

Dr Mahmut Bas, Istanbul Metropolitan Municipality.

"The project outputs have the potential to significantly enhance the BGS's national digital geohazard information system (GeoSure)."

Prof. Martin Culshaw, British Geological Survey.

"Over the last year, our approach to the study of the active tectonics of the Lower Tagus Valley was re-defined following the advent of PSI."

Dr. Joao Fonseca, Institute of Engineering and Structures, Portugal.

If your organisation is interested in participating in Terrafirma or procuring Terrafirma services for a particular area, please contact:

Ren Capes - Terrafirma Project Co-ordinator

NPA Group

Tel: +44 (0)1732 865023 Email: ren@npagroup.com



Terrafirma is one of a number of Service Element projects being run by the European Space Agency under the Global Monitoring for Environment and Security (GMES) initiative. **Terrafirma** is establishing a pan-European ground motion hazard information service in support of policies aimed at protecting the citizen.

For more information on ESA initiatives on GMES, see <http://earth.esa.int/gmes/>

For further information
www.terrafirma.eu.com



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