esa
European Space Agency

The Live Land Project

ARTES Applications Workshop 19th April 2013

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

NSL

CGG

Met Office

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Contents

- 1. Overview of project, expected outputs and benefits
- 2. ESA, Industry Partners and Clients involvement
- 3. Outline of programme
- 4. Progress to Date and next key steps
- 5. Summary

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Overview of project and expected outputs and benefits

Project Overview

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The Live Land team

- Live Land team is led by CGI (previously known as Logica) in partnership with British Geological Survey, UK Met Office, CGG (Fugro NPA) and Nottingham Scientific Limited (NSL)
- All partners are World leaders in their respective fields:
  - UKMO - weather forecasting
  - BGS - Geological mapping, geological process research and monitoring
  - CGG (NPA) – Satellite and terrestrial monitoring
  - NSL - GNSS technology development and applications
  - CGI - Bespoke IT system development and data integration
- Unique partnering enables understanding of geology, weather and climate and its role in the occurrence of landslide and subsidence events and bespoke delivery mechanisms

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Live Land:
An ESA Integrated Application Promotion (IAP)

To improve landslide and subsidence management, Live Land needs to address:

……characterisation of the ***mechanisms for landslides and subsidence****. This includes the geology and geomorphology of the terrain, the environmental conditions triggering these events….*

…… key issue is generally ***soil moisture and rainfall***

…… ***monitoring and hazard mapping*** *can identify those area's which are sensitive to landslide and subsistence in a timely manner, so either measure can be taken to* ***prevent*** *the events from happening or early* ***warnings*** *can be issued to minimise the impact.*

…… With an ***increase in the confidence*** *of forecasting landslides and subsidence, early warning systems will become more effective.*

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Live Land on a slide

Goal

Reducing the disruption and **cost** associated with landslide and subsidence **hazards** on transport networks through the development of a suite of integrated data services.

What is it?

Live Land aims to reduce the impact and exposure of national transport assets to landslide and subsidence hazards. Live Land incorporates a 'catalogue' concept, of enabling technologies (*in-situ* and from Space) that could improve the prediction, monitoring and alerting of Landslides and Subsidence.

Potential benefits to Network Rail

Live Land improves the intelligent forecasting of landslide through the incorporation of forecast and real time, high resolution precipitation and geological modelling. This capability allows risk to be assessed in near real time across the transport network. Intelligent prediction is coupled with tailored monitoring technologies, including the development of low cost GNSS modules, and a suite of alerting technologies / services will provide users with the intelligence to access and manage risk across their transport network.

Relevance to end user, with reference to Network Rail Scotland

With approx 80-90% of Network Rail geological risk management costs and 50% non-availability of rail infrastructure attributed to landslides or rock falls across the network; Live Land aims to reduce the impact and cost of geological hazards Network Rail.

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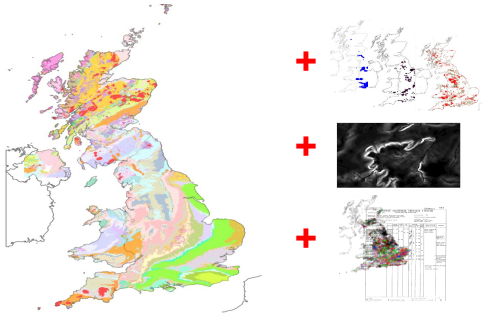
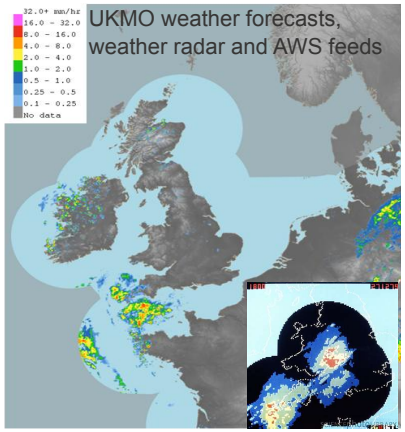
What is Live Land?

Research led forecasting



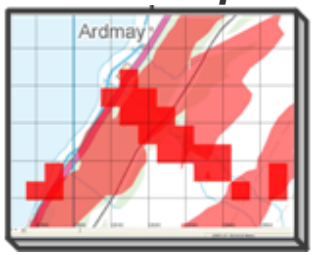
UKMO weather forecasts, weather radar and AWS feeds



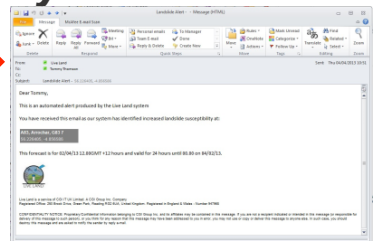
Bespoke Monitoring

LIVE LAND

Hazard Maps



Integrated Alerting Systems



Management tools

High Hazard High Impact	High Hazard Low Impact	High Hazard No Impact
Medium Hazard High Impact	Medium Hazard Low Impact	Medium Hazard No Impact
Low Hazard High Impact	Low Hazard Low Impact	Low Hazard No Impact

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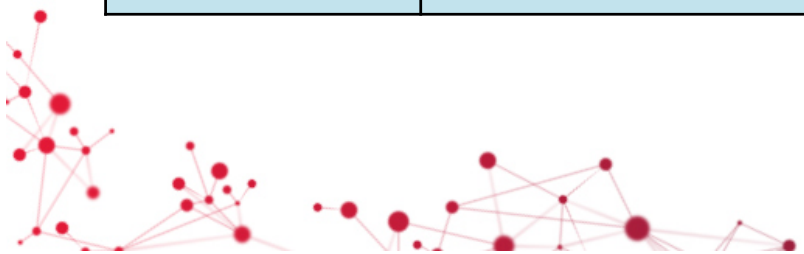
What are we offering?
The Live land Service Concepts

Based on/ additional inputs	Levels of Service	What does the user get?	Licence / Service
BGS Nation GeoSure datasets	Network level hazard assessment - landslides	Web mapping GIS interface Hazard susceptibility ratings Notifications and report accessible 24/7, 365	**Tier 1**
CGG Motion Map / InSAR & BGS GeoSure datasets	Network level hazard assessment subsidence		
BGS GeoSure / Met Office Datasets	Near Real Time Network Hazard Assessment & Network Hazard forecasts – landslides	Include **Near Real Time** and **forecast** Hazard assessment across network SMS & email alerts of updates	**Tier 2**
+ Various sensors	Integrated forecasting and monitoring	Drilled down local analysis Includes **site specific**, bespoke monitoring solutions	**Tier 3**
	Subsidence monitoring		



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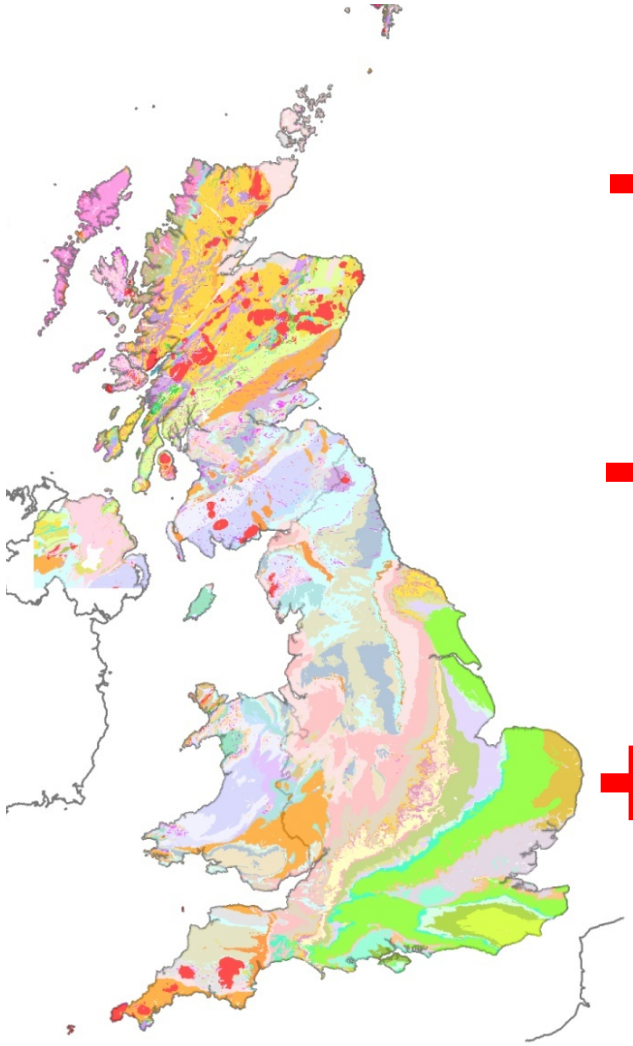
Tier 1 - BGS's National Geohazard Datasets



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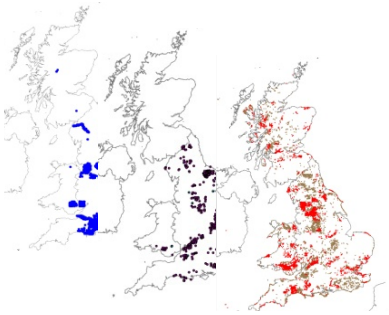

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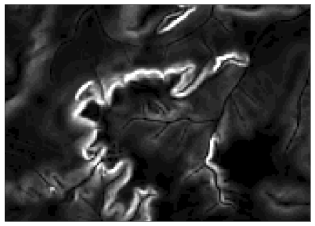

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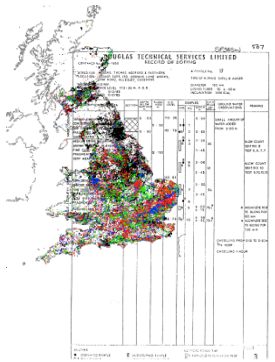

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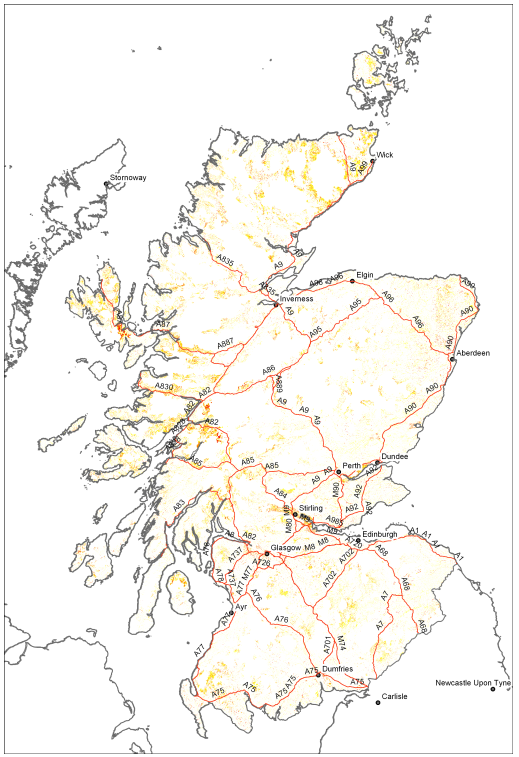
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL



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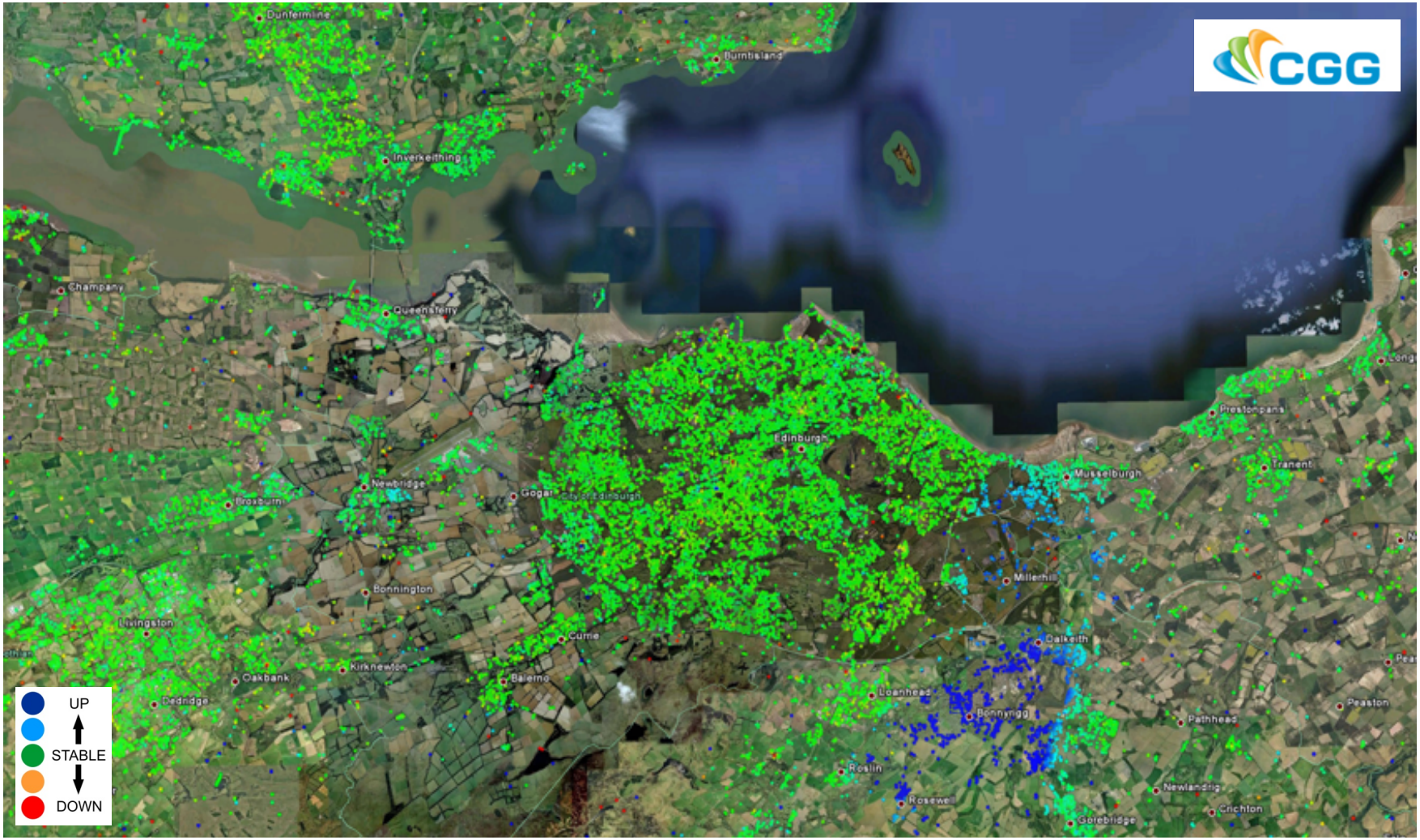
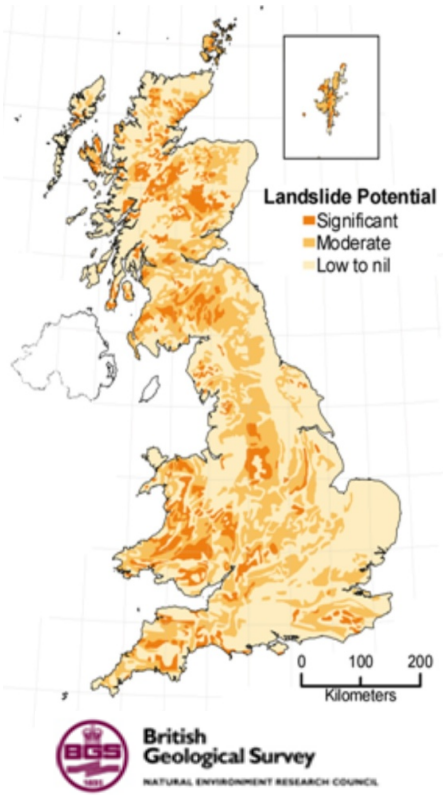
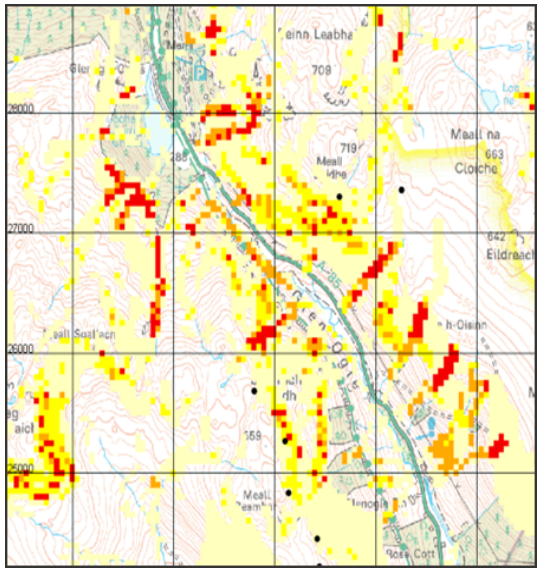
Satellite Monitoring: InSAR – Regional scale subsistence services



Rainfall induced landslide model – The Natural Hazard Partnership

- NHP **Add value** to existing market solutions through enhance the BGS datasets to account for rainfall triggers
- Use of Met Office forecasts and observations (RADAR and AWS) to produce real time and forecast hazard assessments across network





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Monitoring Technologies – The Live Land Catalogue

LiveLand Techniques Review Matrix v.5

Live Land Techniques Review Matrix

SOLUTION CATEGORY & TECHNIQUE	STABILITY APPLICATIONS			SPECIFICATIONS															COST	ENVIRONMENTAL LIMITATIONS		
				SPATIAL COVERAGE			MEASUREMENT AVAILABILITY			MEASUREMENT DENSITY			MEASUREMENT ACCURACY			MEASUREMENT DIMENSION						
	GROUND	SLOPE	STRUCTURES	LOCAL	REGIONAL	NATIONAL	HISTORICAL /ARCHIVE	REAL-TIME	CAMPAIGN/ ON-DEMAND	HIGH < 6 m	MEDIUM 6 – 30 m	LOW > 30 m	HIGH < 1 cm	MEDIUM 1-5 cm	LOW > 5cm	1D	2D	3D	£	GROUNDCOVER	WEATHER	TOPO
A - SATELLITE:																						
• OPTICAL [1]	○	●	○	●	●	●	●	X	●	●	●	●	X	X	○	●	X	X	£-£££	○	●	○
• RADAR:																						
○ INSAR (VARIOUS) [2]	●	●	●	●	●	●	●	X	●	●	●	X	○	●	X	●	○	X	£-£££	○	○	○
○ CHANGE DETECTION [3]	○	●	○	●	●	●	●	X	●	●	●	X	X	X	●	●	X	X	£-£££	○	○	○
• PASSIVE MICROWAVE:																						
○ SMOS [4]	●	●	X	●	●	●	X	●	●	X	●	●	X	X	X	?	?	?	£	?	?	?
B - AIRBORNE:																						
• FIXED WING:																						
○ OPTICAL [5]	○	●	○	●	●	●	○	X	●	●	●	X	X	X	X	●	X	X	£-£££	○	○	○
○ RADAR [6]	●	●	○	●	●	●	○	X	●	●	●	X	X	X	X	●	X	X	£-£££	○	○	○
○ LIDAR [7]	●	●	○	●	●	●	○	X	●	●	●	X	X	X	X	●	●	●	£-£££	○	○	○
○ INFRARED/THERMAL [8]	○	?	X	●	X	X	X	●	X	●	●	X	X	○	○	●	X	X	£-£££	○	○	○
• HELICOPTER:																						
○ OPTICAL [9]	○	○	○	●	●	○	○	X	●	●	●	X	X	X	X	●	X	X	£-£££	○	○	○
○ LIDAR [10]	●	●	○	●	●	○	○	X	●	●	●	X	X	●	●	●	●	●	£-£££	○	○	○
○ ELECTRO MAGNETICS [11]	●	●	○	●	●	○	X	X	●	●	●	●	X	X	●	●	●	●	£-£££	X	●	●
• UNMANNED AERIAL VEHICLE (UAV) [12]	○	○	○	●	X	X	X	○	●	●	●	○	X	●	X	●	X	X	£-£££	○	○	○
C - TERRESTRIAL:																						
• MOBILE:																						
○ OPTICAL [13]	○	○	○	●	●	X	X	●	●	●	●	●	X	●	●	●	●	●	£-£££	●	●	X
○ LIDAR [14]	○	○	○	●	●	X	X	X	●	●	●	●	X	●	●	●	●	●	£-£££	●	●	X
○ GPR [15]	○	○	○	●	●	X	X	X	●	●	●	●	X	X	●	●	●	●	£-£££	●	X	X
○ VISUAL (HUMAN) [16]	○	○	○	●	●	X	X	●	●	●	●	●	X	●	●	●	●	●	£	●	●	●
○ GPS [17]	●	●	●	●	●	X	X	●	●	X	●	●	○	●	●	●	●	●	£-£££	●	X	●
• STATIC/REMOTE:																						
○ TOTAL STATIONS [18]	●	●	●	●	X	X	X	●	●	X	●	●	●	●	●	●	●	●	£-£££	X	●	●
○ LIDAR [19]	○	●	●	●	X	X	X	●	●	●	●	●	○	●	●	●	●	●	£-£££	●	●	●
○ RADAR [20]	○	●	●	●	○	X	X	○	●	●	●	●	○	●	●	●	●	X	£-£££	○	○	○
○ INFRARED/THERMAL [21]	○	X	X	●	X	X	X	●	X	●	●	X	X	○	○	●	X	X	£-£££	○	○	○
○ ELECTRICAL IMAGING [22]	●	●	●	●	●	X	X	●	●	●	●	●	X	X	●	●	●	●	£-£££	●	X	X
○ SEISMIC [23]	●	●	●	●	●	X	X	●	●	●	●	●	X	X	●	●	●	●	£-£££	●	X	X
• IN-SITU:																						
○ GPS [24]	●	●	●	●	●	X	X	●	●	X	●	●	●	●	●	●	●	●	£-£££	●	X	●
○ INCLINOMETERS [25]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	X	X	£-£££	X	X	X
○ PIEZOMETERS [26]	●	●		●	X	X	X	●	●	○	○	●	●	●	●	●	X	X	£-£££	X	X	X
○ EXTENSOMETER [27]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	X	X	£-£££	X	X	X
○ ACCELEROMETER [28]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ ELECTRO LEVELS [29]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ RASNIK [30]	X	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ FIBER-OPTICS [31]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ ACOUSTIC [32]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	X	X	X	£-£££	X	X	X
○ STRAIN GAUGES [33]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ PRESSURE CELLS [34]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ CRACKMETER [35]	●	●	●	●	X	X	X	●	●	○	○	●	●	●	●	●	●	●	£-£££	X	X	X
○ WEATHER STATION [36]	●	●	●	●	X	X	X	●	●	○	●	●	●	●	●	X	X	X	£-£££	●	X	X
○ LEVELLING [37]	●	●	●	●	X	X	X	●	●	○	●	●	●	●	●	●	X	X	£-£££	○	●	X
○ ELECTRO MAGNETICS [38]	●	●	●	●	X	X	X	○	●	●	●	●	X	X	●	●	●	●	£-£££	X	●	●
○ RESISTIVITY [39]	●	●	●	●	X	X	X	●	●	●	●	●	X	X	●	●	●	●	£-£££	●	X	X
[illegible]	●	●	●	●	X	X	X	●	●	●	●	●	●	●	●	●	●	●	£-£££	X	X	X

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Satellite Monitoring: InSAR – Local scale

ESA, Industry Partners and Clients involvement

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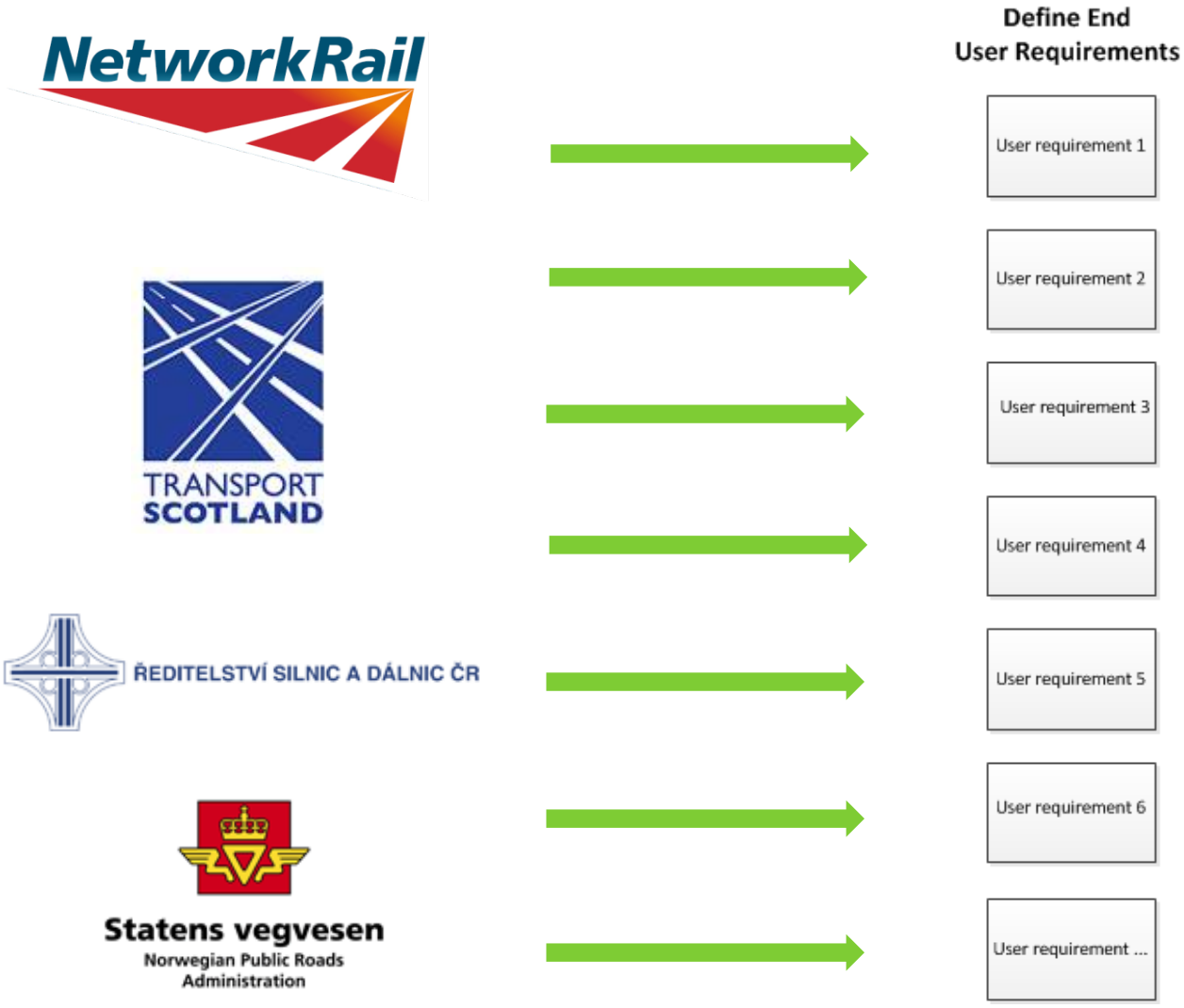
From end user needs to system requirements….



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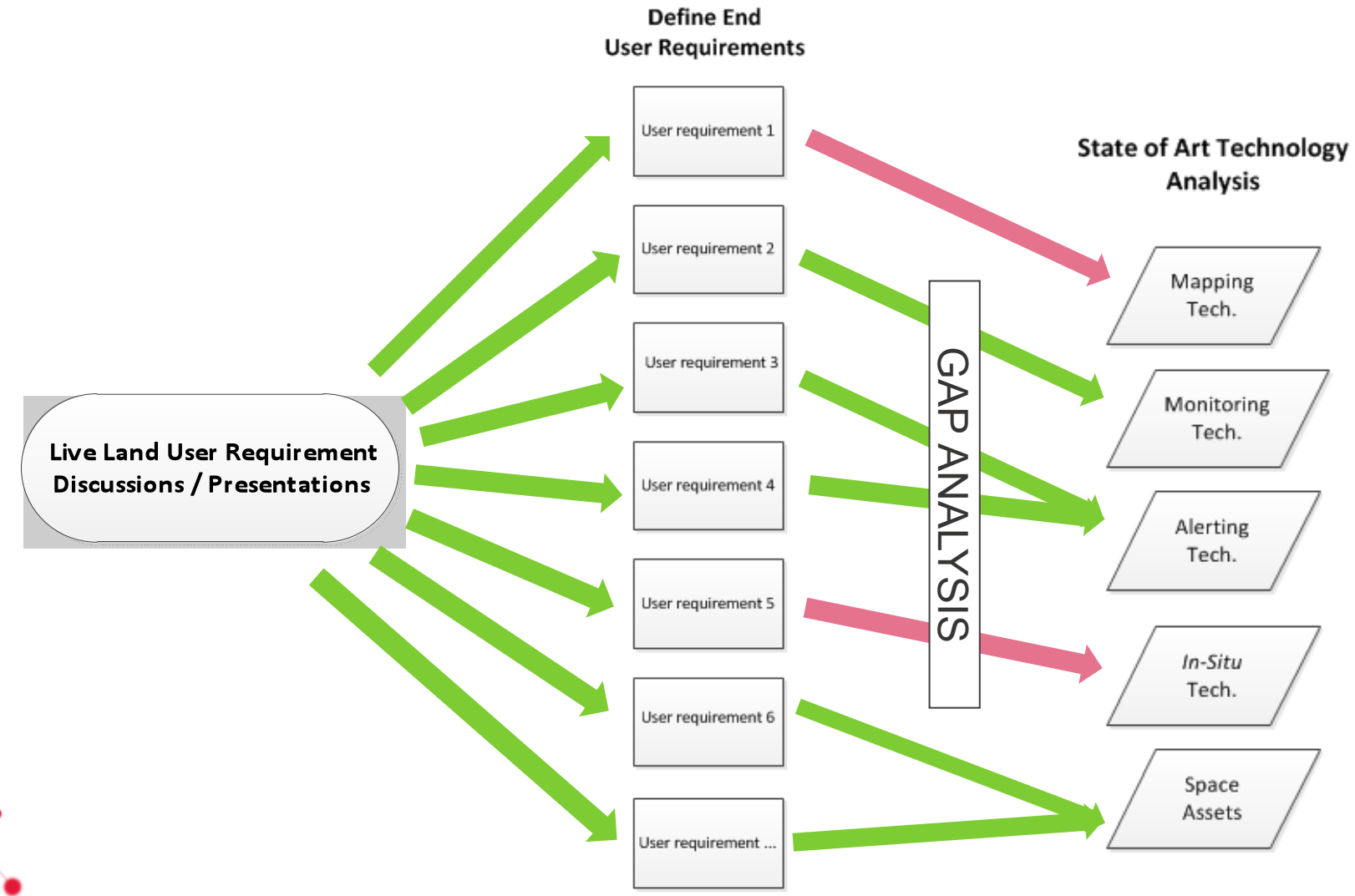
Defining User Requirements & State of Art Technology Analysis



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Progress to date & key next steps

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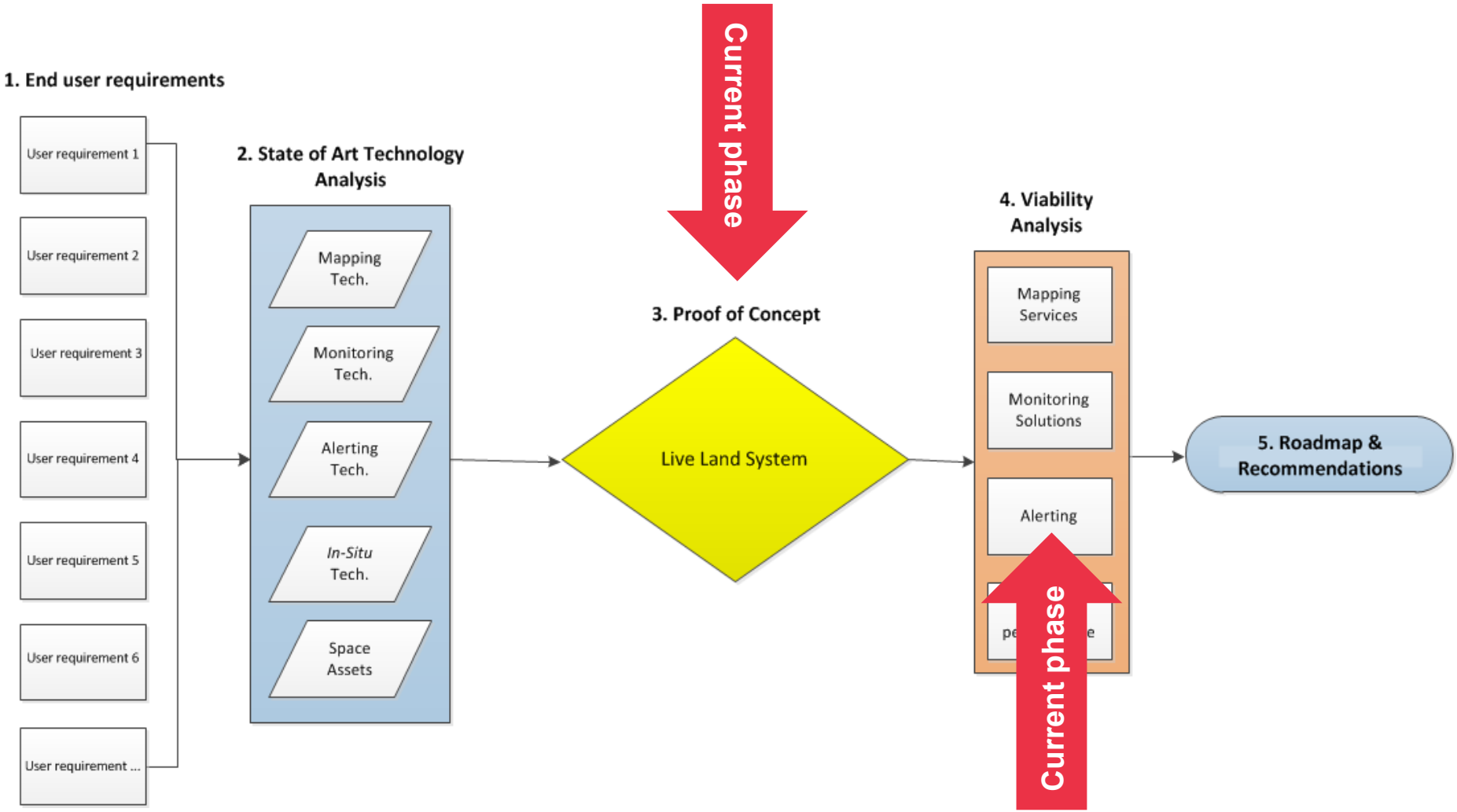
Progress to date



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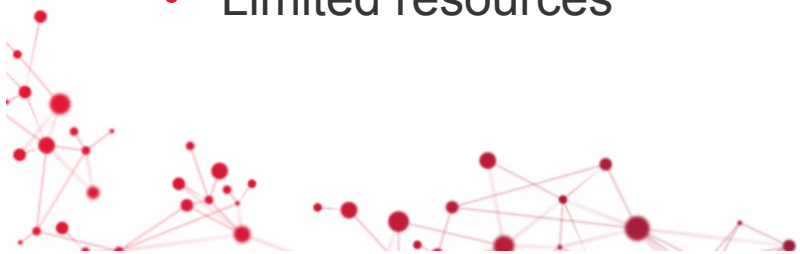
Proof of Concept - Purpose

- What is the Proof of Concept?
  - An activity to validate the feasibility of the most critical parts of the proposed Live Land solution
  - Demonstration and/or research activity
  - Validates technical feasibility/viability.
  - Commercial viability is carried out separately

- What it is not!
  - Implementation of the system outlined within the Service and System Specification
  - Demonstration of an operational system

- Why?
  - Limited timescale (5 month activity)
  - Limited resources



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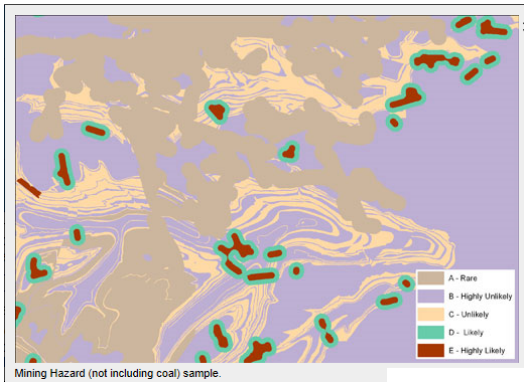
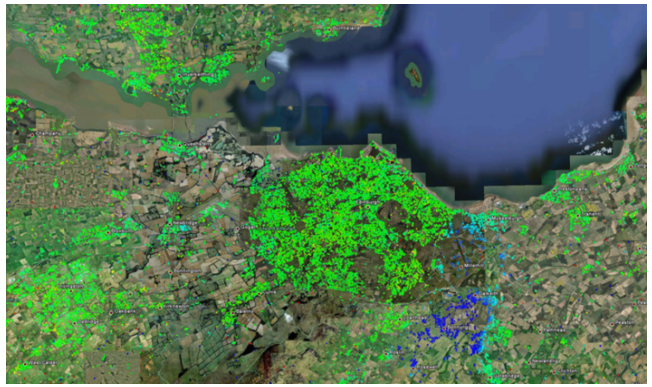
Tier 1 Critical Element - Subsidence Susceptibility Datasets

- Data integration is critical to add value to existing datasets and monitoring technologies
- Integration of InSAR satellite (MotionMap) data and BGS GeoSure subsidence datasets provides end users with locations of areas susceptible to subsidence and recent trend analysis (rates of surface deformation)
- Trials in Falkirk area and N.E England

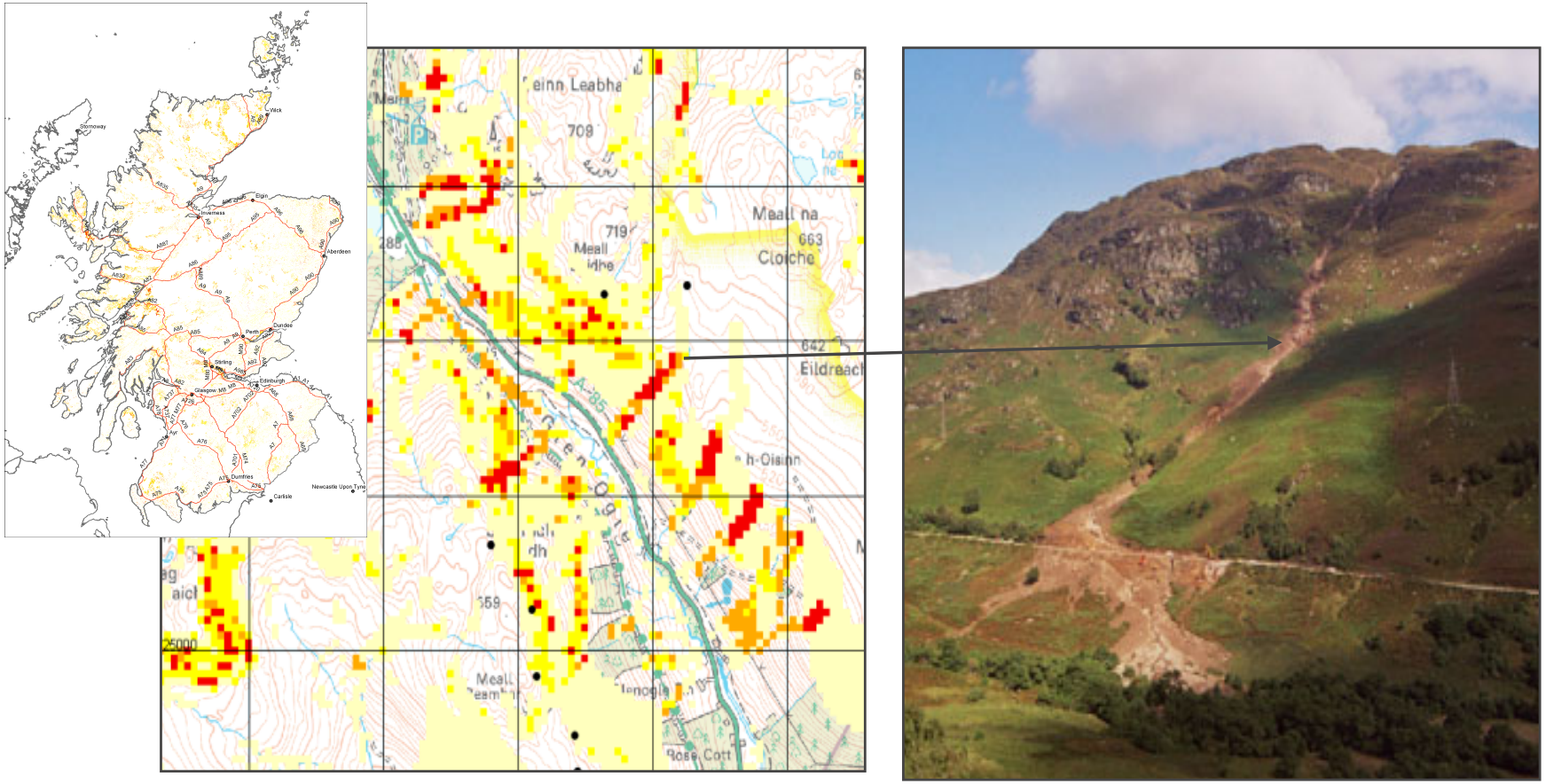


Mining Hazard (not including coal) sample.



The Proof of Concept

Tier 2 Critical Element - Network level hazard landslides assessment



Example of HNP output from Glen Ogle

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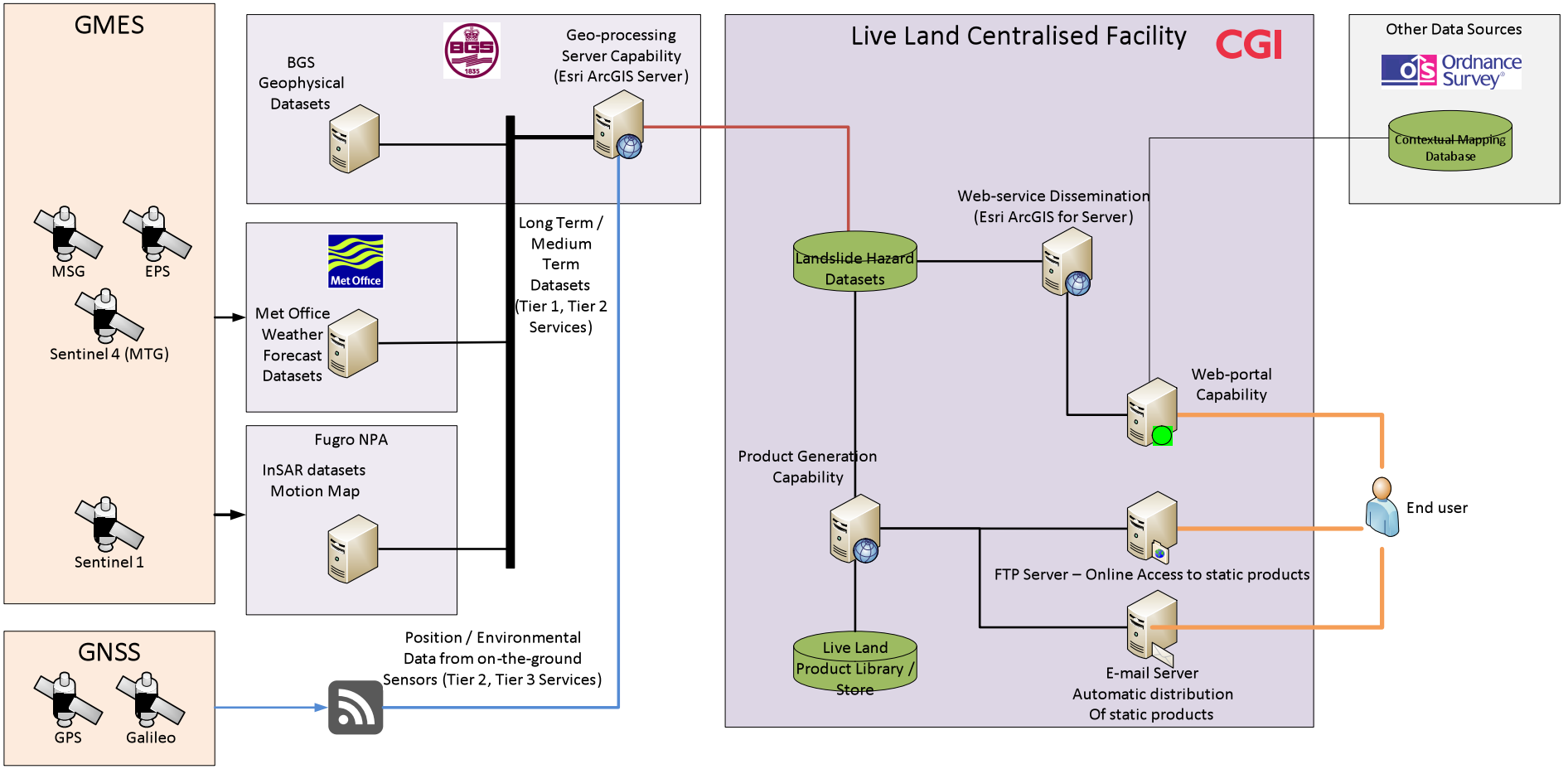
Tier 3 Critical Element - GNSS

- GNSS for precise surveying (< 2cm) traditionally requires high cost equipment (~ £10K)
- Live land has highlighted a market gap for low cost GNSS equipment to be used for land and infrastructure monitoring
- Low cost GNSS chip set
- Measures GPS and Glonass (and Galileo) carrier phase data
- Processed with RTK software to produce 1-2cm accuracies for static sites
- GSM as comms (other options possible)
- Decent battery
- Solar power recharge capability
- Data storage
- Programmable microcontroller
- Waterproof enclosure and fixings

High Level System Concept



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Overview of the Live Land system

- Builds on excellent research and expertise of the BGS, including their widely used GeoSure datasets
- Provides commercialisation of BGS – UKMO research developed under Natural Hazard Partnerships' Hazard Impact Model. This provides characterisation of geology, soil moisture and enables forecasting of landslide susceptibility at defined time steps.
- Bespoke tier 3 monitoring solutions – Live Land expert systems
- Unique GNSS solution to monitor slope movements in high risk areas
- Integration with end user monitoring assets
- GIS web mapping service that provides 24/7 access to tier 1-3 services.
- Live Land designed to provide access to datasets via download (shapefile, .txt, .csv) and ftp (according to licence) to provide compatibility with in-house GIS systems.