



Terrafirma

Pan-European ground motion hazard information service in support of policies aimed at saving lives, improving safety and reducing economic loss

PART OF ESA'S CAPACITY BUILDING FOR GMES



GMES

Global Monitoring for Environment & Security (non-mil.)

An independent system specific to Europe

Although potentially global in scope

Providing satellite and ground data to meet needs of users

Joint initiative of EC and ESA

Around 2bn. Euro budget 2007-2013

**R&D Project phase conducted by EC (Integrated Framework Projects)
and ESA (GSE – inc. Terrafirma)**

Now moving towards operations;

Fast Track Services; Land, Marine and Emergency Response

Launch of Sentinel 1 – C band radar around 2012

Terrafirma Project overview

3-stage project. 1st, 2-year stage = consolidation. Now in 2nd, 3-year stage = roll-out. *There may be a 3rd. Stage.*

Based on satellite PSI terrain motion measurements.

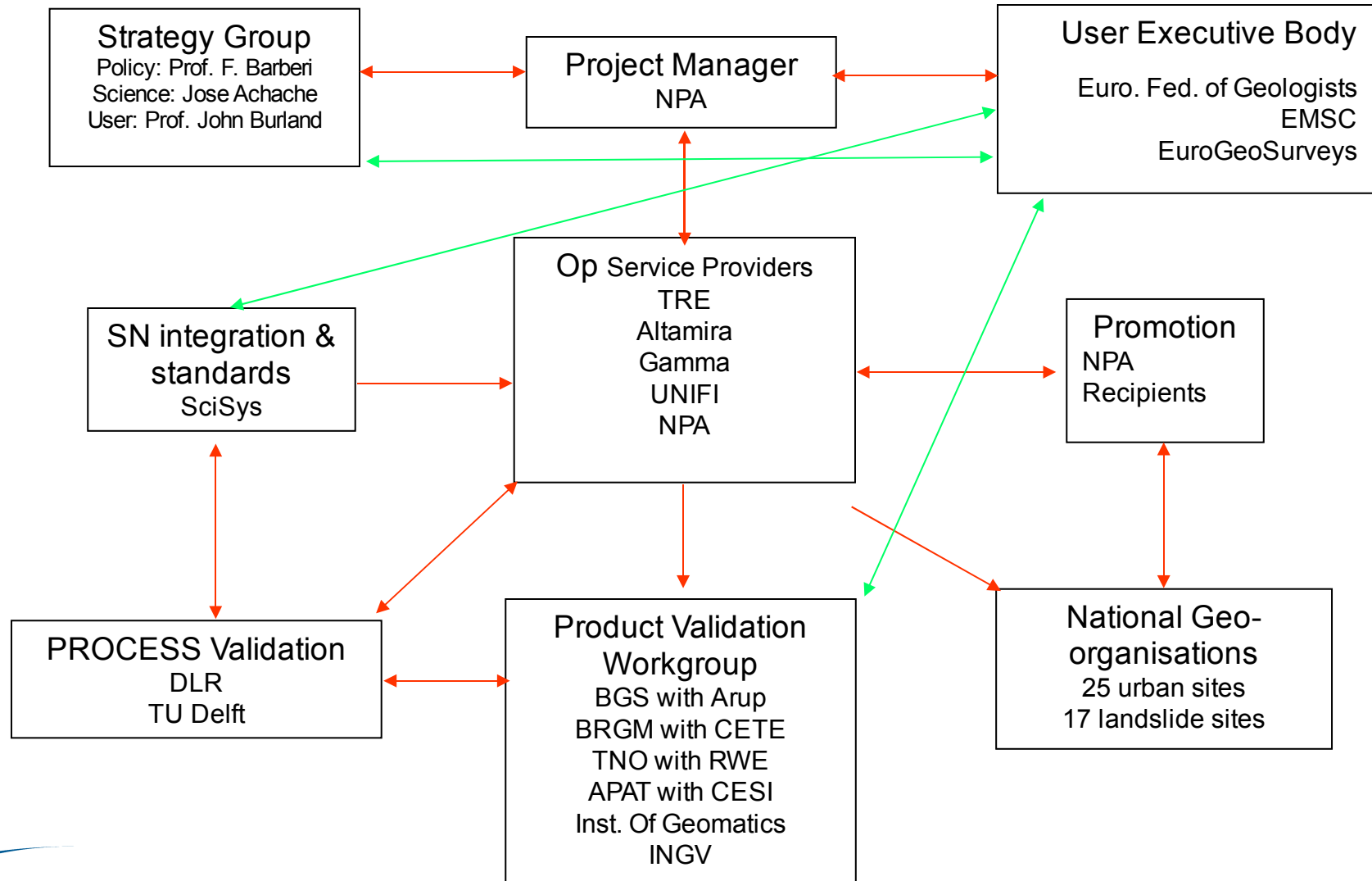
Value-adding by national geological surveys, civil engineers and civil protection authorities.

Apps: Urban stability (variety of subsidence phenomena), landslide detection and monitoring, flood management, seismic risk management.

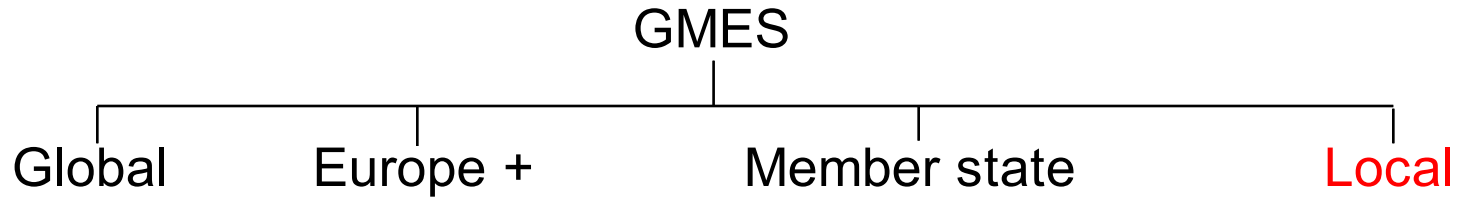
Emphasis on validation and quality control.

Truly pan-European: All EU 25 countries involved.

Stage 2 project team



Policy Foundation Review



Local

Mining, e.g. F: Loi no. 99-245 du 30 mars 1999.

Planning law specific to each local country.

National

Environment assessment, e.g. UK Town & Country Planning Act 1990.

Public participation, e.g. Freedom of Information Act 2000.

Emergency response & civil protection.

European

Aarhus Convention.

6th Environmental Action Programme.

Directive on Assessment of Effects of Public & Private Projects on Environment.

Policy Situation

Although need for ground stability monitoring is recognised, actual EU Legislation to require it to be undertaken is weak.

The European Parliament has recently produced a report on

The Regional Impact of Earthquakes (2007/2151(INI)) which is helpful

Climate Change is a significant factor

Flooding, Landslides and other geohazards

But actual policies are still missing

Climate Change + 2C to 3C in 50 Years

Will drive:

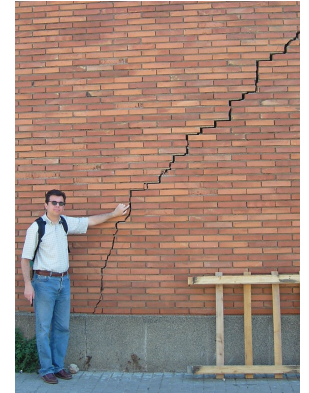
Shrink-swell ground conditions

Landslides

Localised flooding impact (coast/ inland)

e.g. Brussels, London, New Orleans

Cost to combat Climate Change is 1%GDP = €500 million per year (IPCC)



Service portfolio to date

Two types of product: Historical and Monitoring.

Historical Products:

Integrations of ERS-1/2 SAR and ENVISAT ASAR data **already in archive.**

3 levels of sophistication:

Basic Terrain Motion: Base product - 'raw' PSI output.

Interpreted Terrain Motion: Causal Product (initial interpretation).

Modelled Terrain Motion: Forecasting.

Monitoring Terrain Motion: Implies specific satellite tasking, or ordering of next 'visible' acquisition(s).

Landslide Inventory: Basin analysis.

Landslide Monitoring: Specific landslide event.

Service Level Agreements

All product manufacture is formalised and governed by a Service Level Agreement.

SLA places obligations on suppliers:

Feasibility assessment, quality assurance, delivery specifications, support.

SLA places obligations on users:

Make interpretations, exploit results, get feedback from downstream users, report.

Stage 2 will see 59 SLAs ratified (45 so far).

40 products delivered so far (+15 in Stage 1).

Hazards by country

SITE HAZARDS	Vienna, Austria	Liege, Belgium	Lefkosa, Cyprus	Prague, Czech Rep	Esbjerg, Denmark	Parru, Estonia	Vaasa, Finland	Toulouse, France	Hburg/Stassfrt, Germany	Larissa, Greece	Budapest, Hungary	Cork, Ireland	Rome, Italy	Riga, Latvia	Vilnius, Lithuania	Luxembourg	Malta	Alkmaar, Netherlands	Rybnik-Ostrava, Poland	Greater Lisbon, Portugal	Bratislava, Slovakia	Ljubljana, Slovenia	Murcia, Spain	Stockholm, Sweden	Bristol/Bath, UK
Miscellaneous									Blue			Blue	Blue												
Tectonic Movement		Green	Blue		Green					Blue	Green		Green		Green			Green	Blue	Blue		Blue			
Seismic Vulnerability		Green	Blue										Green					Green	Green	Blue		Red			
Flooding		Blue		Red	Red	Blue						Red				Green		Red	Red						Green
Oil/gas Extraction																									
Engineered Excavation		Green		Blue	Green			Blue			Green	Blue			Green	Green									
Reclaimed Land																									
Landfill/Waste Disposal										Green									Blue						
Landslip	Red			Blue		Green					Blue	Green	Red		Blue	Blue			Red	Blue					Blue
Grd Water Recharge		Blue				Blue			Green	Green	Green								Blue	Green					
Grd Water Abstraction		Blue	Blue			Blue		Blue	Blue	Red		Green	Blue		Green	Green						Green	Red	Blue	
Shrnk/Swl/Compr Soils		Blue					Green		Blue				Blue	Blue	Blue			Blue				Green	Blue		Blue
Natural Cavities		Blue								Green	Blue	Red	Blue	Red											Green
Active Mining		Green		Green	Green					Green									Blue						
Mining Legacy		Red	Blue						Red	Green	Blue					Green			Red						Red
GMES TerraFirma Cities																									

Filled squares show the hazards identified or anticipated in each country's TerraFirma site.
 Colours indicate a qualitative level of concern about each hazard: green=low, blue=moderate, red=much
 Landslides not included



Example service penetration

not all countries included

SECTORS/AGENCY	Austria	Belgium *	Bulgaria*	Cyprus	Czech Rep	France *	Germany *	Greece *	Ireland *	Israel *	Italy *	Lithuania	Netherlands *	Norway *	Poland *	Portugal *	Russia *	Spain *	Switzerland	Turkey *	UK *	
Others																						
Insurance																						
Politicians																						
Gvt Departments																						
Civil Protection																						
Env Agencies																						
Utilities																						
Mines																						
Rail/Road Agencies																						
City Authorities																						
EO Providers																						
Engineers																						
Geosci Insts/Univs																						
EU25 countries are shown in blue																						



Product validation

Validation is an absolute necessity for PSI.

Terrafirma has a Product Validation Workgroup, Chaired by BGS (UK).

PVW made up of 4 international teams of geological survey and civil engineer, e.g. BGS and Arup for UK.

Plus Institute of Geomatics and INGV.

Objectives:

Oversee validation to their satisfaction

Help design products

Make specific value-added products.

Compile users' PSI Validation Manual.

Exploitation

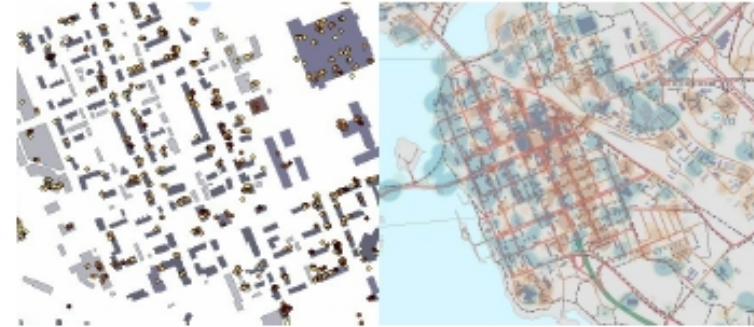
28 Service Level Agreements
demand exploitation activity

Stimulates wider interest

Has led to several spin-off
independently-funded projects.



Monitoring surface deformations with SAR interferometry



Vaasa subsidence maps

The point colours indicate the values in surface movements (mm/year).

The average subsidence or uplift is interpolated from the points.

Surface deformations can be determined in favourable conditions even within a millimetre/year. The techniques based on stable targets (persistent scatterers, PS) are needed to measure deformation in time frames where traditional differential interferometry (DINSAR) measurements are not feasible.

Traditional radar (InSAR)

With traditional interferometry (InSAR), two radar images, acquired from almost a similar orbit, determine the surface topography using the signals' phase differences. This method gives an elevation accuracy of a few metres.

Differential interferometry

DInSAR uses 2-4 radar images. The phase differences from satellite geometry and topography are eliminated, using another interferogram or DEM. The result shows changes in the target geometry (deformation). The accuracy of DInSAR is within centimetres.

Persistent Scatterers – PSI

Permanent fast and sharp targets like bedrock and building roof corners are quite important as scatterers. The persistent scatterers are detected by acquiring several radar images (>15) within a long time frame, and stacking the images or interferograms.

Simultaneously, the atmospheric artefacts can be modelled and eliminated, and we reach even a 1 mm/year accuracy for long-term deformation measurements of these coherent targets.

GMES TerraFirma

TerraFirma is one of the Service Element projects by European Space Agency under Global Monitoring for Environment and Security (GMES).

The project establishes a pan-European ground motion hazard information service. Many European cities have already been processed using this PSI technique. Pöyry Environment has made an agreement with TerraFirma, and Vaasa was processed as the first city in Finland.

Possibilities

The PSI techniques can be optimally exploited for determining deformations for built-up areas. Three subsidence maps have been made from Vaasa, Turku and Helsinki. Other application areas are monitoring the deformations of nuclear repository areas, or measuring land subsidence due to ground water or oil pumping, or sub-surface activities like mining.

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POYRY



Example brochure made by
Pöyry of Finland

Publicity

Terrafirma Atlas 1 (Stage 1 results)

Terrafirma Atlas 2 (Stage 2 results – early 2009)

Over-arching brochure (Nov 07)

Landslide product brochure (Nov 07)

2/6 Case Study leaflets (ongoing

2 x Newsletters (3rd late 2008).

Terrafirma Validation Manual (summer 2008)

GMES Current

Sentinel 1(Cband SAR) to be the first satellite; ESA says focus is climate change

But InSAR is clearly recognised as an important aspect & main beneficiary.

GMES services are split between

CORE – for the public good, funded by EC

Downstream – addressing local or commercial issues, not centrally funded

Three broad FAST TRACK CORE service areas initiated under FP7

Land

Marine

Emergency Response

Projects dominated by French, Italian & German aerospace giants

Terrafirma has not found a niche in these projects

There is a small amount of InSAR work on landslides in ER

Terrafirma future?

We need the EC to adopt Terrafirma as an ongoing, routine monitoring service for public good...

...though EC does not currently recognise geohazards except as response to emergency.

National lobbying now critical:

Allow ESA to continue Terrafirma with 3rd stage

Convince EC that a pan-European ground motion information service should be centrally funded.

Concept of a further stage is to focus down on specific CORE application themes of 'European' cross-border nature and create quality case studies as lobbying tools:

Seismicity (inter-seismic crustal deformation); earthquake preparedness

Flood risk (coastal lowlands; sea level rise, floodplains)

Monitoring water abstraction problems at the regional level

Regional geohazard areas from mining activity (eg. crossing national borders)