Sentinel Benefits Study Workshop

Using Satellite Data

An Experience From Italy

The Colosseum, Rome

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ENGINEERING GEOLOGY Applied to Infrastructures

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My name is Flavio Capozucca, Senior Engineering Geologist, operating in Anas Spa, National roads Company, since 1989.

- 1989 – 2003: Department Geologist
- 2003 – 2024: Design & Construction Geologist
- 2024 up today: Unit Manager "*Technology & Territory*"

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ITALY GEOMORFOLOGICAL FRAMEWORK AND ANAS ROAD NETWORK

An Extensive Road Network on a Geologically “Young and Dinamic” Territory…

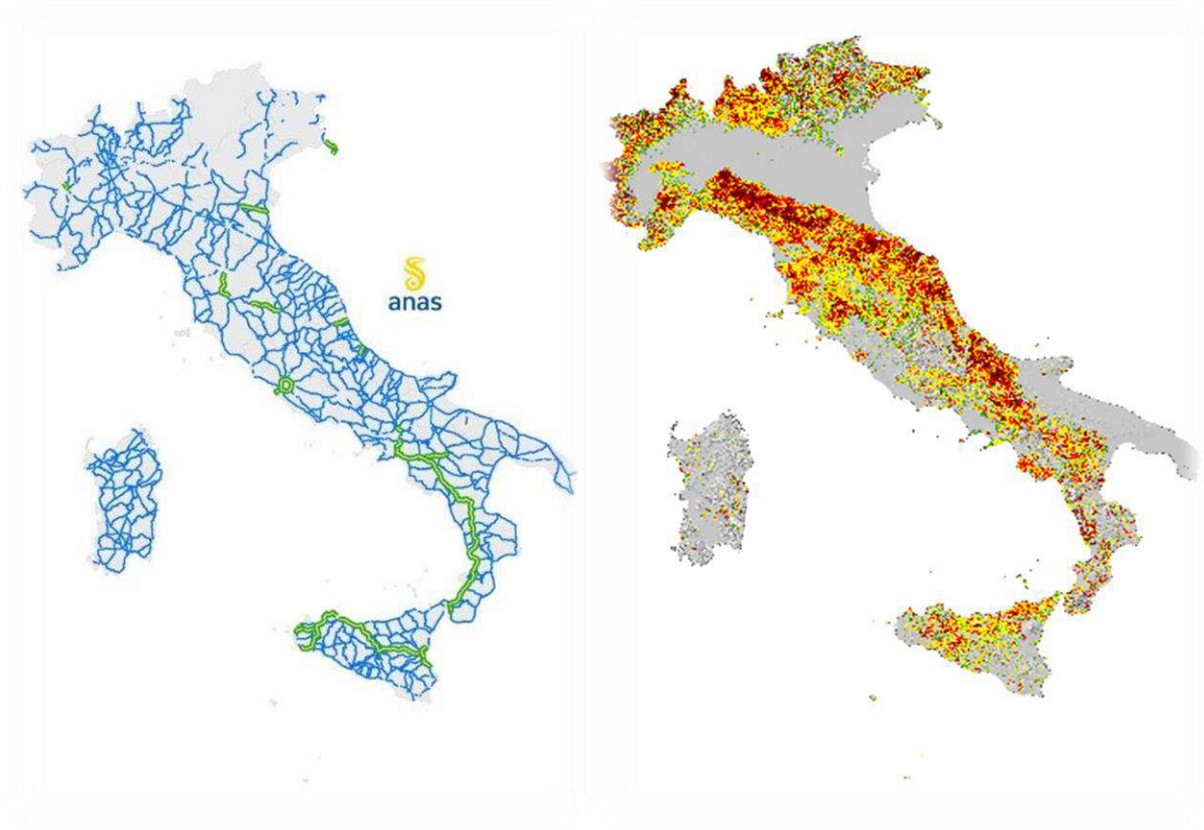
ANAS road network

32.000

Kilometers of roads managed directly by **ANAS**

2.034 TUNNELS

18.600 BRIDGES



Italian landslides Catalogue by State Geological Survey

Landslide events in Italy

620.000

Landslide with various degrees of activity actually present on italian territory.

24.000

Km^2 of Landslide Area.
7.9% of national Territory

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HIDROGEOLOGICAL HAZARD

Predisposing characteristics & Importance of Monitoring Systems

Geological Conditioning

Mount Gran Sasso - Abruzzo; IT

Two young mountain ranges with hight energy

The famous Vajont torrent - Veneto; IT

Narrow Hidrographic Basins with a quick hydrologic answer

Human Conditioning

Vaja storm – Triveneto, Alto Adige & Veneto; IT

Lack slopes maintenance and uncontrolled deforestation since 60's, with current consequences

Casamicciola's Landslide - Ischia, Campania; IT

Locally uncontrolled and excessive exploitation of the territory.
Lack of awarness of consequences.

All supported by a climate changing

SATELLITE DATA

ANAS “Satellitar” story

2005 - 2006 → First use in Anas of satellite data, for the project of a section of the highway now called “Autostrada del Mediterraneo”.

2005 - 2018 → Sporadic use, directed by the specific geological-geomorphological context, according to “sensitivity” of the specialist in charge of the project.

2017 - 2018 → A new contractual form has been established, designed specifically for geotechnical-structural monitoring. Specific items have been included, regarding both terrestrial and satellite interferometry.

2019 2020 → Technical Standards have been updated, with an extensive part relating to Geotechnical-Structural Monitoring, with a specific chapter on interferometric analysis. Starts an more extensive use of satellite data.

2023 → Extensive use of interferometric data EGMS during the control phase of projects

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HIDROGEOLOGICAL HAZARD

Predisposing characteristics & Importance of Monitoring Systems

InSar Technology in Anas:
The First Eye on Ground Motion!

Anas currently uses InSar data in specific contexts:

- where ground movements are creating difficulties for the existing network
- in construction sites
- when new road infrastructure projects cross unstable areas

Future developments in ANAS satellite use:

- monitoring the unstable areas near bridges, viaducts and tunnels along the network
- During new designs, to be able to evaluate in advance costs and critical issues
- Monitoring areas most subject to increasing effects of climate change

SATELLITE DATA

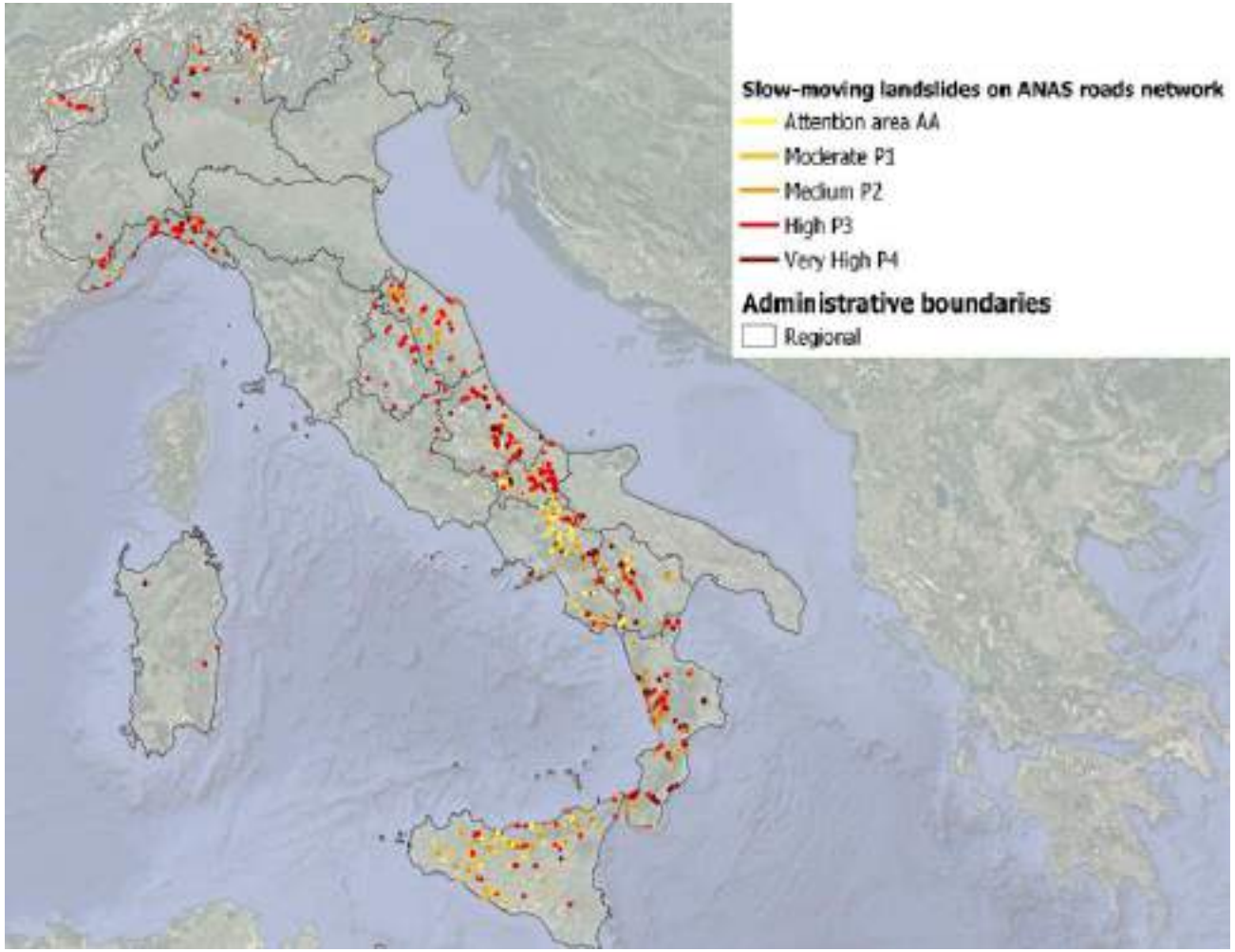
Applications to

Projectual phase

Maintenance phase

SATELLITE DATA

Applications to Maintenance Planning



ANAS S.p.A. road infrastructural network intersects over **2400** ***slow-moving landslides*** points for total **500** km.

With a Risk related to

Human Life

1973 – 2022*
- 1.076 dead
- 10 missing
- 1.443 injuried
- 144.806 evacuated

Restoration

Of geotechnical existing slope protection works

Emergency Restoration

Use of satellite data for a first detection of critical contests (eg floods, etc)

*https://polaris.irpi.cnr.it/report/last-report/

SATELLITE DATA

Applications to Maintenance Planning

Emergency Maintenance → **Predictive Maintenance**

HOW?

ANAS S.p.A. started in 2020 to build a large database mapping from satellite interferometry, on **30 slow-moving landslide** sites, related to high exposed value.

That's allows to

- Support decisional aspects on risk management maintenance planning
- Evaluating the functionality of geotechnical structures yet realized
- Installation of terrestrial monitoring technique on the site

SATELLITE DATA

Design Application: The “Col di Tenda Landslide”

The Colle di Tenda tunnel, on *State Road 20* "del Colle di Tenda and Valle Roja“ Connect Italy to France.

With the length of **3.182** meters, it was the longest road tunnel ever built!

The *Intergovernmental Commission for the Improvement of Franco-Italian Connections in the Southern Alps (CIG*) has provided for the construction of a new tunnel and the enlargement of the existing one.

SATELLITE DATA

Projectual application: The “Col di Tenda Landslide”

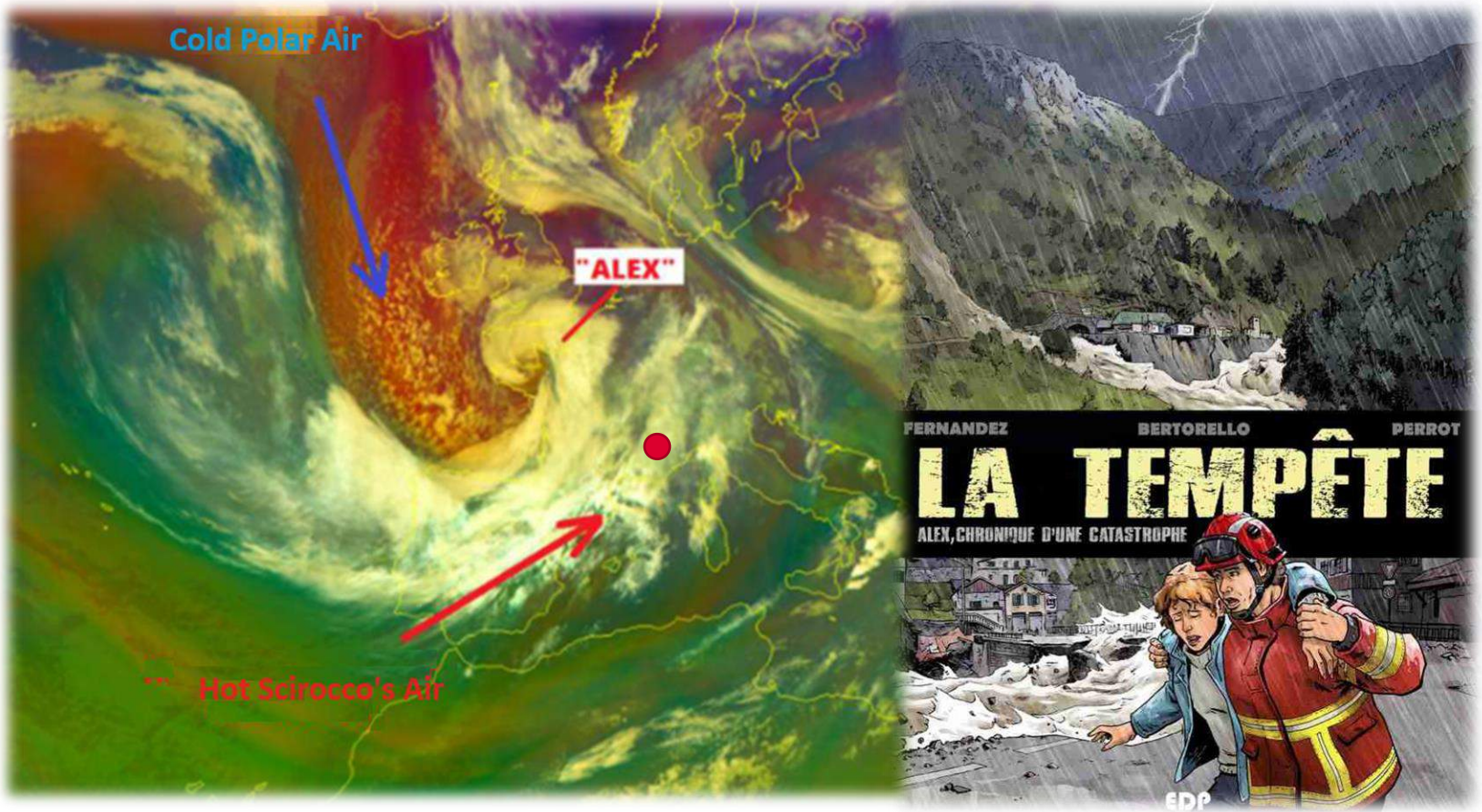
Storm ‘’Alex’’ Event

October 2, 2020

Humid and warm southern air blowed over the southern Piedmontese Alps and caused exceptionally strong rains

Over ***650*** mm of rain in 24\36 hours, in relation to the altitude and the exposure of the slopes.

50% of the annual average rainfall



SATELLITE DATA

Projectual application: The “Col di Tenda Landslide”

The day after…

Connection Italy – France damaged and closed

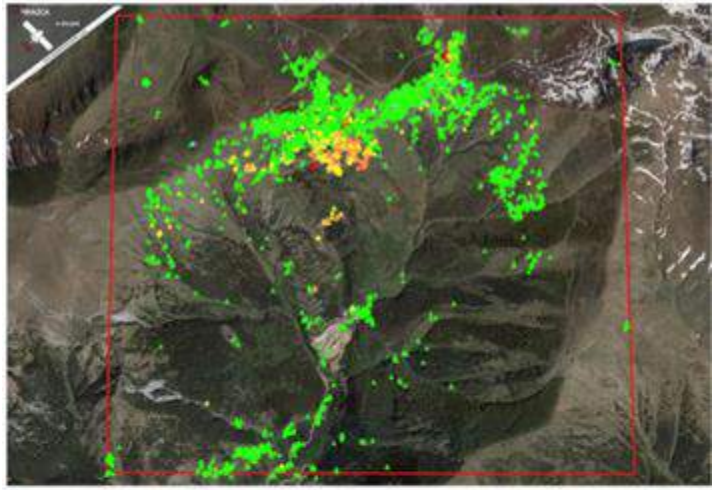
130.000 m^3 of destructurated Flysh and deposites evoluted in rapid “Debris Avalanche”

SATELLITE DATA

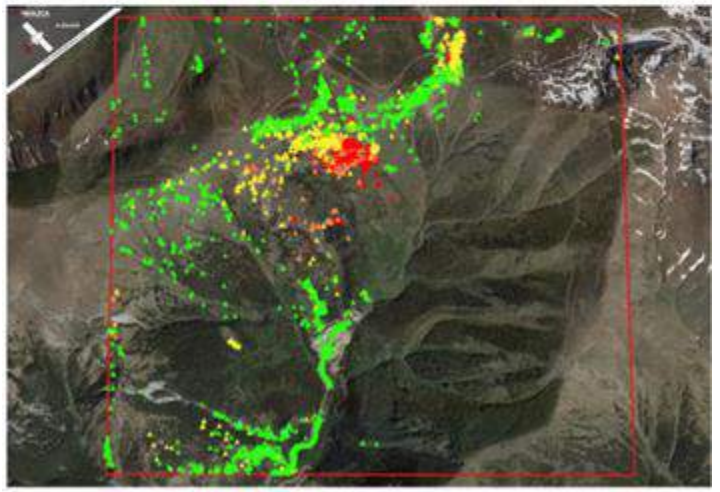
Projectual application: The “Col di Tenda Landslide”

InSar Monitoring

Sentinel-1 (European Space agency)
Acquisition interval: 2014 – 2021
Images nr.: 359 (Asc) – 345 (Desc)
Orbital geometry: Double
C-Band: λ = 5,6 cm;
Resolution: 20 m x 5 m



COSMO-SkyMed (Italian Space Agency)
Acquisition interval : 2010 – 2022
Images nr.: 134 (Asc) – 159 (Desc)
Orbital geometry: Double
X-Band: λ = 3,1 cm;
Resolution : 3x3 m



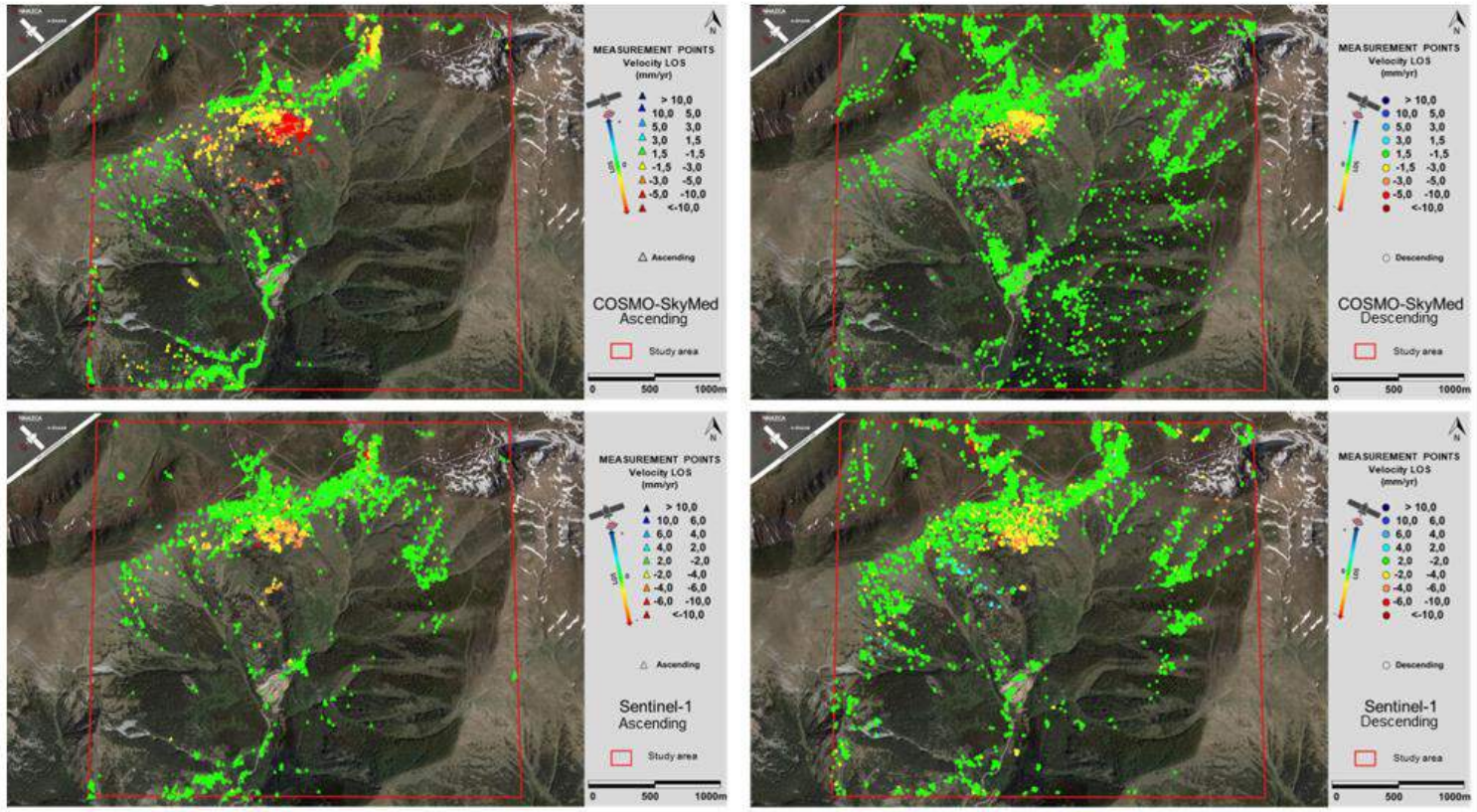
SATELLITE DATA

Projectual application: The “Col di Tenda Landslide”

InSar Monitoring

ASI COSMO-SkyMed Ascending and Descending Line of Sight (LOS) measured displacements

ESA Sentinel-1 Ascending and Descending Line of Sight (LOS) measured displacements



A widespread sector affected by slight long-term deformations (ranging from 2 to 6 mm/year) is detected in both satellite constellations and both orbital geometries

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SATELLITE DATA

Applications to a real case: The “Col di Tenda Landslide”

InSar Monitoring, T-InSar Monitoring & Multiparametric DMS Columns

InSar monitoring gave a first and crucial view, looking at the past micro movements, helping the reconstruction of the phenomena.

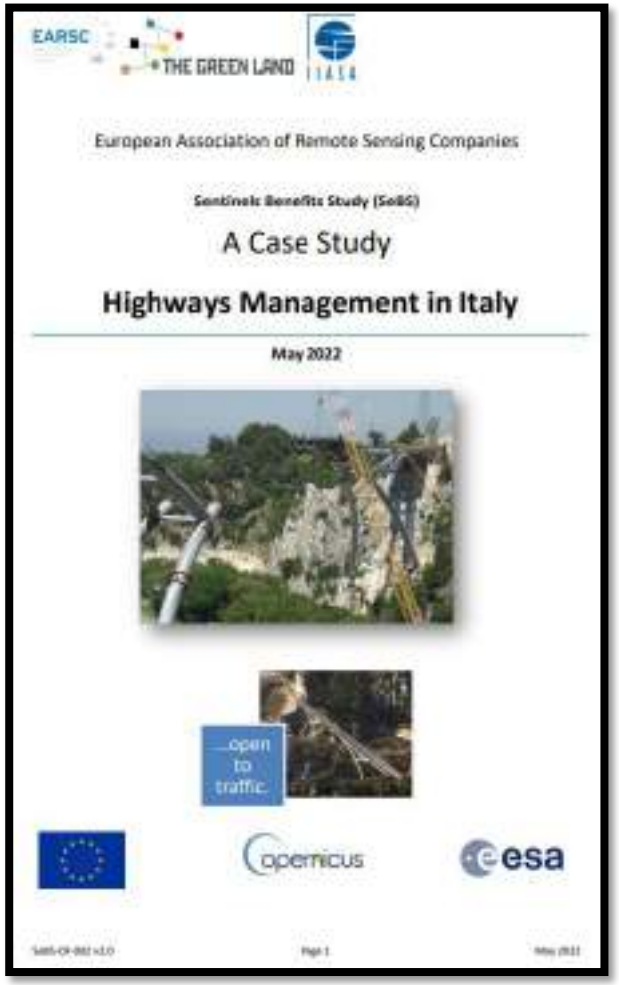
Moving from these data, others technological monitoring systems were applied to “Col di Tenda” slope, actually trying to identify principal characteristics of the landslide and activate alert function

DMS is a Multiparametric Column, able to detect landslide’s movement, piezometric level, temperature, with the possibility to monitor in real time the data collection.

SATELLITE DATA

Conclusions & Future Projects

Highway Managment whith Satellite data



ANAS S.p.A. is Co-Author of an important Paper published by EARSC

The study allowed to appreciate that the use of Satellite data is becoming essential and appliable on large scale

Since 2023 the satellite data are officially part of the project line in the TECHNICAL DIRECTION.

MAJETTA S., CAPOZUCCA F., COPPA I., BONELLA A., LOI E., MARTINO M., FERRARI C. & DANDINI A. .
https://earsc.org/sebs/wp-content/uploads/2022/05/Road-Infrastructure-monitoring-in-Italy-final.pdf

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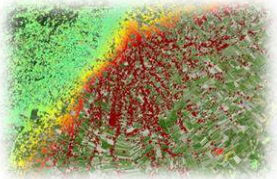
SATELLITE DATA

Conclusions & Future Projects - 1

Highway Managment with Satellite data

Highways Overview

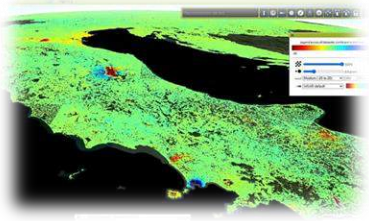
Viaduct & Bridges monitoring



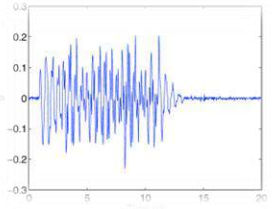
Warning areas

Planned Maintenance

Landslides



Ground Motion analysis for design



Earthquakes effects

Early Warning

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SATELLITE DATAS

Conclusions & Future Projects - 2

Iride: A Constellation of Constellations

Like national satellite data User, ANAS is called by ESA like PILOT USER in the IRIDE constellation Project.

- Iride Project was conceived as a Need of Users
- The one of the most important European Space Programs for the earth observation
- An Italian Proposal entirely *in–house* developed

esa

Agenzia Spaziale Italiana

COSMO SKYMED

saocom

sentinel-1

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Thanks for your kind attention!

Anas men at work in 20’s

Anas men at work Today

We try to have the most powerful technologies
We can look the world from the space…

But the man is always the main actor!

For any questions write us: f.capozucca@stradeanas.it

Flavio Capozucca & Jacopo Crognale June 2024