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NATURAL HAZARDS CONTROL AND ASSESSMENTS

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SMART GAM: Using Monitoring Technologies to Manage Geotechnical Assets

Mazzanti Paolo

TRB2017
Implementation of Geotechnical Asset Management

Washington DC, 11-01-2017

SMART?

"SMART" (adj.): equipped with, using, or containing electronic control devices

Smart….car

Smart….phone

Smart….house

Smart….GAM?

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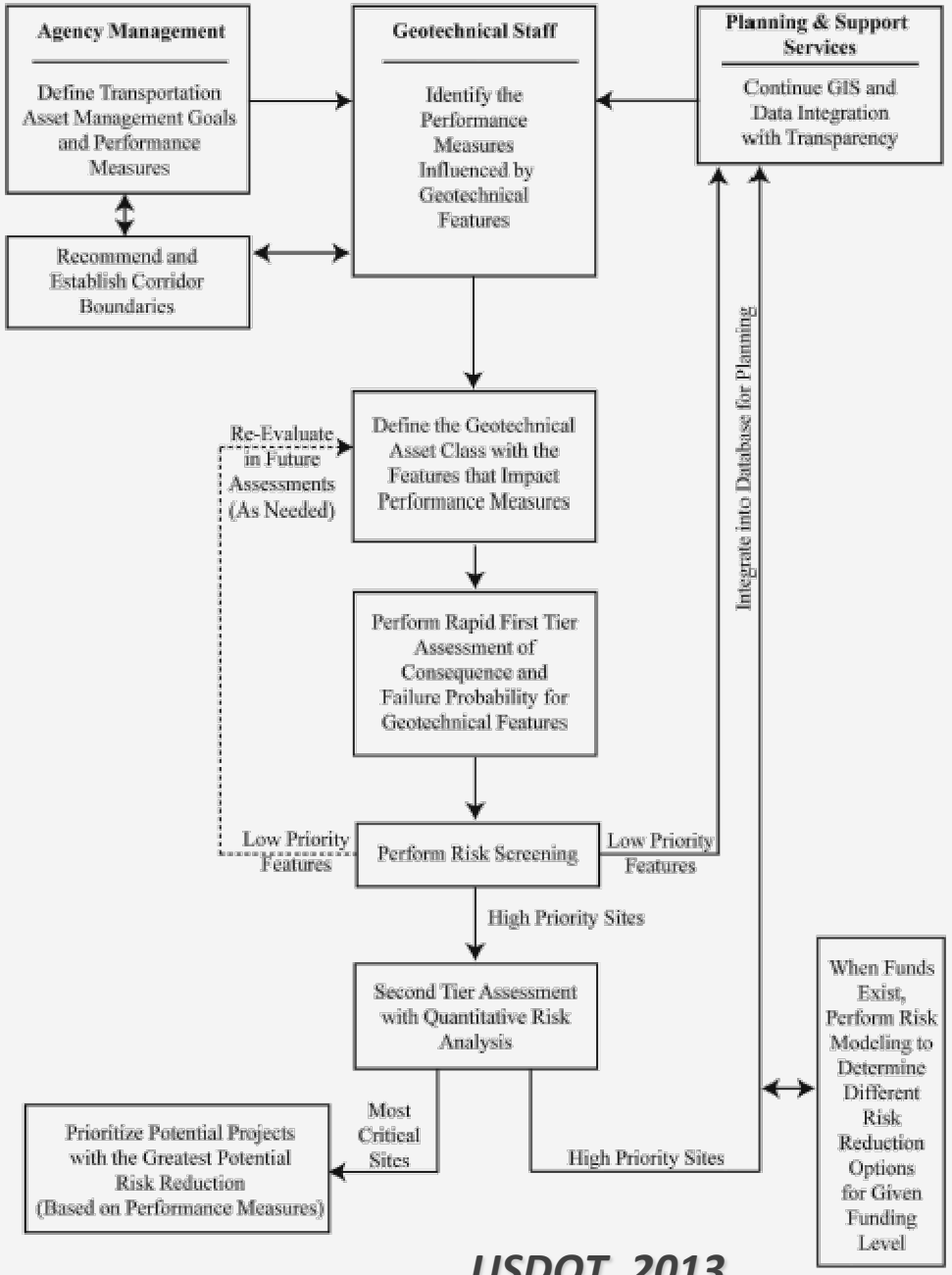
Geotechnical Assets Management



USDOT, 2013

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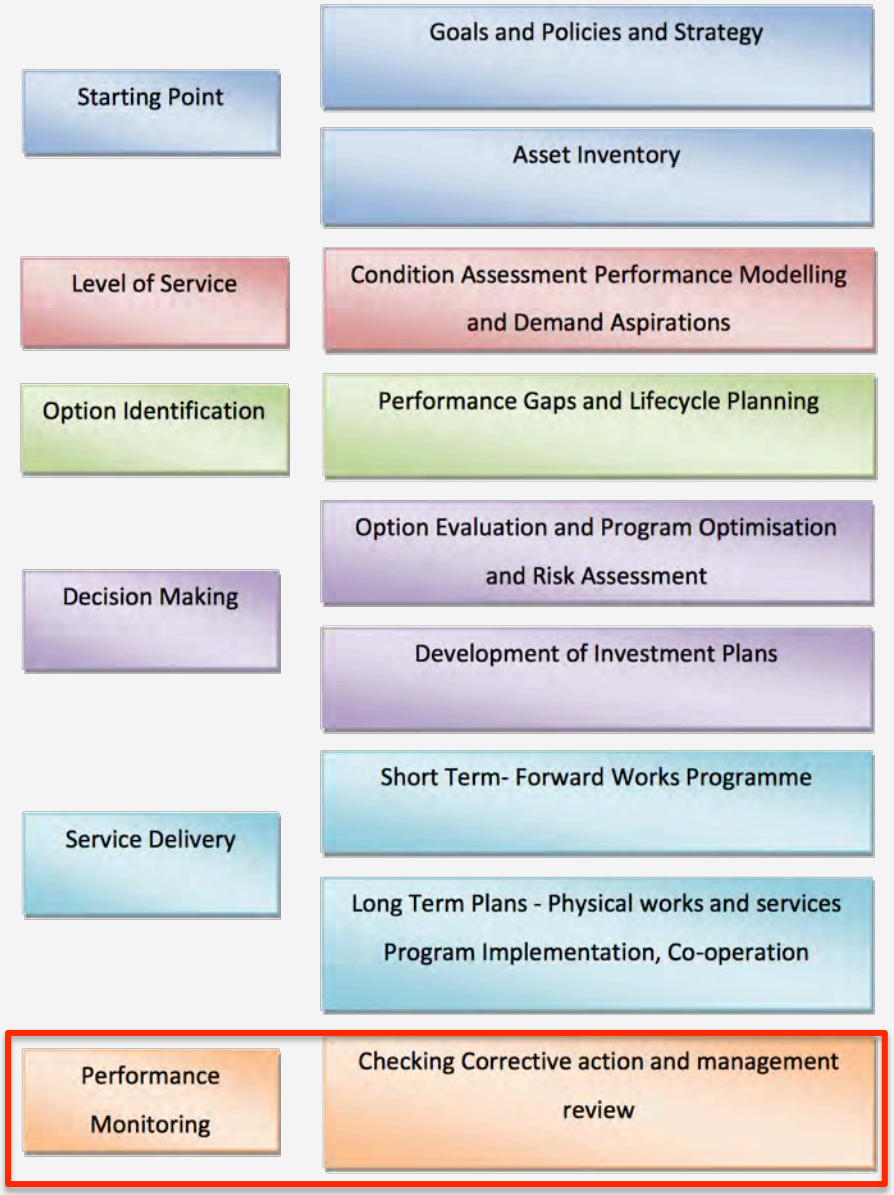
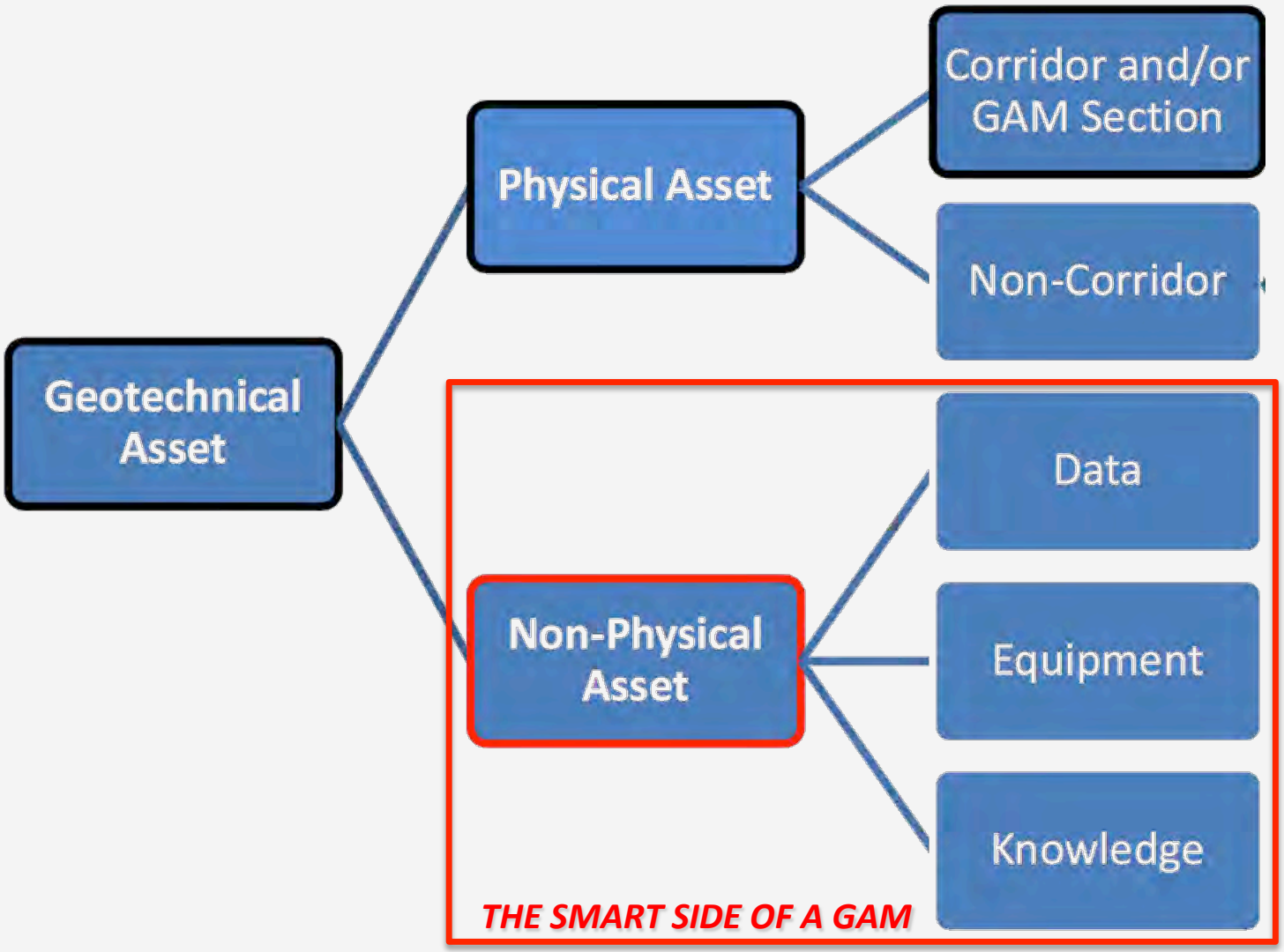
Geotechnical Assets Management



JANVI PANKAJ SHAH, 2014. **Resilient Geotechnical Asset Management**, PhD Thesis, Univ. Birmingham.

"SMART" Geotechnical Assets Management



DATA & KNOWLEDGE ARE CONTINUOSLY UPDATES BY USING SUITABLE MONITORING EQUIPMENT!!

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S.A. Anderson, V.R. Schaefer, S.C. Nichols, 2016. **Taxonomy for Geotechnical Assets, Elements, and Features**

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The leitmotif

Application of New Sensing and Monitoring Technologies to the Assessment and Control of Natural Hazards and Civil Strutures and Infrastructures

THE OBSERVATIONAL METHOD!

Karl Terzaghi 1937

Settlement of structures in Europe and methods of observations. American Society of Civil Engineers. Proceedings, Vol. 63, pp. 1358-1374

Ralph Peck 1969

Advantages and limitations of the observational method in applied soil mechanics. Géotechnique, 19(2), 171-187

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THE NEED OF GEOTECHNICAL MEASUREMENT EQUIPMENT….
….60 YEARS OF TECHNOLOGICAL "r"EVOLUTION

1950s	1960s	1970s	1980s	1990s	2000s	2010s
Stressmeter			Continuous Monitoring			
Levelling				Early Warning Monitoring	European Standards	Digital Image Correlation
Theodolite			US standards			
Extensometer	Vibration Monitoring		Total Station	GSM data transmission	Laser Scanner	Drones
Piezometer	Submarine Monitoring	Data-logger	Time Domain Reflectometry	Fibre Optics technology	Multi-parametric borehole systems	Web based data management
Load cell	Inclinometer	Laser distance-meter	In place inclinometers	GNSS Technology	Interferometric Radar technology	Wireless monitoring

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Mazzanti P., 2017. Toward transportation asset management: what is the role of geotechnical monitoring? Journal of Civil Structural Health Monitoring. DOI 10.1007/s13349-017-0249-0

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What we monitor….

Parameters	Contact instruments	Remote instruments
Displacement (deformation)	Surface and probe tiltmeter, inclinometer, extensometer, liquid level gauge, crack gauge, TDR, fibre optic, pendulum, deflectometer, convergence gauge	GNSS, total station, optical levelling, lidar, satellite SAR interferometry, terrestrial interferometric radar, digital image correlation, photogrammetry
Vibration	Accelerometer, velocimeter, seismometer, geophone	Terrestrial interferometric radar, digital image correlation
Acoustic emission		
Groundwater pressure	Piezometer, observation well	n.a.
Stress	Earth pressure cell, stress-meter	n.a.
Load and strain	Load cell, strain gauge	n.a.
Temperature	Thermometer, thermocouple	InfraRed camera

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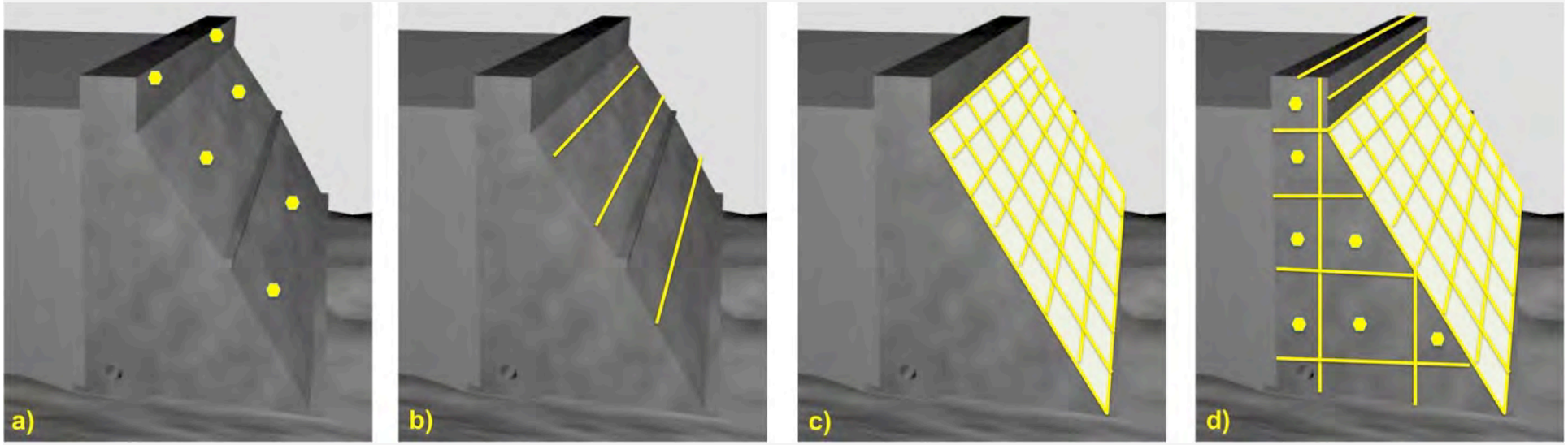
…where we monitor…



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Monitoring Table for SMART GAM!

	Common applications	Common Instruments
Knowledge Monitoring	Design phase Standard maintenance Screening after paroxysmal events (earthquakes, floods, etc)	LiDAR, Satellite SAR Interferometry, Terrestrial Interferometric Radar, GNSS, Photogrammetry, Observation Well, Piezometer, Inclinometer, TDR, Earth Pressure Cell, Accelerometer, Velocimeter, Seismometer
Control Monitoring	Construction phase in medium risk areas Advanced maintenance (critical segments) Verification of high risk area	LiDAR, Satellite SAR Interferometry, Terrestrial Interferometric Radar, GNSS, Photogrammetry, Total Station, Optical Levelling, Digital Image Correlation, Observation Well, Piezometer, Inclinometer, TDR, Extensometer, Earth Pressure Cell, Stress-meter, Load Cell, Strain Gauge, Fibre Optic, Pendulum, Deflectometer, Convergence Gauge, Surface and probe Tiltmeter, Liquid Level Gauge, Crack Gauge, Accelerometer, Velocimeter, Seismometer
Emergency Monitoring	Construction phase in high risk areas Early warning systems for operation in high risk areas	LiDAR, Terrestrial Interferometric Radar, GNSS, Total Station, Piezometer, Inclinometer, Extensometer, Strain Gauge, Fibre Optic, Pendulum, Surface and probe Tiltmeter, Liquid Level Gauge, Crack Gauge, TDR, Convergence Gauge, Accelerometer, Velocimeter, Seismometer

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But…which equipment is SMART?

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Example 1: Monitoring of one Geotechnical Asset

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Example 1: Monitoring of one Geotechnical Asset

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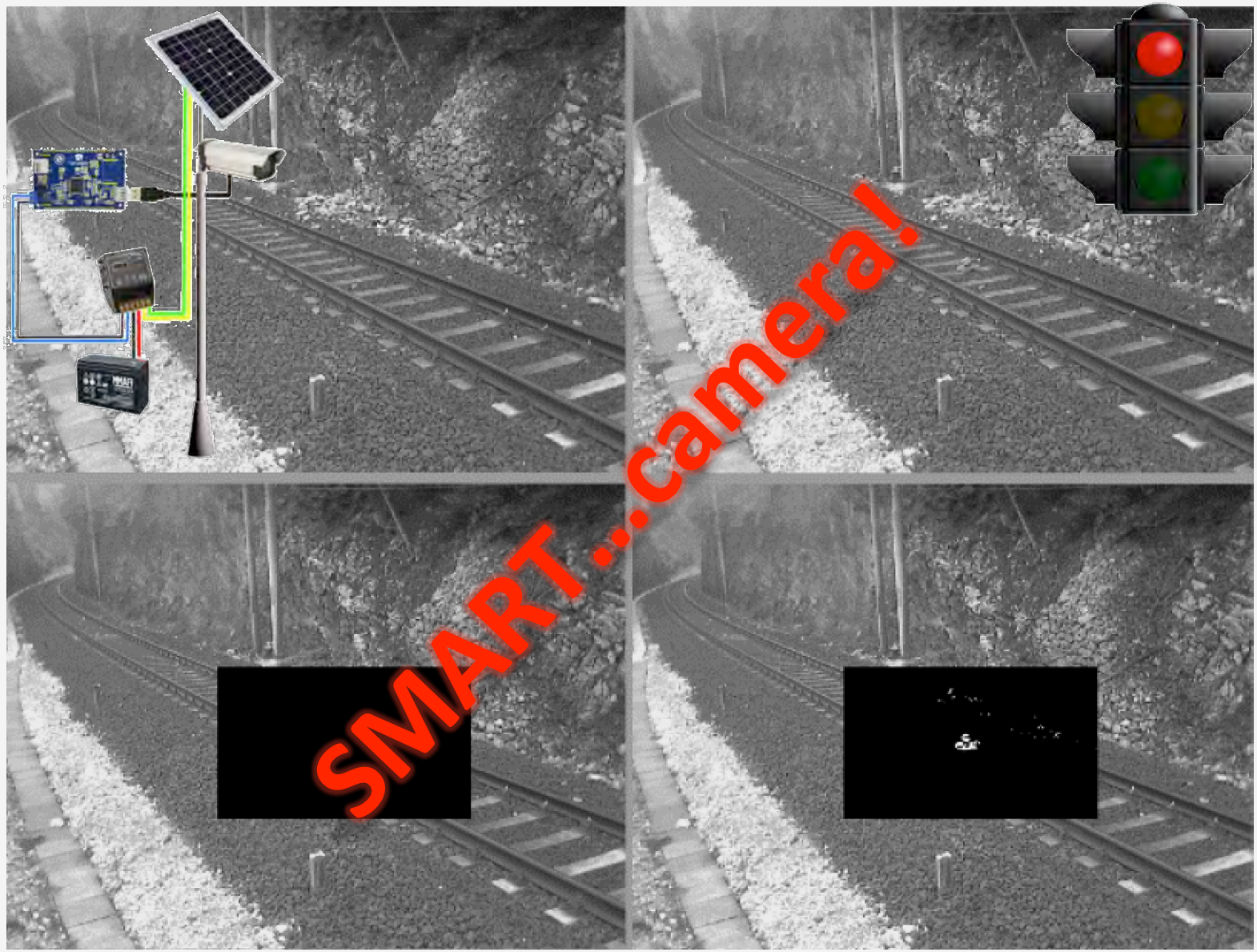
Example 2: Monitoring one Geotechnical Asset



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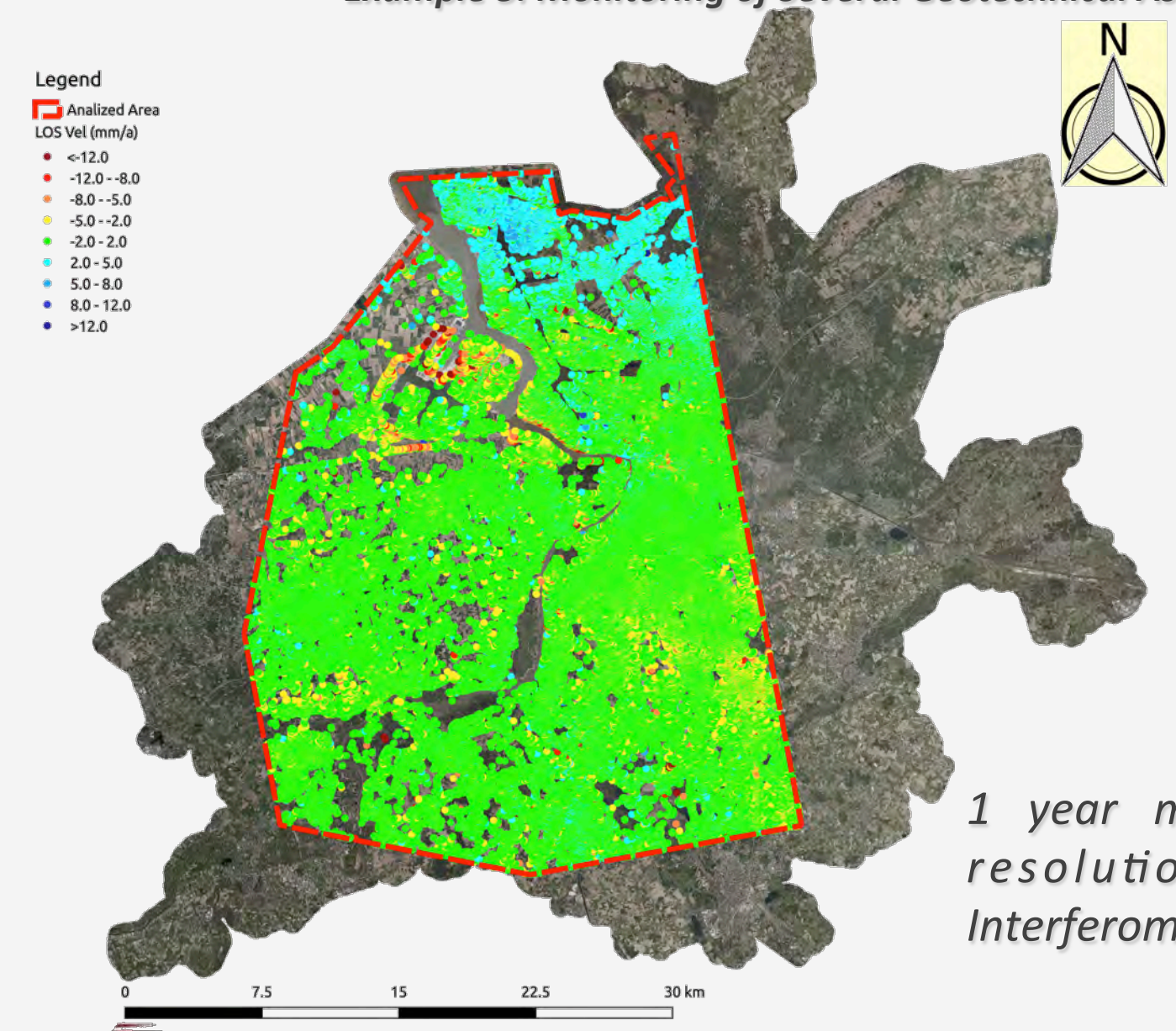
Example 3: Monitoring of Several Geotechnical Assets



1 year monitoring by high resolution Satellite SAR Interferometry

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Example 3: Monitoring of Several Geotechnical Assets

- *About 100 $ per km²*
- *Few $ for each asset*
- *0,02 $ per monitored point!*

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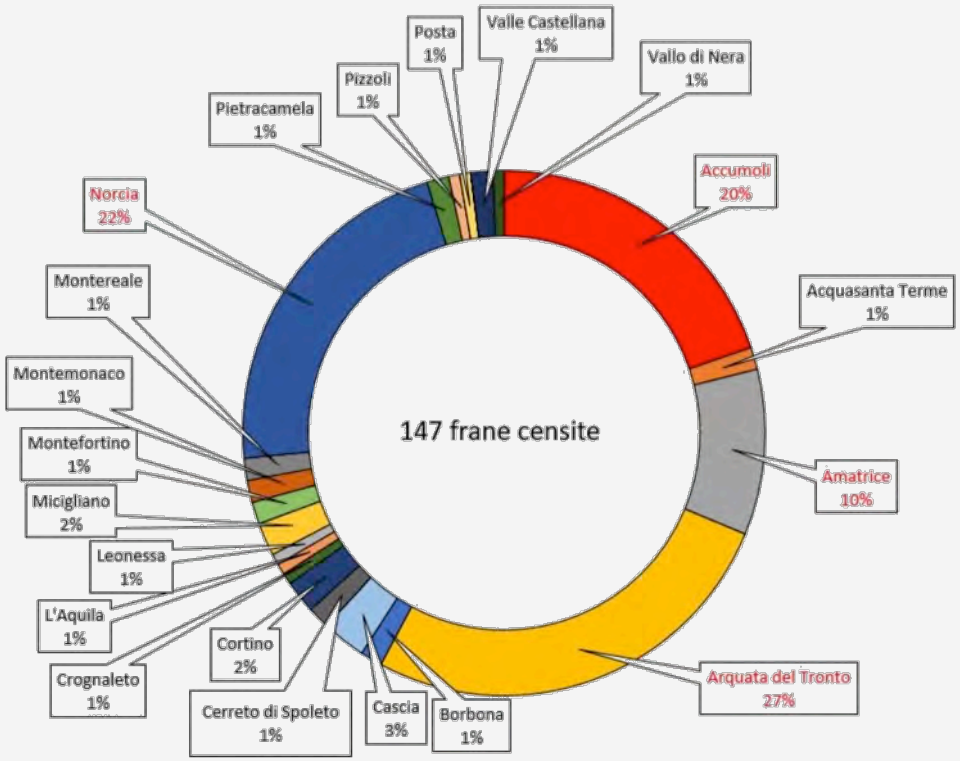
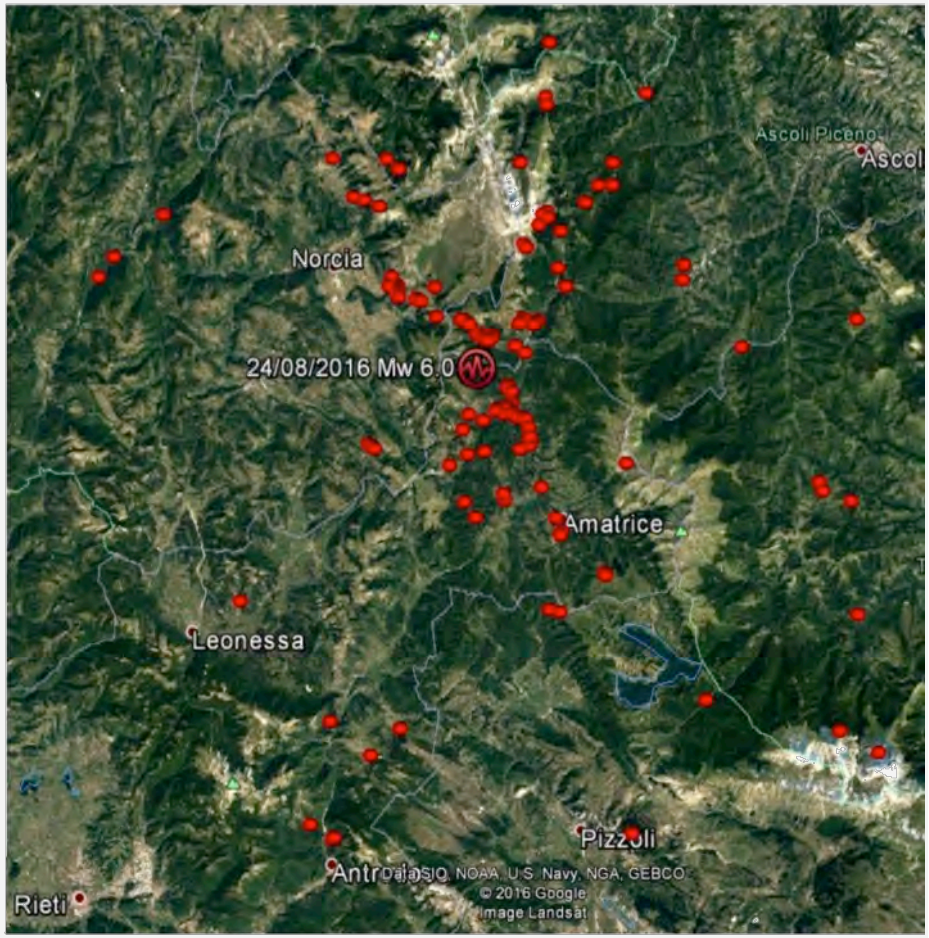
How managing geotechnical asset after a major natural event? The 2016 seismic sequence in Central Italy





Field Surveys of Slope Failures

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Martino et al, 2017. Ground Effects triggered by the 24th August 2016, Mw 6.0 Amatrice (Italy) earthquake: Surveys and inventorying to update the CEDIT catalogue. Geografia Fisica e Dinamica Quaternaria 40(1):77-95

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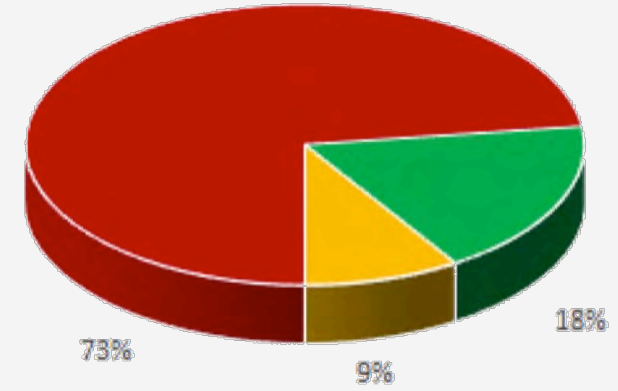

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How managing geotechnical asset after a major natural event?
The 2016 seismic sequence in Central Italy

Online database

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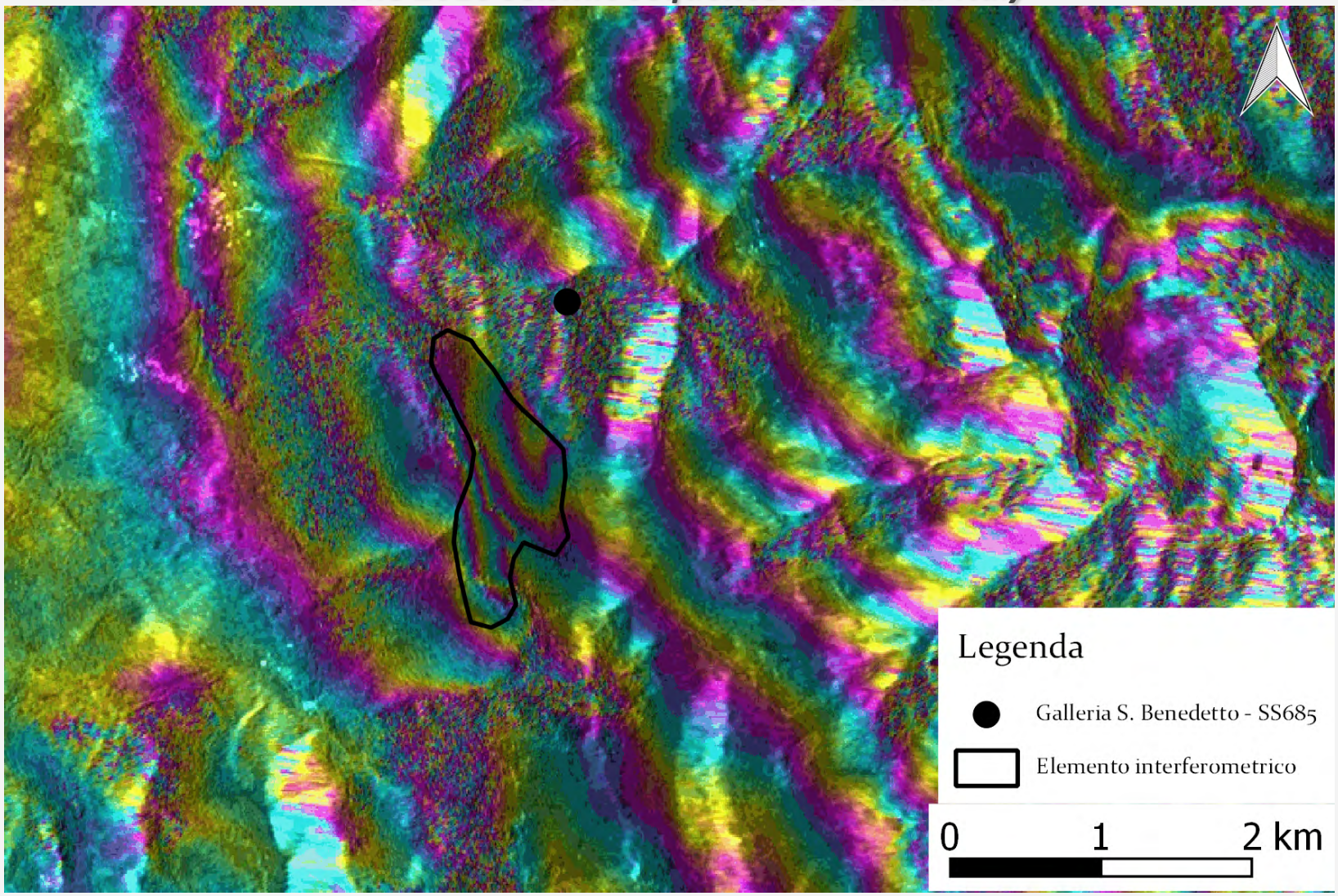

Remote Sensing Survey

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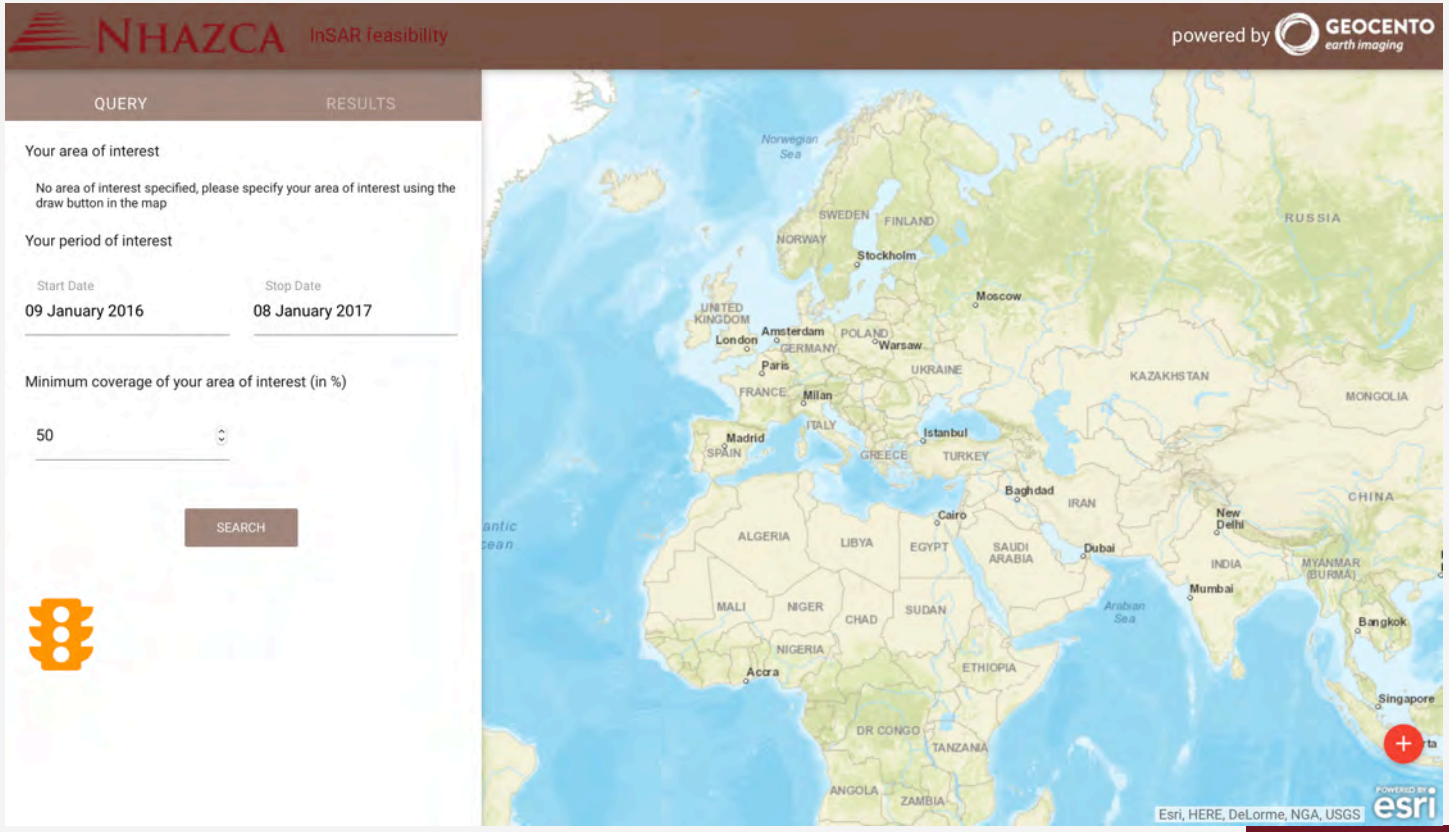
How we can move forward with the SMART GAM?

Reduce the distance between innovative monitoring solutions and GAM managers:

1) Development of suitable tools;

www.sarinterferometry.com



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How we can move forward with the SMART GAM?

Reduce the distance between innovative monitoring solutions and GAM managers:

2) Training about geotechnical monitoring at graduate and post-graduate level

www.geotechnicalmonitoring.eu

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What I see in the future

STEP 1: Monitoring will be a key part of each geotechnical asset program and not just an option

STEP 2: The "monitorability" concept will enter in the dictionary of designers and insfrastructure owners

"…. Dear Paolo, after our meeting end of November last year …., I talked the project leader responsible for the engineering project in …..He was really interested in the concept of making the infrastructure (bridges, fly-overs, tunnels, retaining walls …) monitorable."

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