Ministry of Science and Higher Education
Republic of Poland

JAGIELLONIAN UNIVERSITY IN KRAKÓW

EUROPEAN SPACE AGENCY

15 - 19 June 2026 | Auditorium Maximum of the Jagiellonian University, Kraków, Poland

FRINGE 2026

ISABHEL: An integrated satellite-to-sensor Digital Twin service for bridge lifetime assessment and decision-ready alerts

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Presented by: A. Nobile (adriano.nobile@nhazca.com)

ESA CALL 5G FOR L'ART

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- **ARTES 4.0 Business Applications and Space Solutions integrating space asset(s) and 5G networks in L'Aquila/the Abruzzo region, Rome and Municipality of Turin (L'ART). Ref.: CfP 5-50001/23/NL/AF**
- The tenderer shall make use of the local 5G infrastructure deployed in the perimeter of the above Municipalities and Regions, through the following initiatives:
- **Torino has been a pioneer in Europe in creating and activating the 5G connectivity infrastructures and in building 5G services.**
- L'Aquila was selected as one of the 5G key cities by the Italian Ministry of Economic Development to conduct a series of 5G pilots from 2018 to 2020.
- **The specific scope of the activities shall be related to the "Structural Health Monitoring and Risk Modelling" addressing at least one of the identified use cases.**

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REGIONE ABRUZZO

CITTA' DI TORINO

ISABHEL - USE CASE

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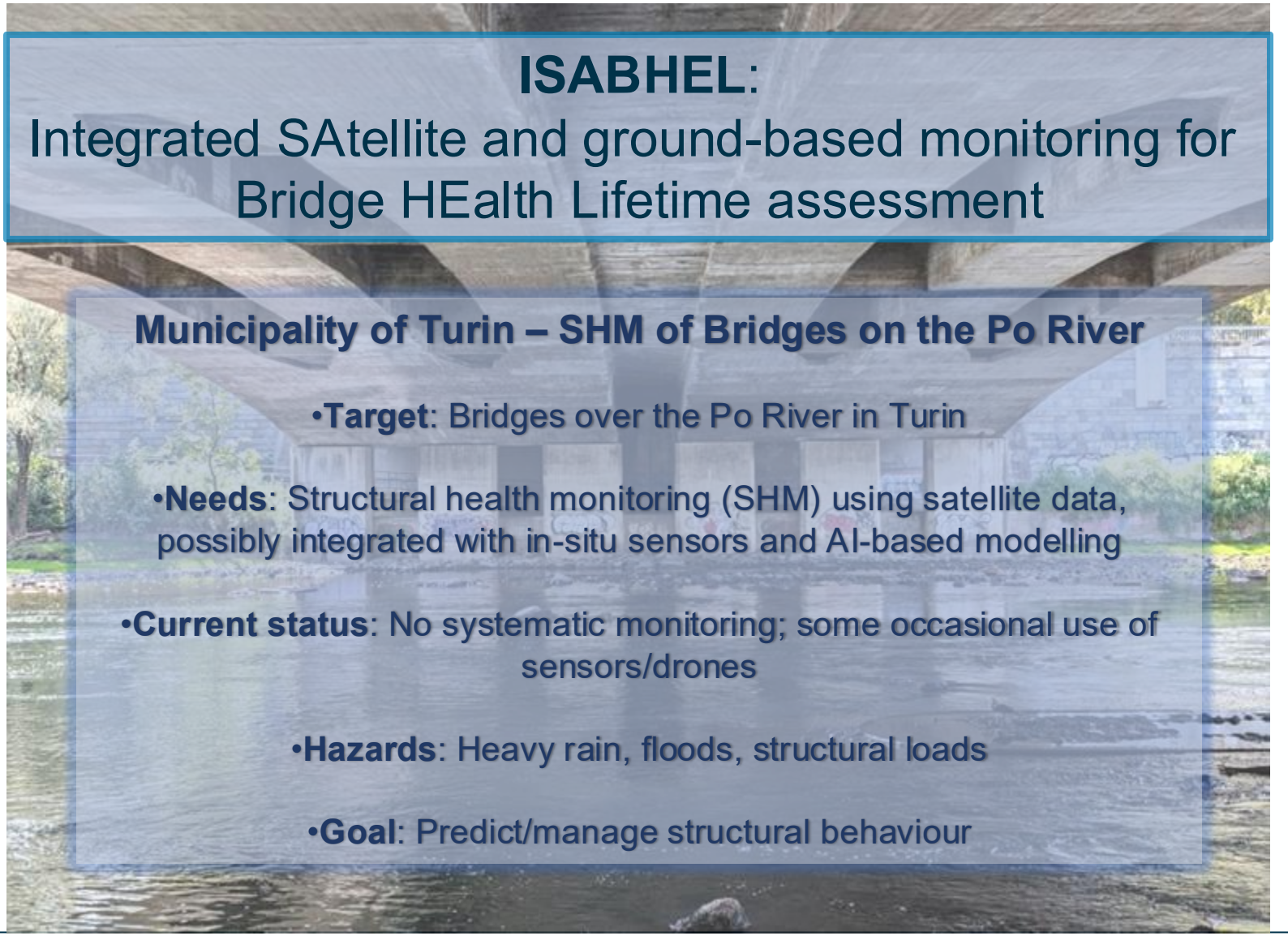

ISABHEL:
Integrated SAtellite and ground-based monitoring for Bridge HEalth Lifetime assessment

Municipality of Turin – SHM of Bridges on the Po River

- **Target**: Bridges over the Po River in Turin
- **Needs**: Structural health monitoring (SHM) using satellite data, possibly integrated with in-situ sensors and AI-based modelling
- **Current status**: No systematic monitoring; some occasional use of sensors/drones
- **Hazards**: Heavy rain, floods, structural loads
- **Goal**: Predict/manage structural behaviour

ISABHEL - TEAM

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NHAZCA
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S2R
SEISMIC RISK REDUCTION

1859

nplus

NHAZCA has expertise in natural hazards and infrastructures monitoring through remote sensing technologies – Terrestrial and Satellite SAR Interferometry and PhotoMonitoring™, with the greatest technological innovations at the service of asset management.

S2R is a consulting company providing services in civil and environmental engineering fields from buildings, roads, bridges, tunnels, dams to specialized seismic and geotechnical construction. S2R has been solving very complex infrastructure challenges with a legacy of expertise, experience, innovation.

The Politecnico di Torino is Europe's leading research and teaching universities. DISEG is the reference point for research activities related to the safety and design of built environment, taking into account environmental and human actions and their integration with the surrounding built space.

Nplus is the leading company in Italy in the field of SHM technologies and services for bridges and viaducts with a portfolio of more than 800 bridges. Nplus is the only one active in its three main vertical fields: Hardware and System integration; Software; SHM Engineering Services.

CASE STUDIES

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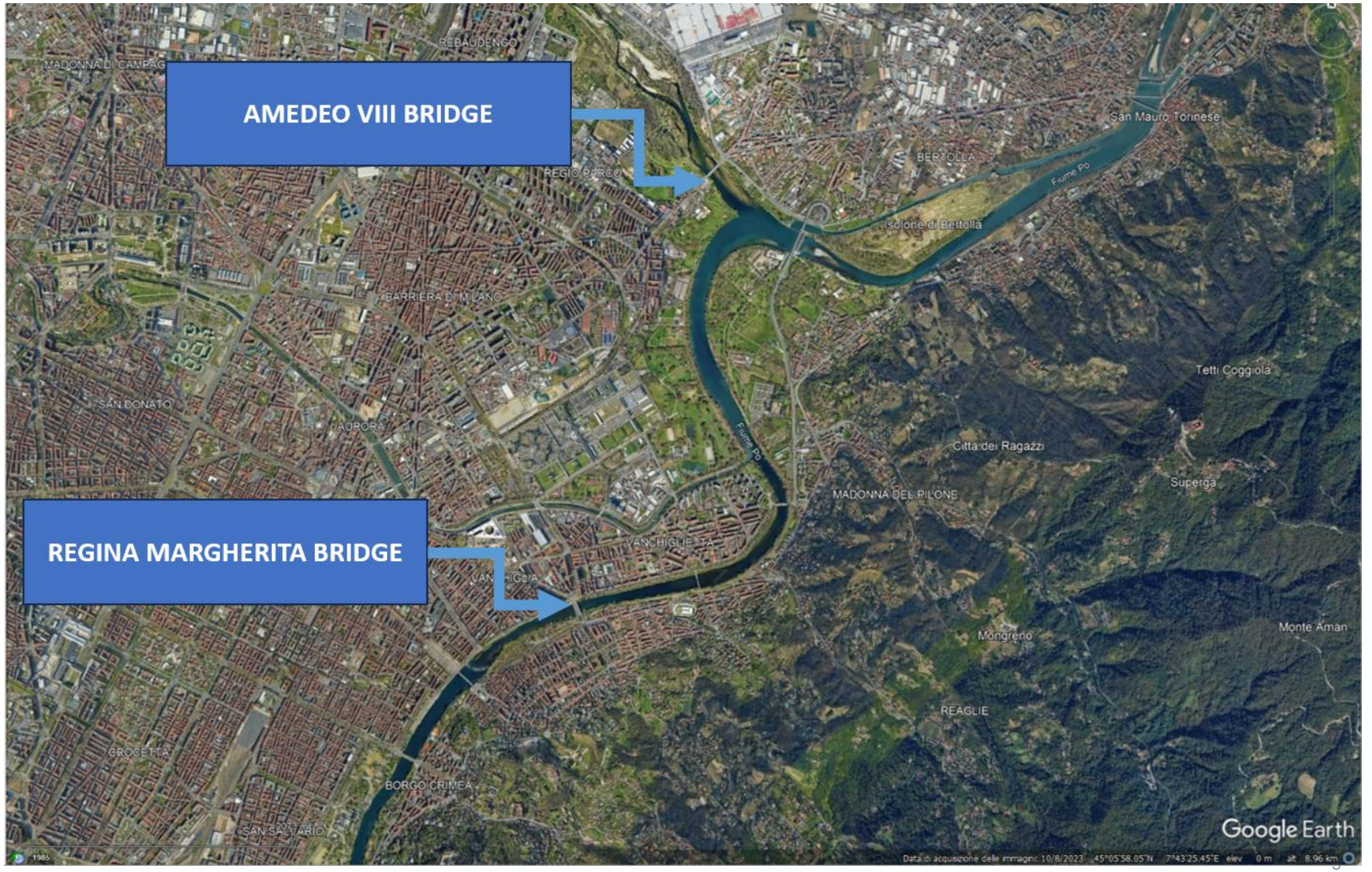
Amedeo VIII Bridge

- Built in 1933
- Over Stura di Lanzo River

Regina Margherita Bridge

- Built in 1972
- Over the Po River



CASE STUDIES

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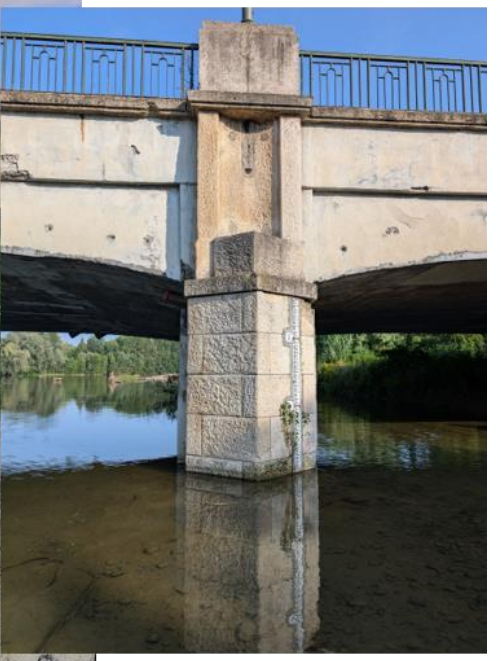

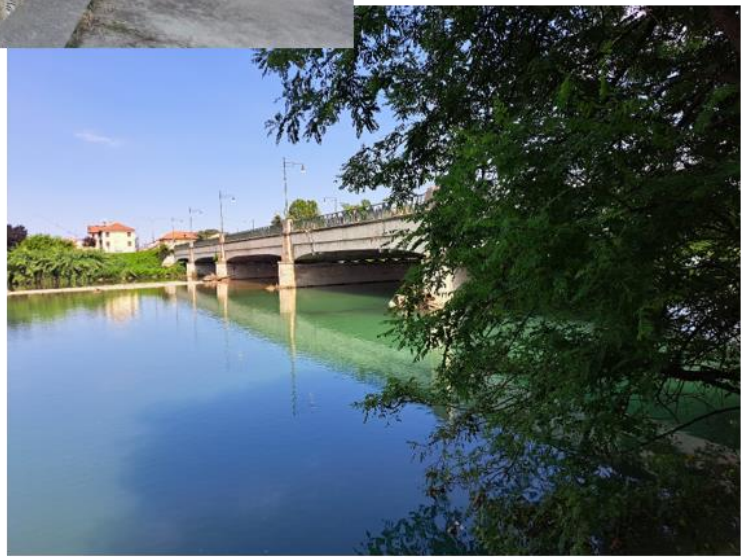

ISABHEL - PROJECT

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Satellite InSAR
- detect deformations and geological instabilities

Photomonitoring™
- cameras + image analysis (Change Detection & DIC)

Contact sensor
- accelerometers, inclinometers – monitor static/dynamic behaviours

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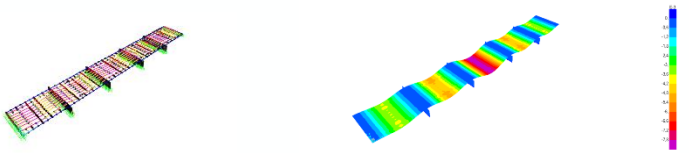
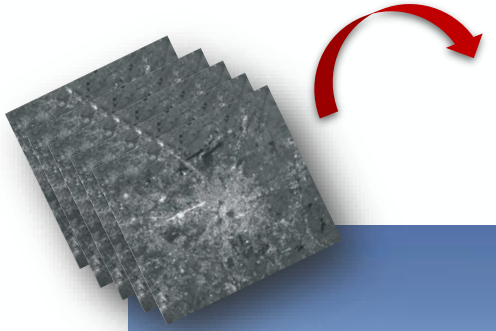
5G connectivity
- real-time data transfer



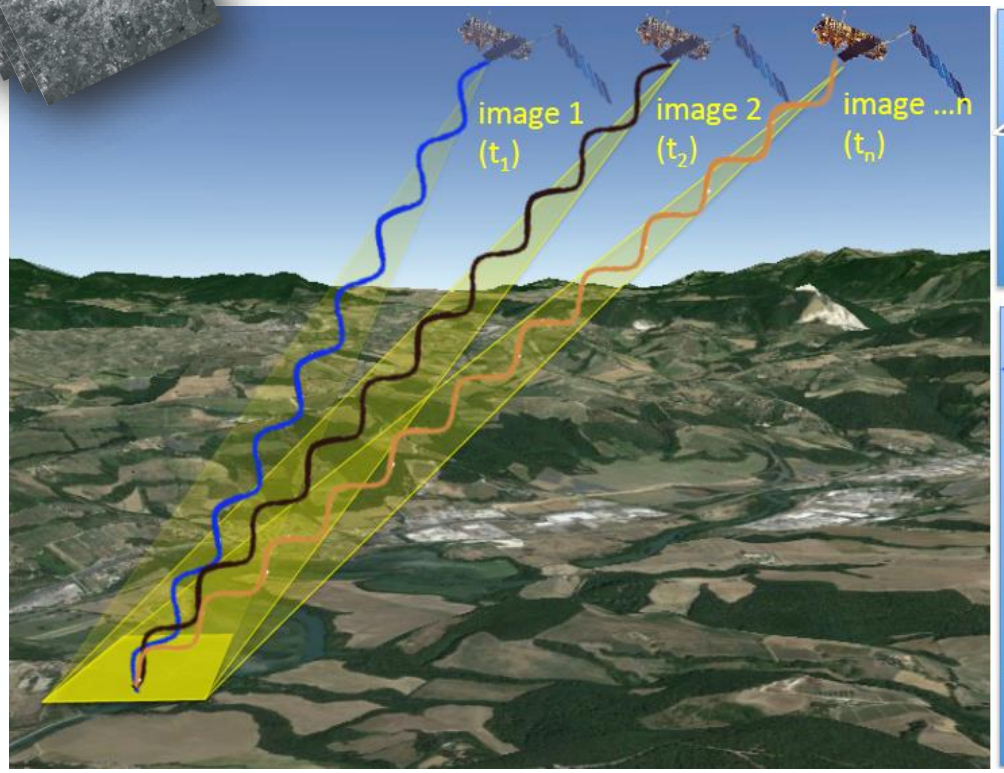
Digital twin
- Calibrated Finite Element Models using satellite, sensor & historical data

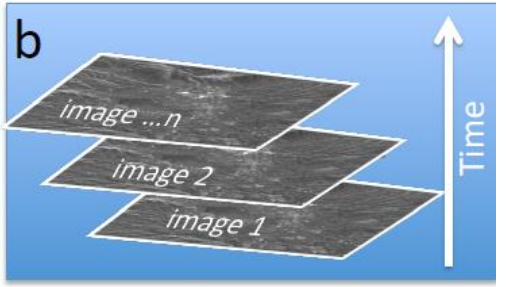
Output
- Web platform for **real-time monitoring**, early warning, and smart asset management

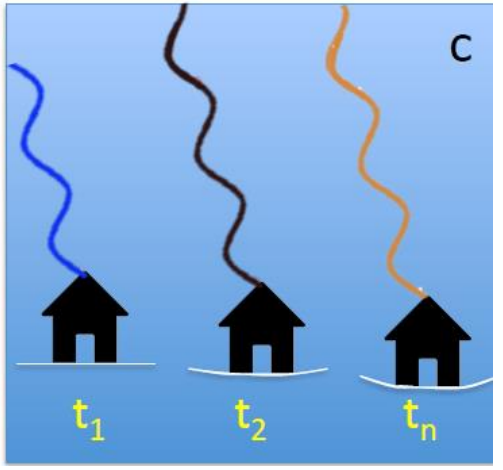
A-DInSAR ANALYSIS



Multi-image analysis
A-DInSAR (Advanced Satellite Differential SAR Interferometry)







- Persistent Scatterer Interferometry (PSI)
- COSMO-SkyMed constellation
- Ascending and descending orbits
- Observation period: 2011–2025
- Processed dataset: 500 SAR images

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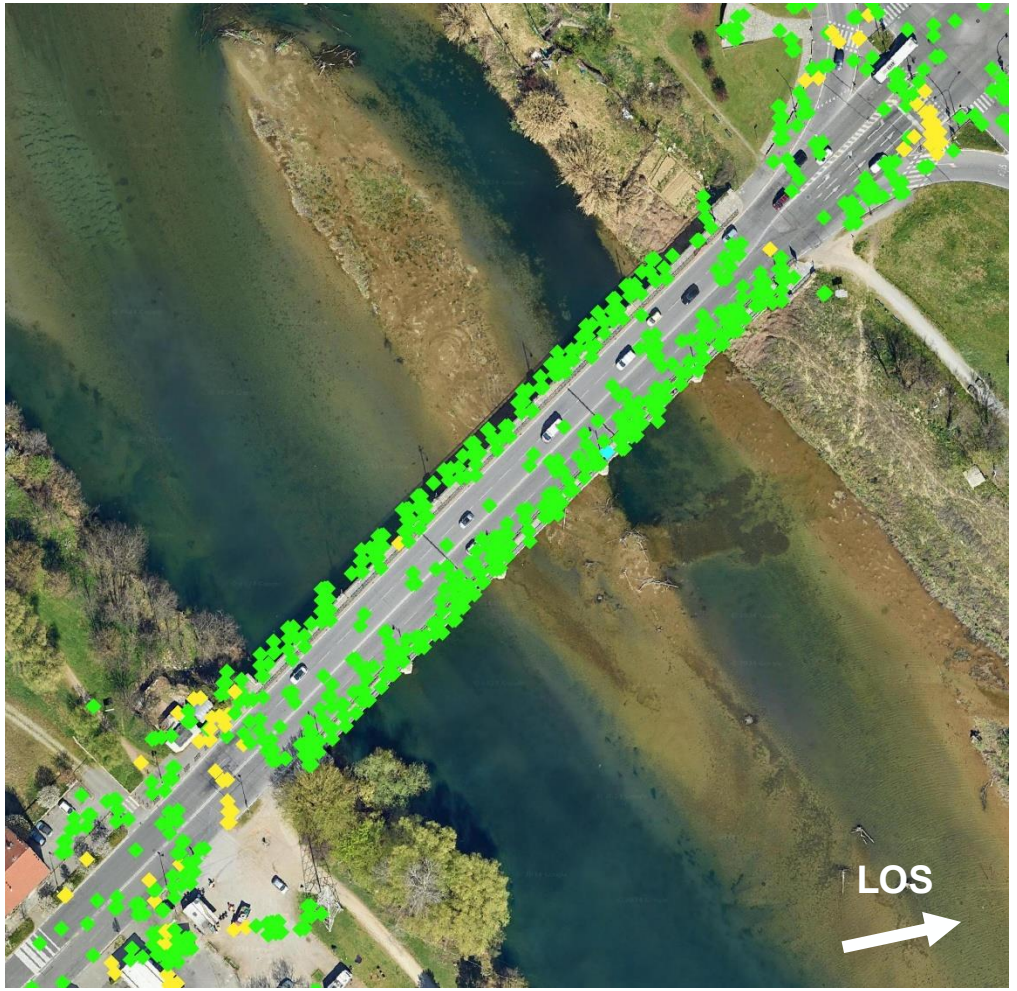
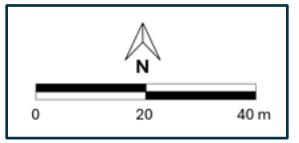
Amedeo VIII Bridge





Displacement rate LOS (mm/yr)

- -100.0 ÷ -10.0
- -10.0 ÷ -6.0
- -6.0 ÷ -4.0
- -4.0 ÷ -2.0
- -2.0 ÷ -1.0
- -1.0 ÷ 1.0
- 1.0 ÷ 2.0
- 2.0 ÷ 4.0
- 4.0 ÷ 6.0
- 6.0 ÷ 10.0
- 10.0 ÷ 100.0

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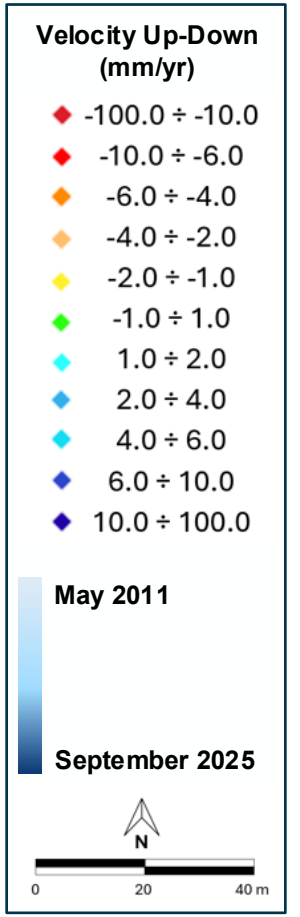
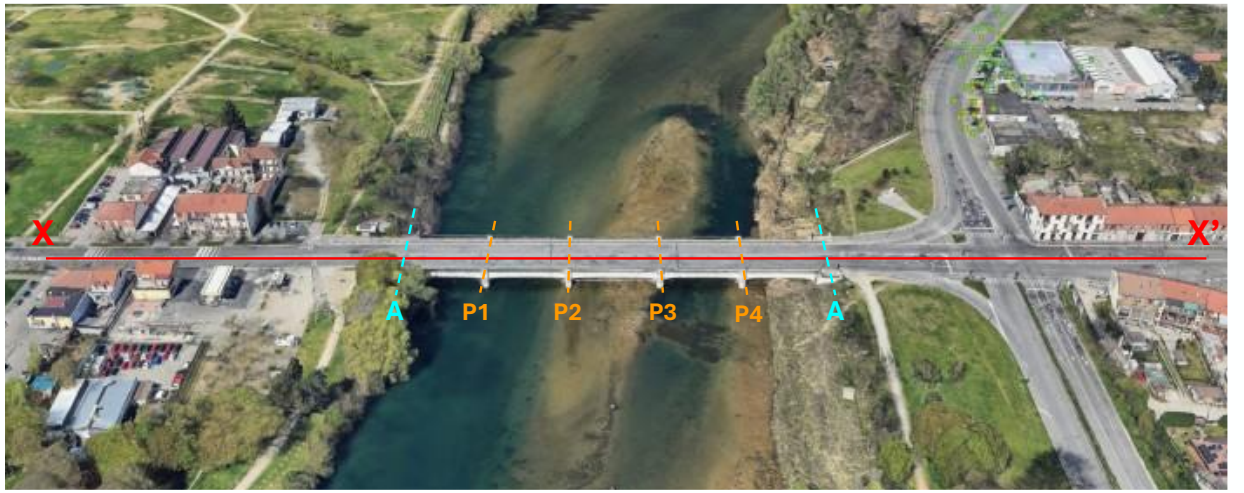
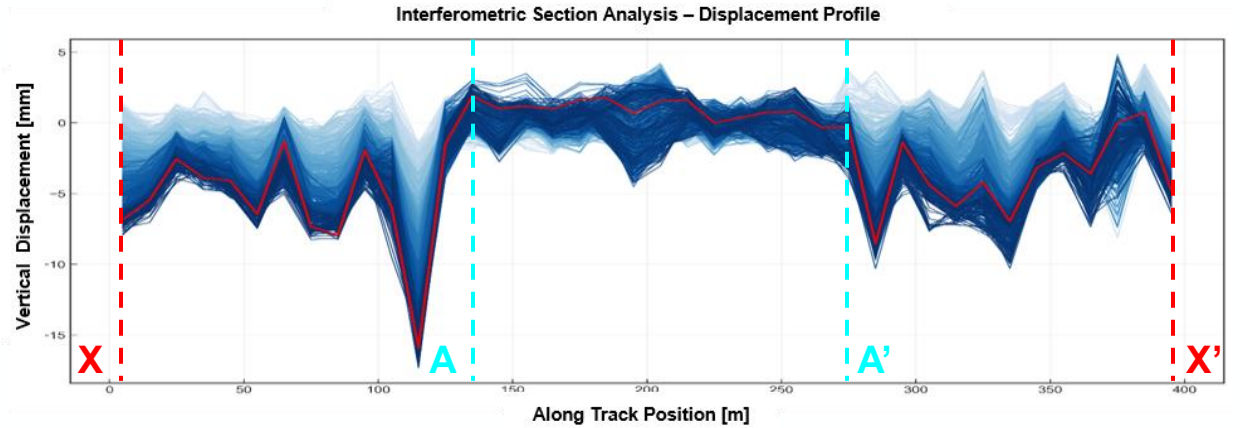
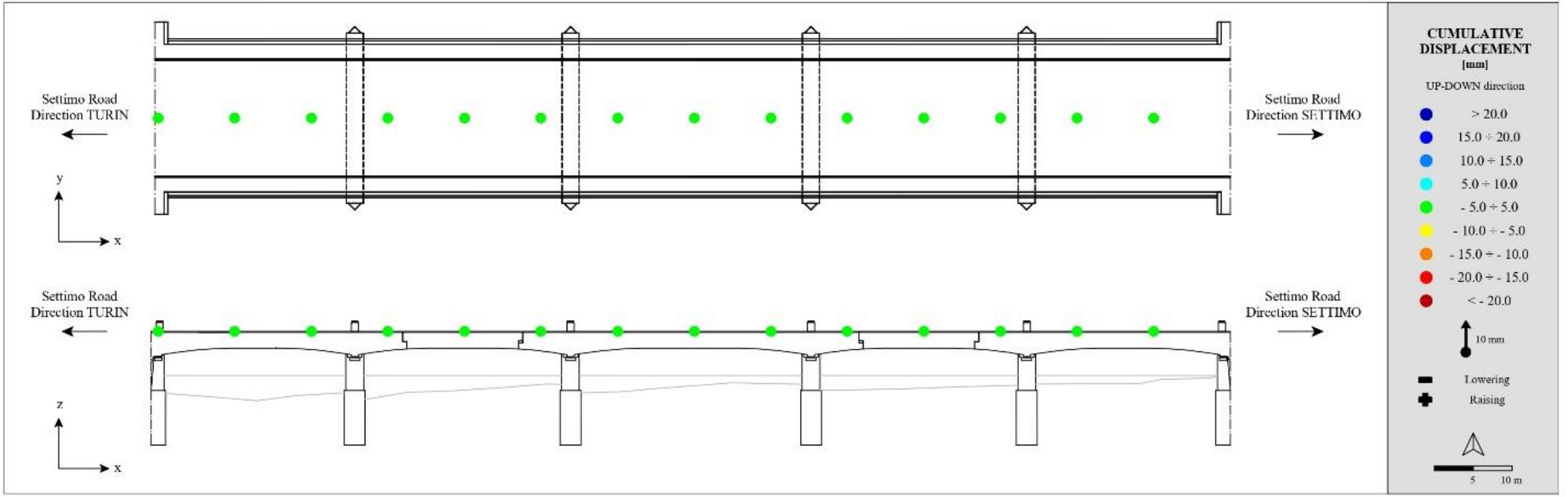
Amedeo VIII Bridge







Amedeo VIII Bridge



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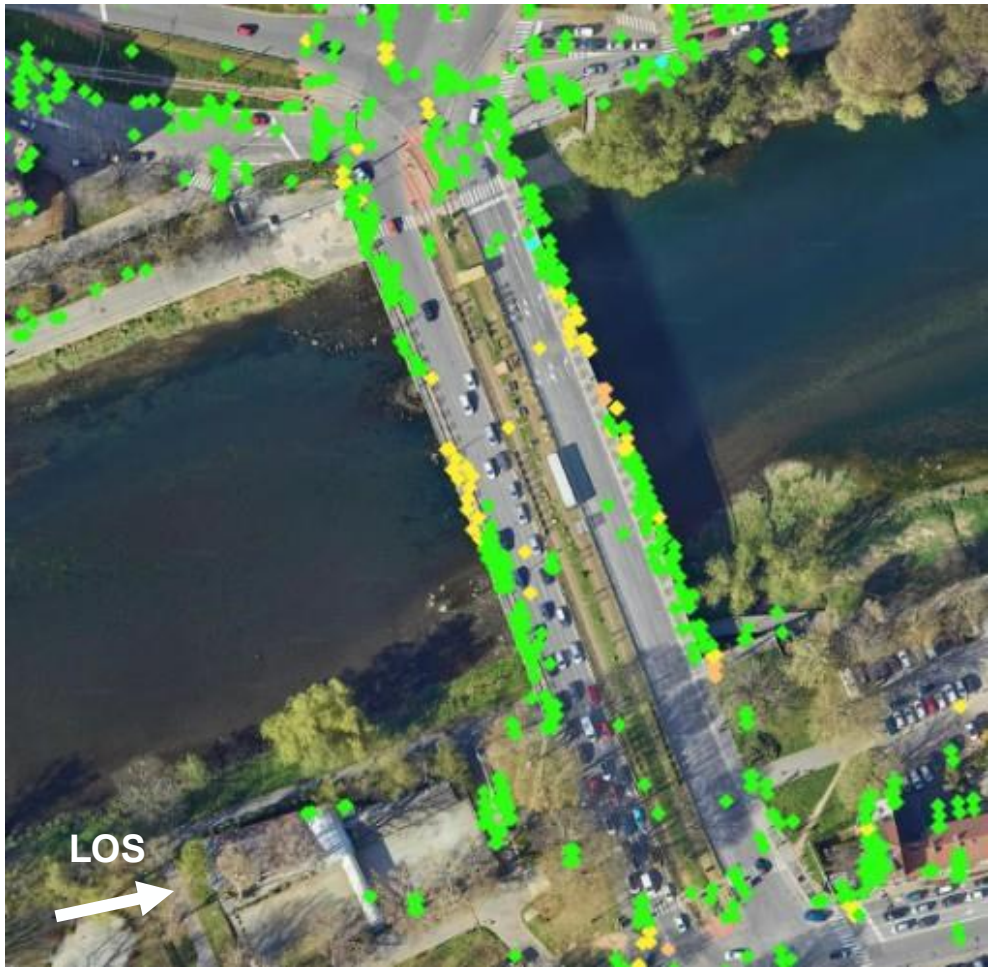
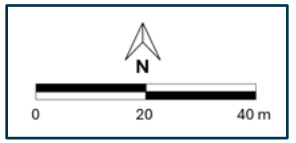
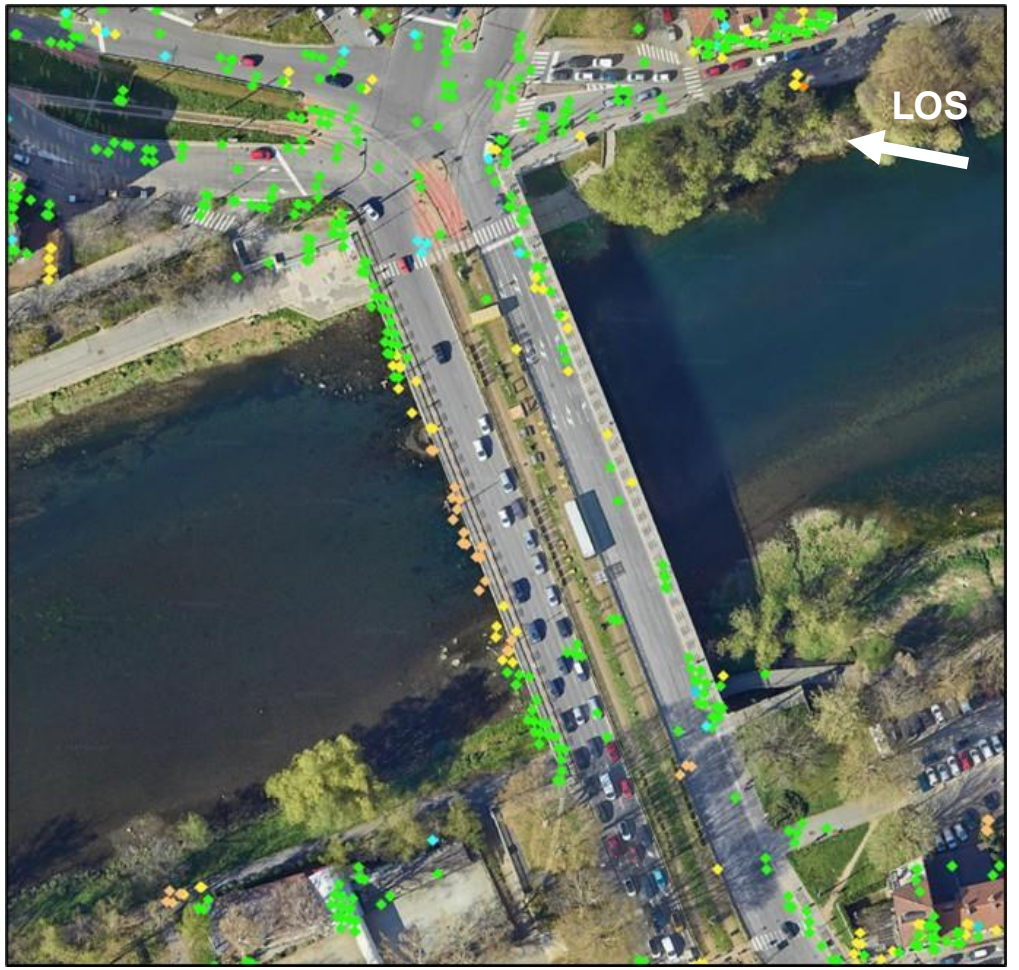
Regina Margherita Bridge



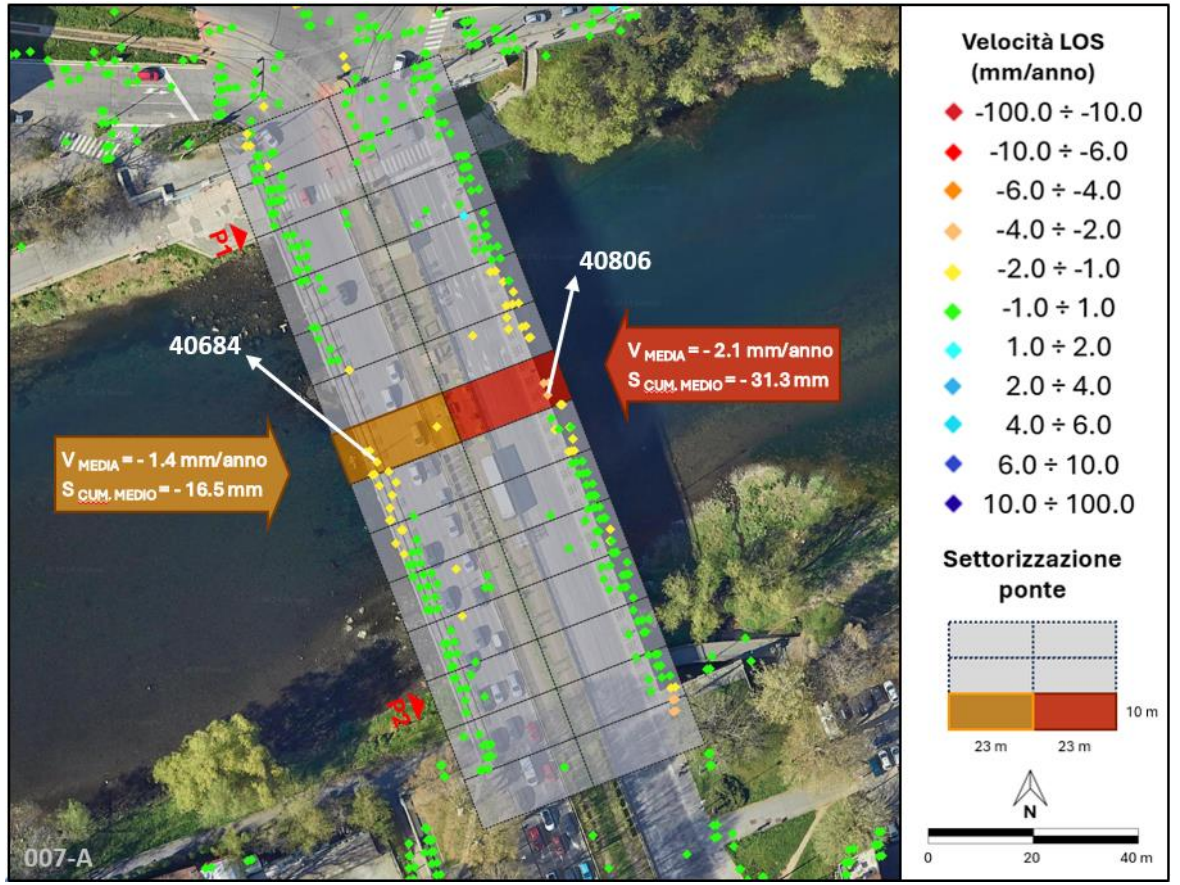


Displacement rate LOS (mm/yr)

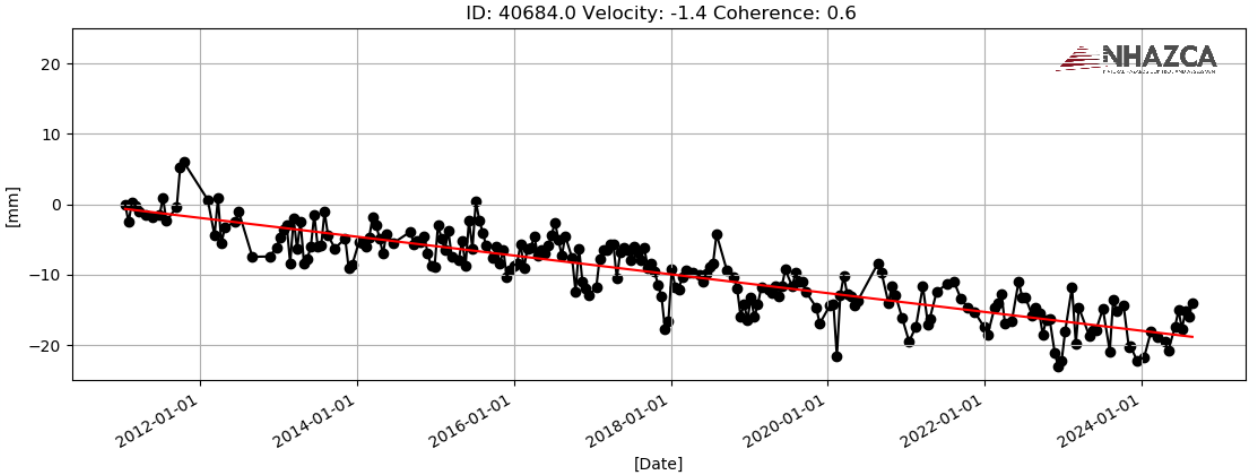
- -100.0 ÷ -10.0
- -10.0 ÷ -6.0
- -6.0 ÷ -4.0
- -4.0 ÷ -2.0
- -2.0 ÷ -1.0
- -1.0 ÷ 1.0
- 1.0 ÷ 2.0
- 2.0 ÷ 4.0
- 4.0 ÷ 6.0
- 6.0 ÷ 10.0
- 10.0 ÷ 100.0

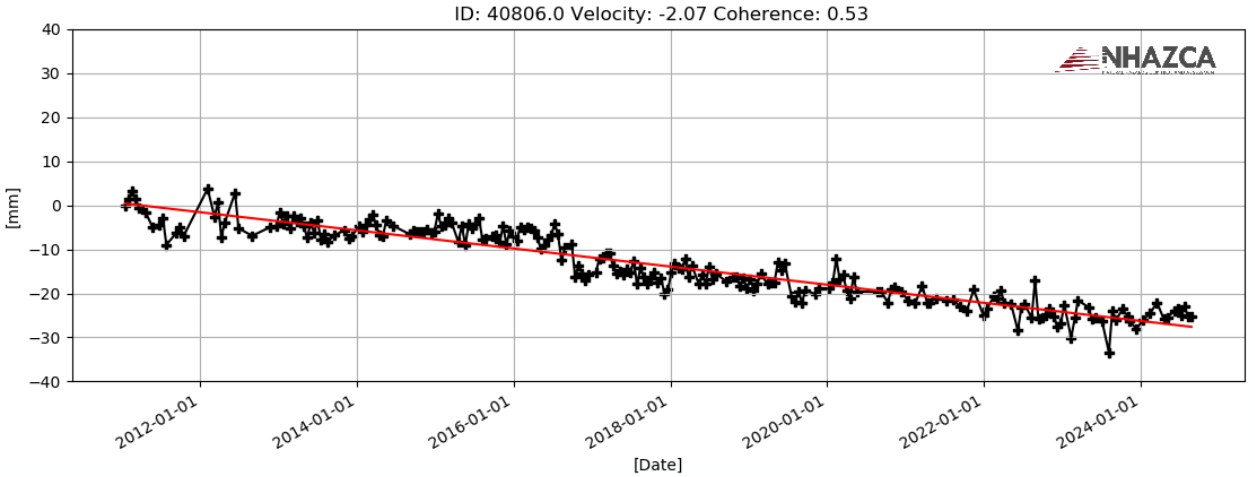


Regina Margherita Bridge



Ascending geometry





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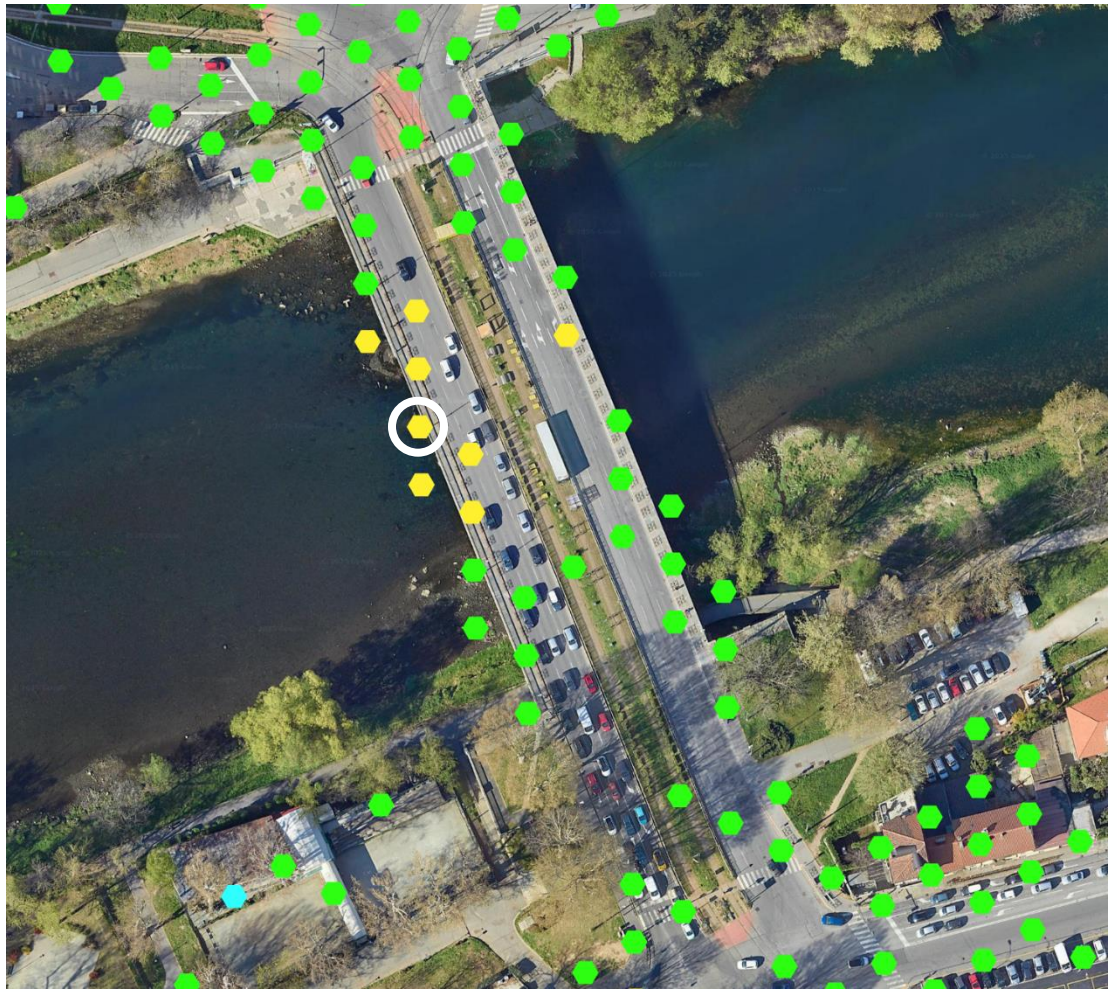
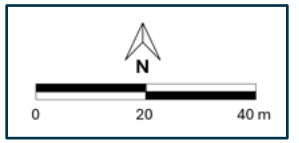
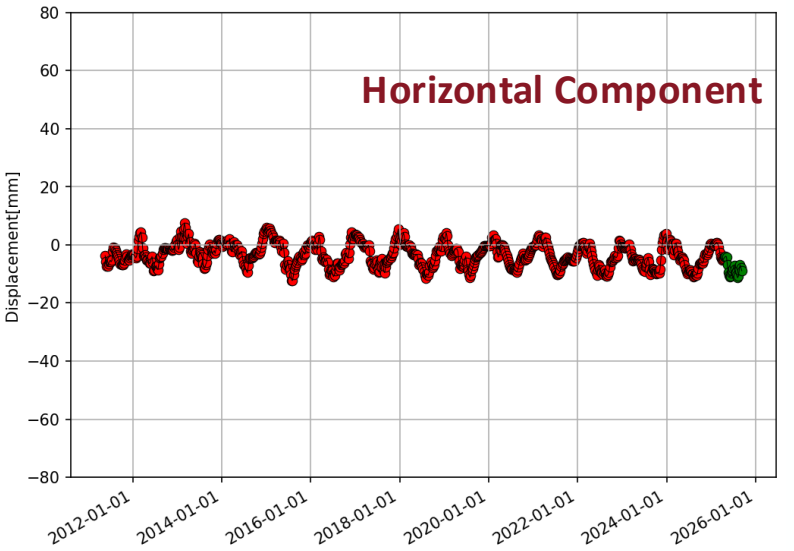
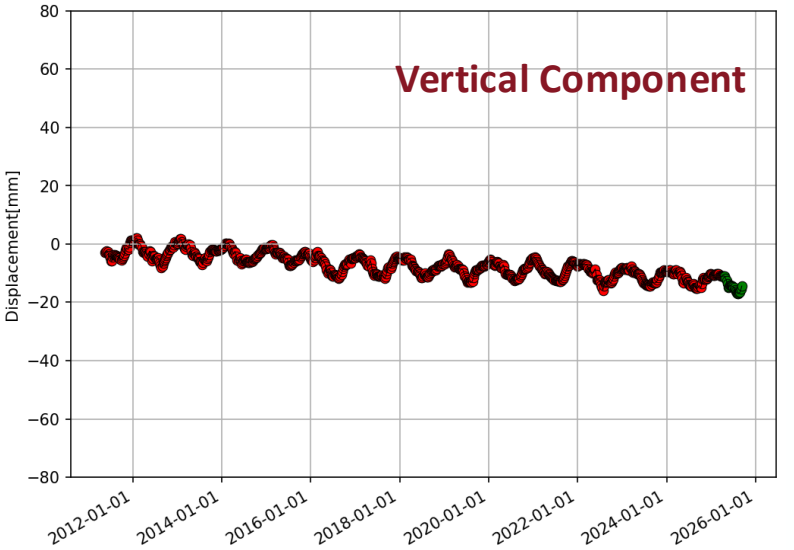




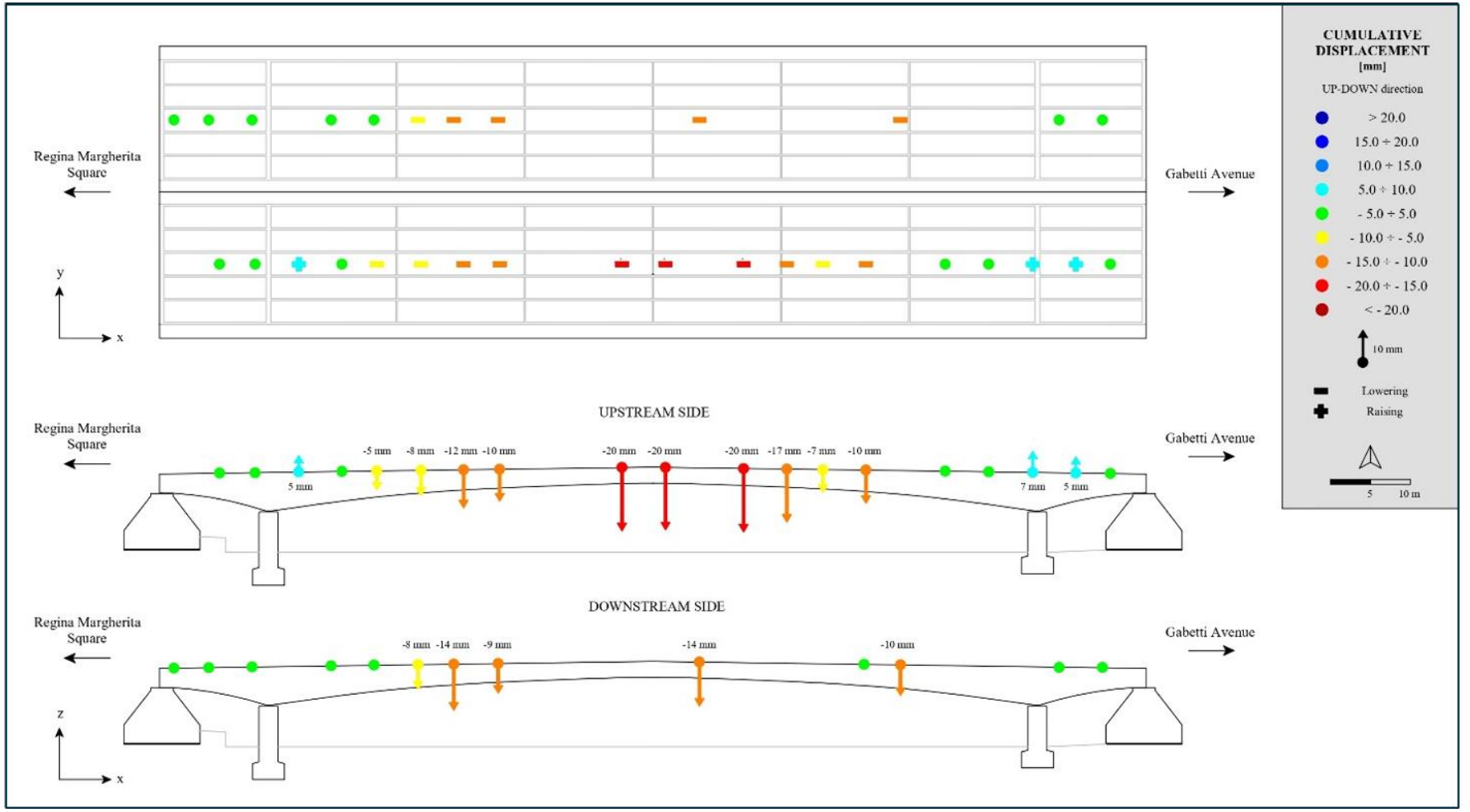
Velocity Up-Down (mm/yr)

- -100.0 ÷ -10.0
- -10.0 ÷ -6.0
- -6.0 ÷ -4.0
- -4.0 ÷ -2.0
- -2.0 ÷ -1.0
- -1.0 ÷ 1.0
- 1.0 ÷ 2.0
- 2.0 ÷ 4.0
- 4.0 ÷ 6.0
- 6.0 ÷ 10.0
- 10.0 ÷ 100.0





Regina Margherita Bridge



PHOTOMONITORING

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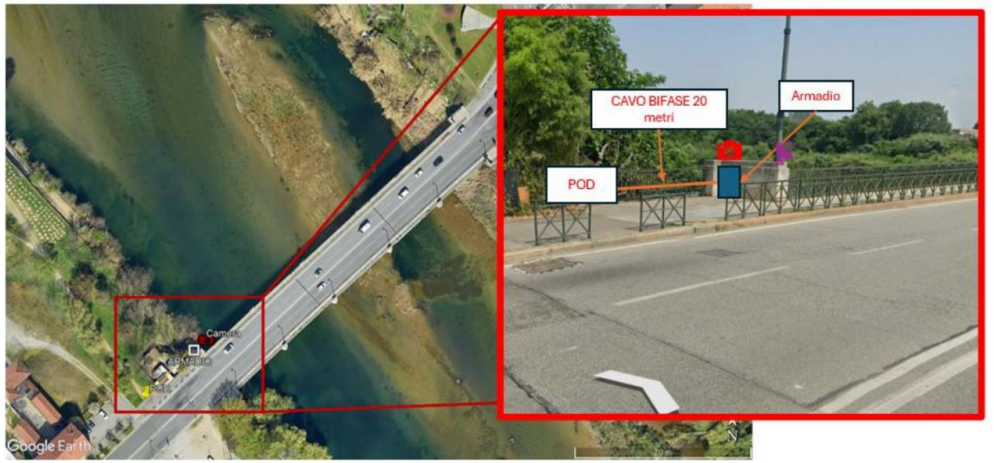
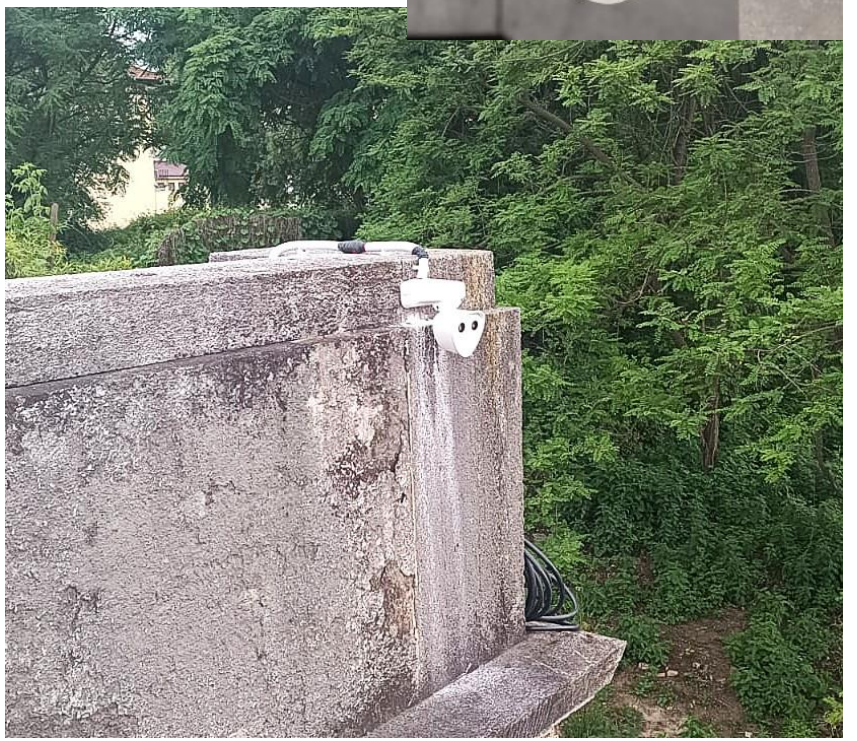
Amedeo VIII Bridge Monitoring Focus

- Hydraulic action leading to scouring of the bridge piers.
- Accumulation of materials around the piers.
- Detection of structural changes in the spans

A single camera on the western side of the bridge, with DUAL LENS CONFIGURATION

- Global View: A wide-angle lens will capture a big part of the bridge
- Focused View: A telephoto lens will target a specific pier
- Image Frequency: Capturing static images every 5 minutes.





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Objective

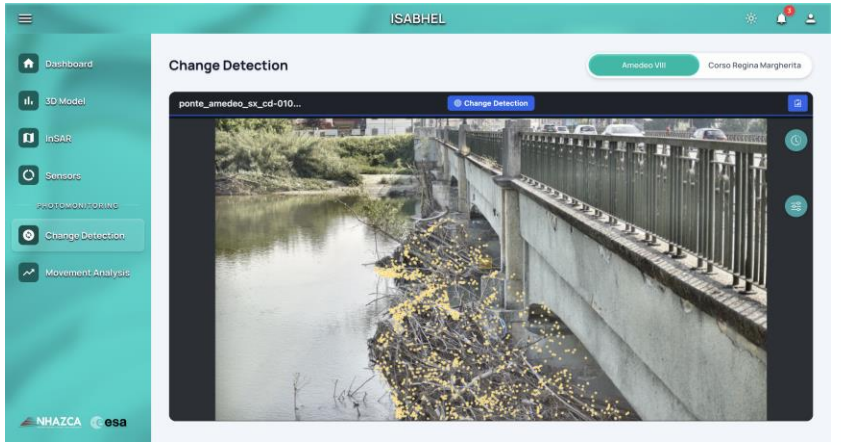
- Detect and measure structural movements and surface changes from Mobotix camera images via IRIS software.

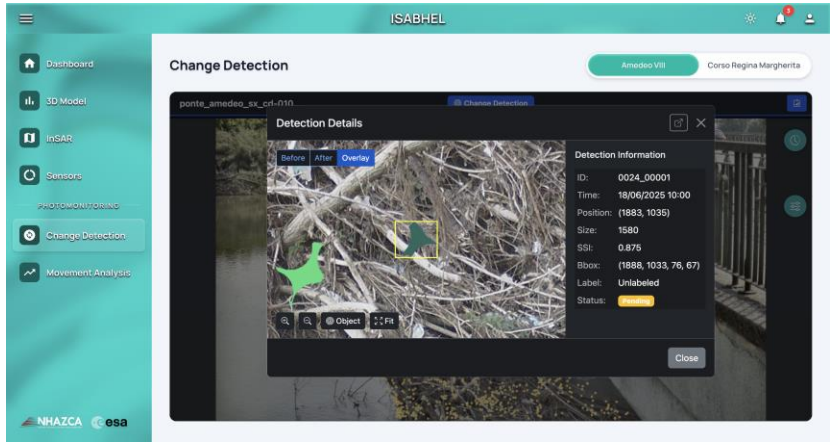
Procedure

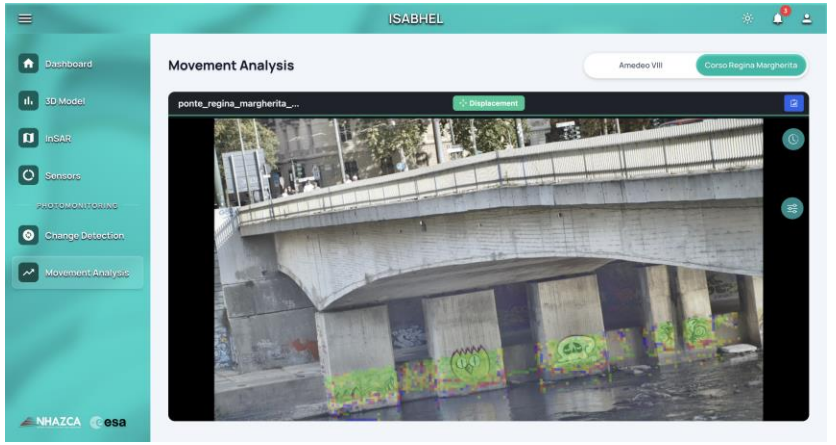
- Image coregistration & displacement analysis
- Change detection (polygon extraction)
- Multi-temporal time-series generation
- Accuracy check vs. visual inspection

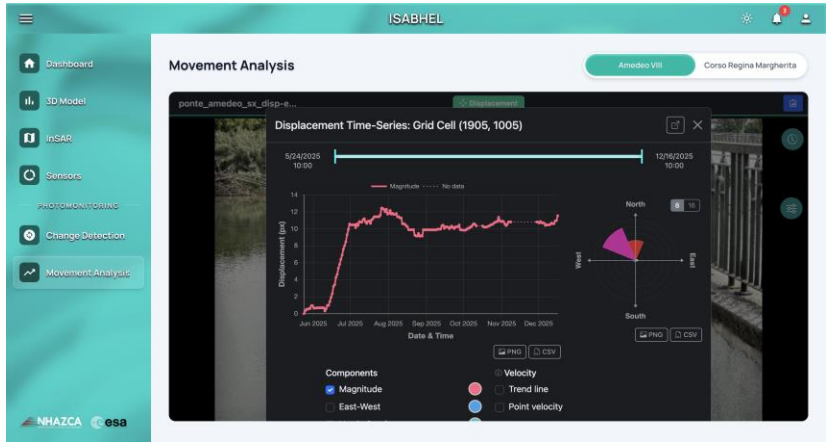
Acceptance criteria

- Registration < 1 pixel
- Displacement accuracy ± 0.5 px (stable targets)
- Change polygon overlap ≥ 85%
- Processing time < 2 min/image pair









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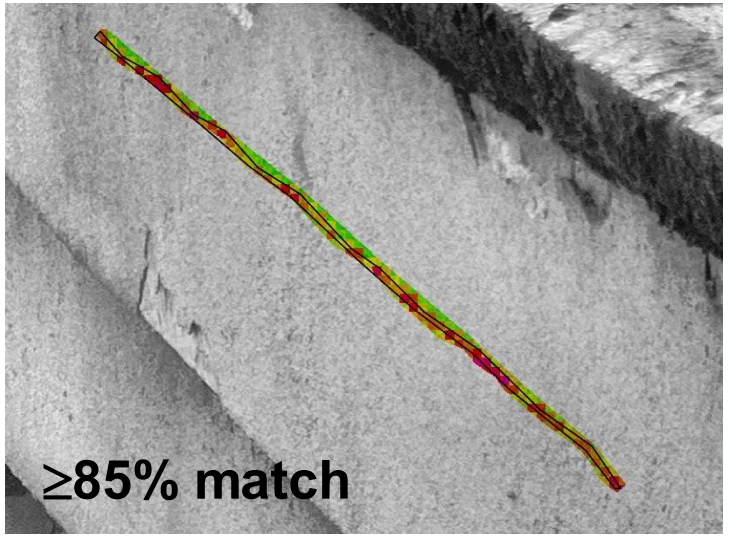
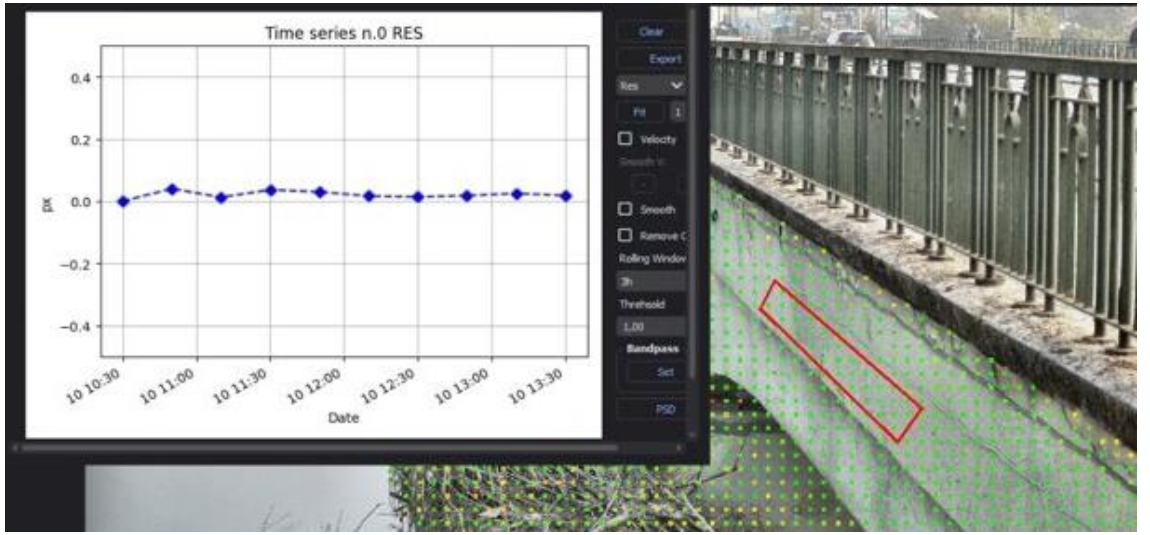
Change detection

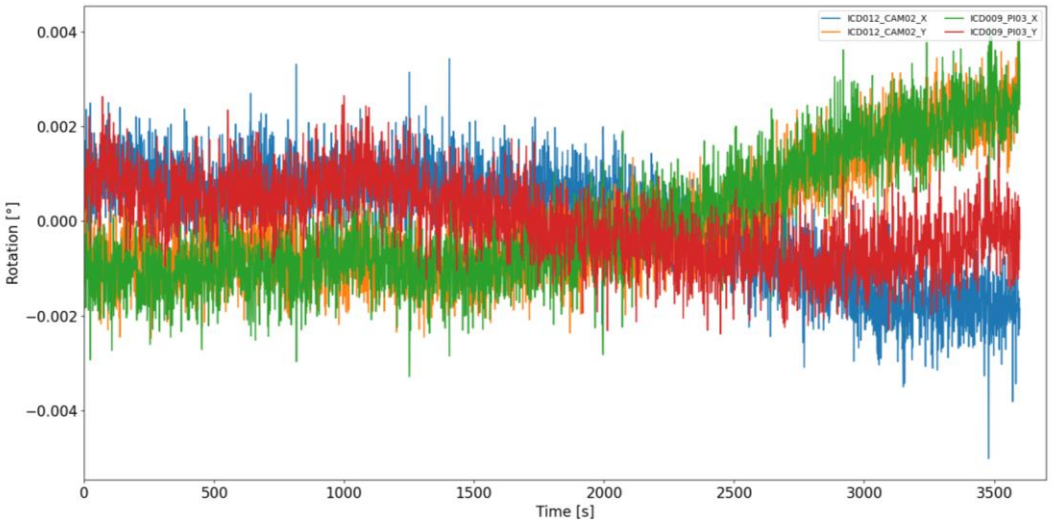


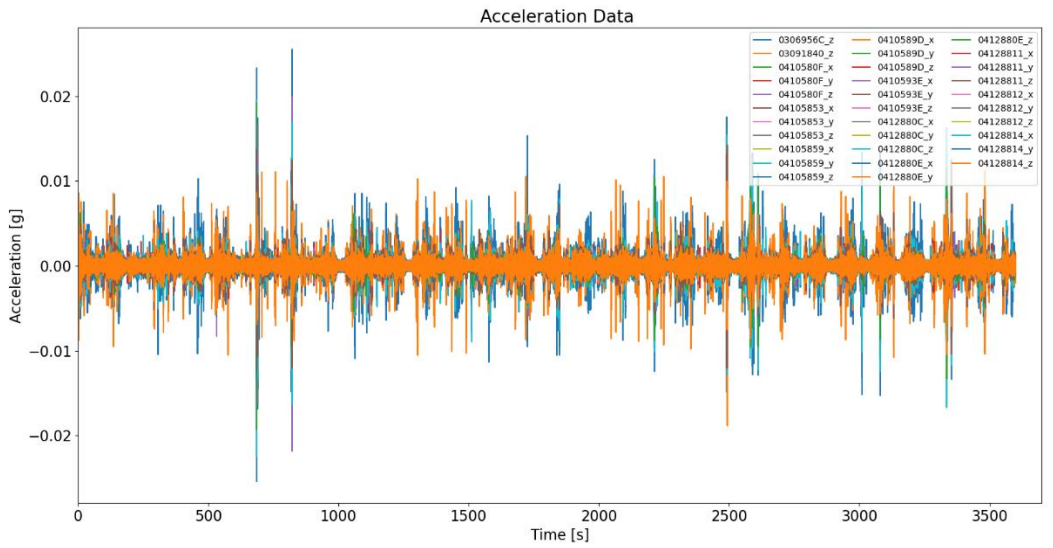
Displacement

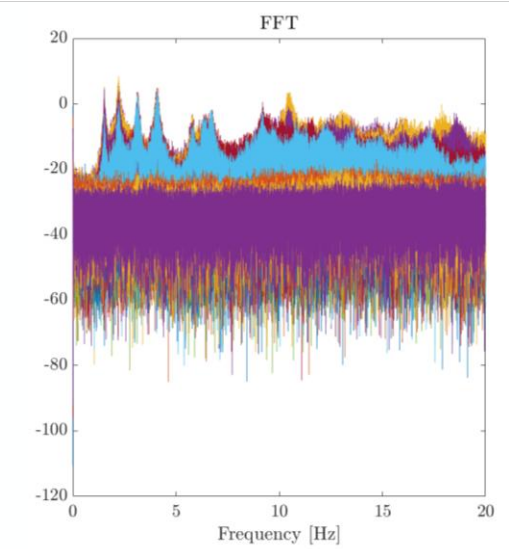


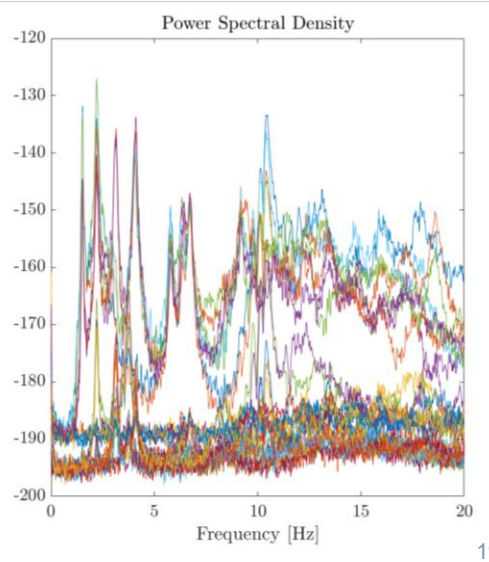
CONTACT SENSORS

- **Inclinometers** – Static monitoring
- **Accelerometers** – Dynamic monitoring









DIGITAL TWIN

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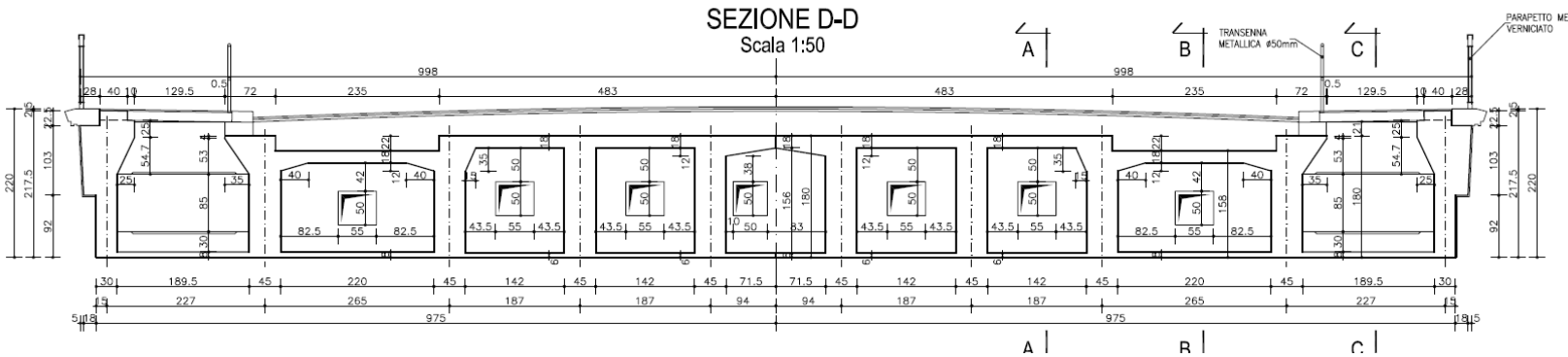
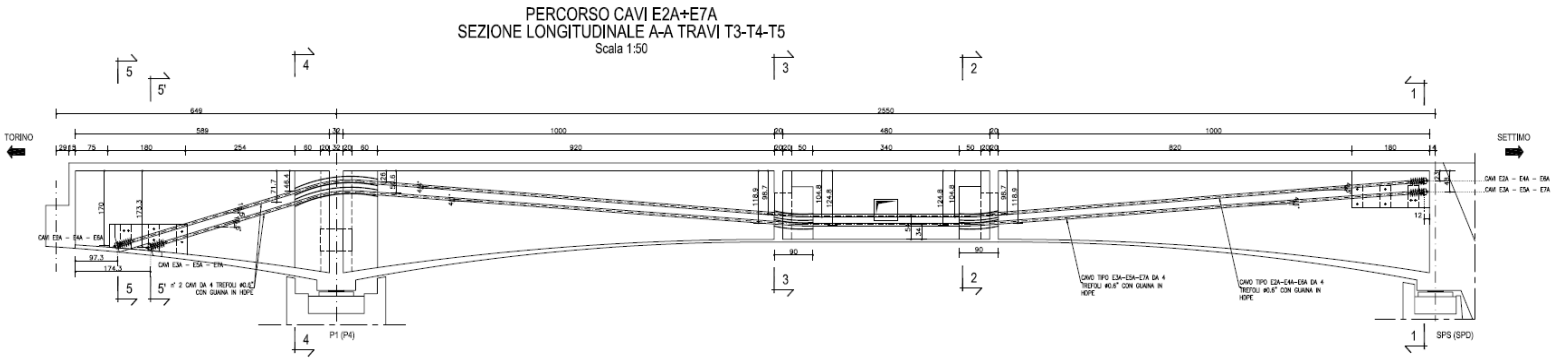
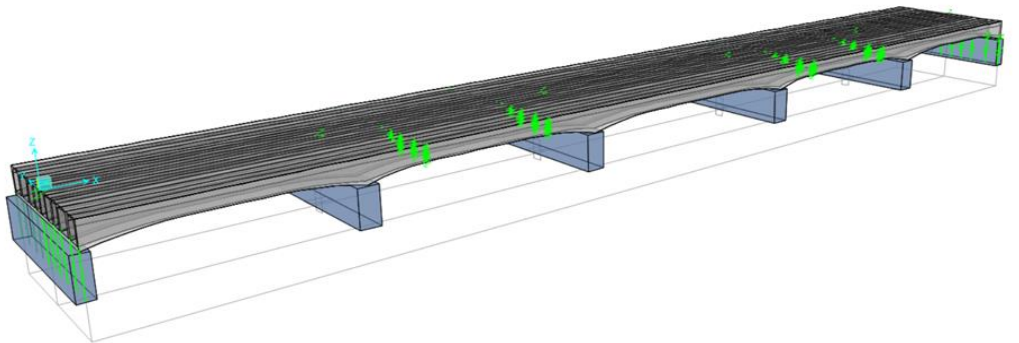
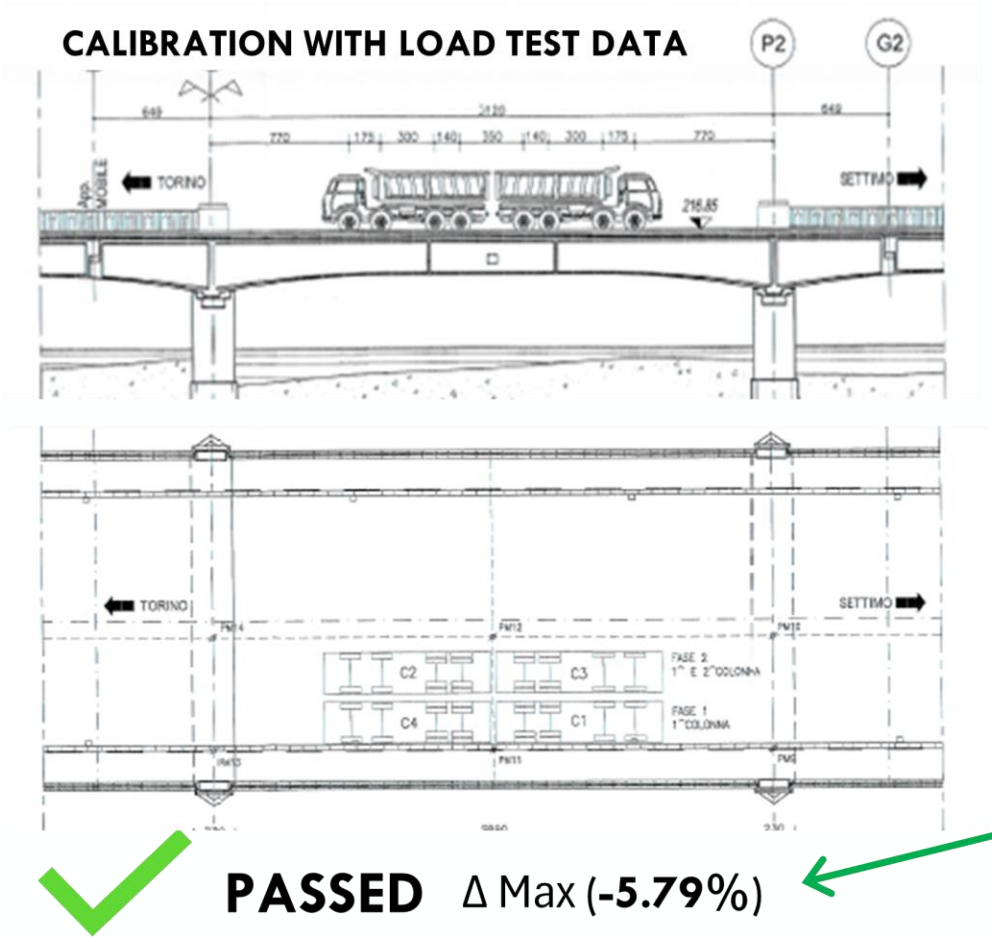
- Geometric parameters from the original projects
- Self load calculations for stability check

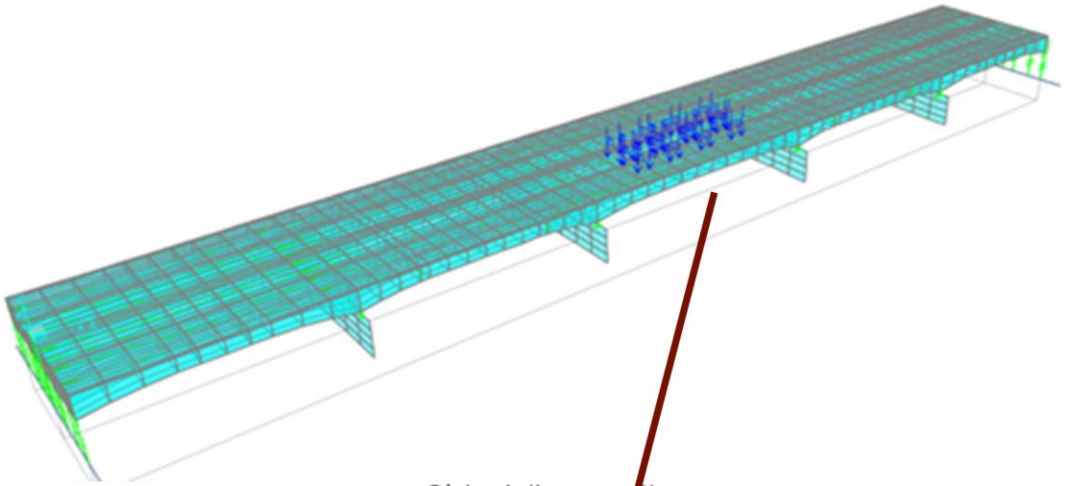


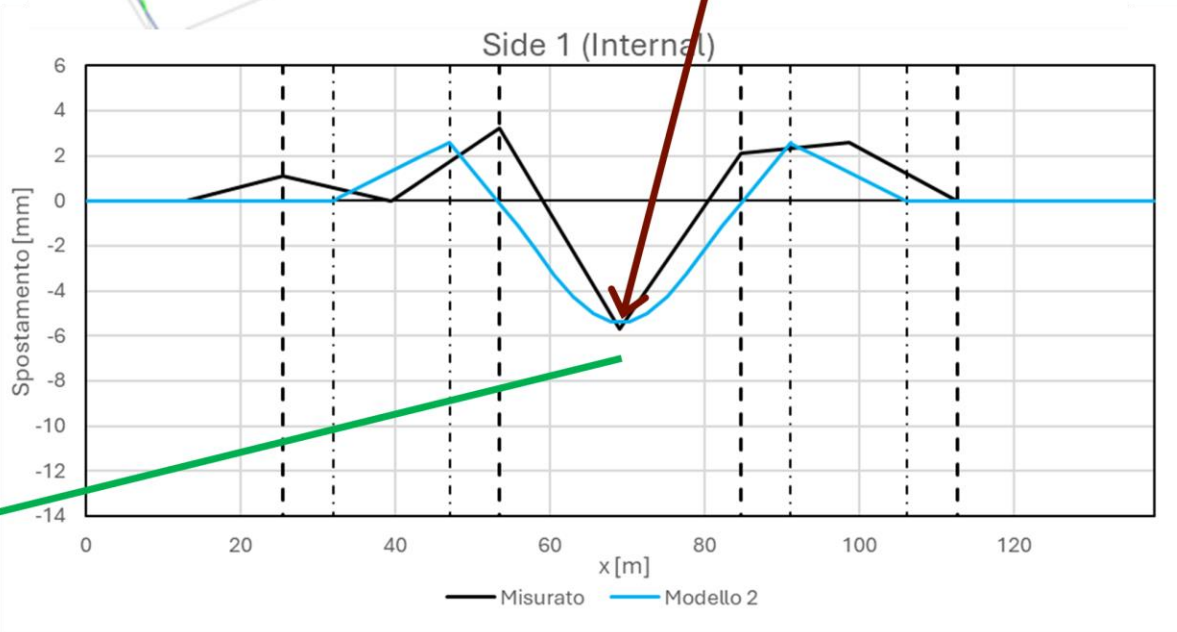




DIGITAL TWIN







PASSED Δ Max (**-5.79%**)

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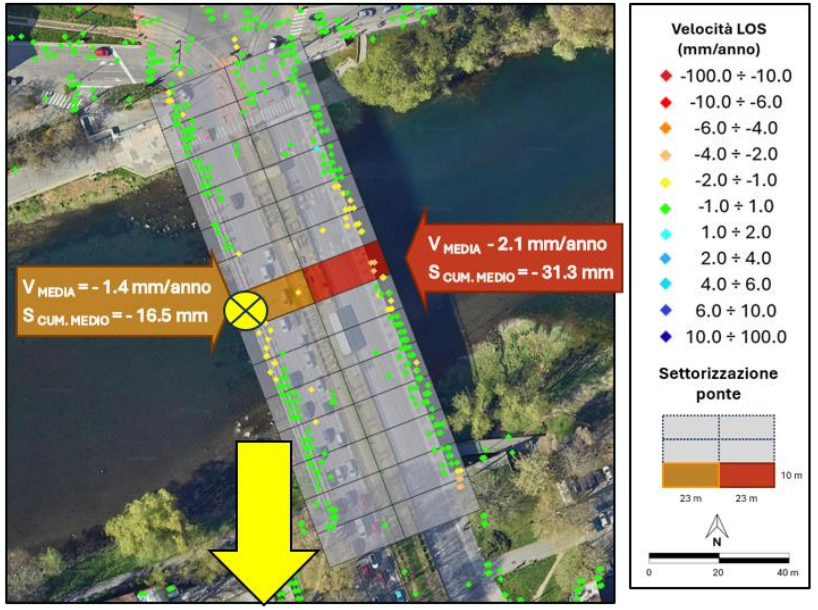
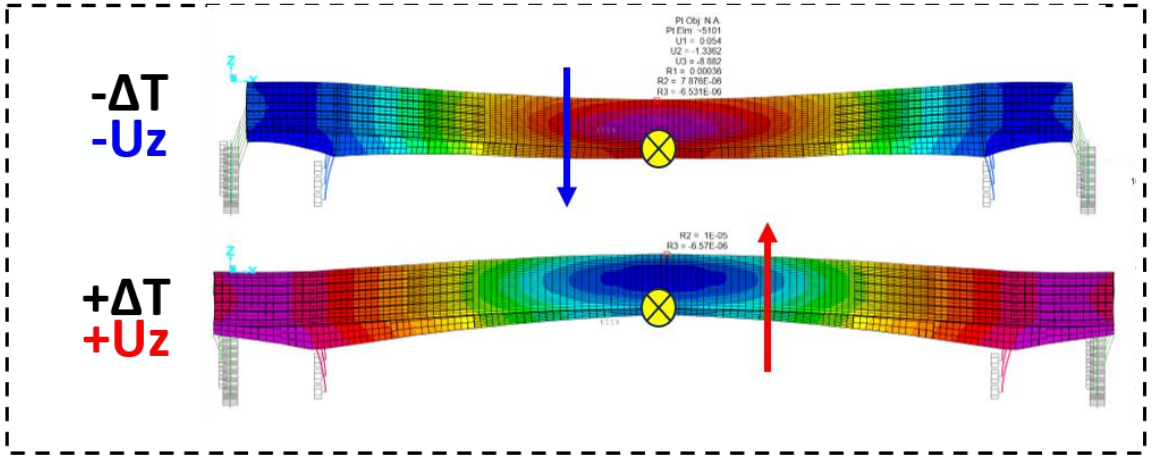
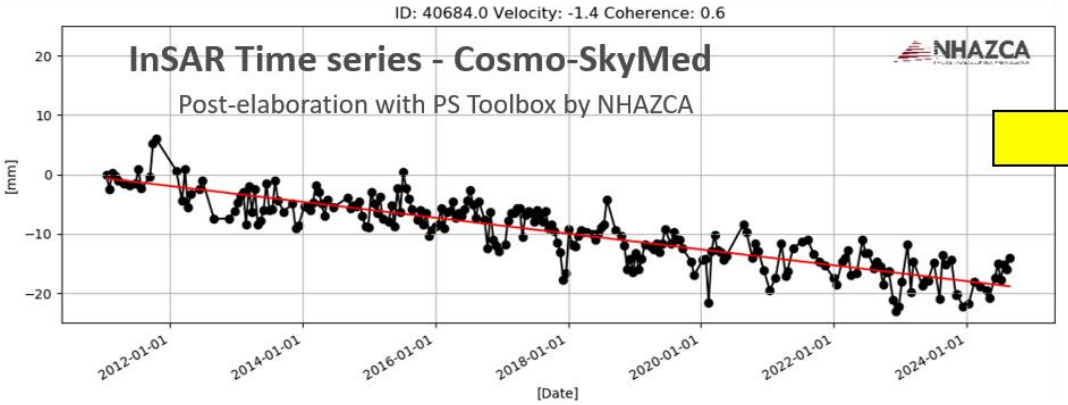
DISPLACEMENTS INDUCED BY TEMPERATURE VARIATIONS (ΔT)

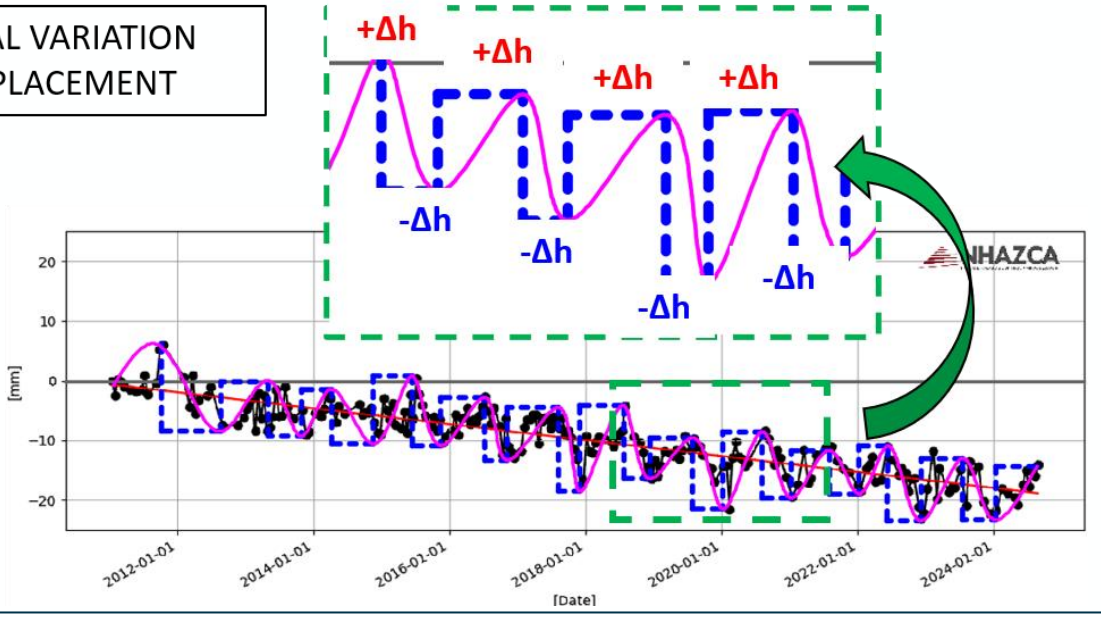


THERMAL LOAD VARIATION



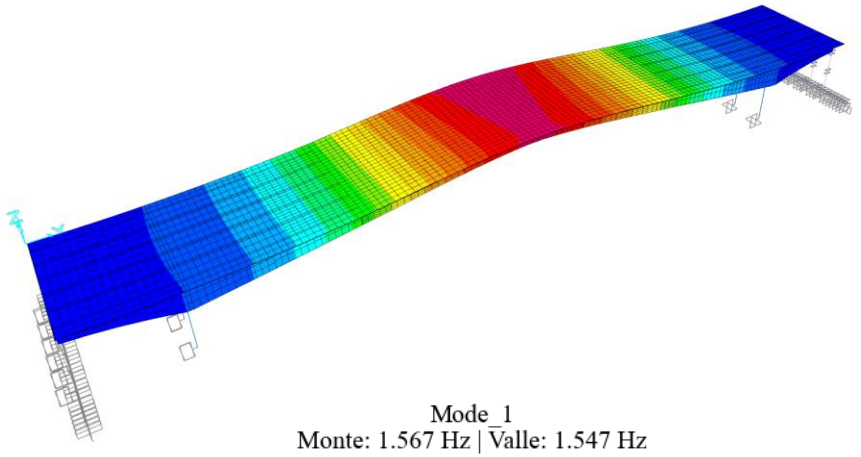
ΔT: UNIF. THERMAL VARIATION
Δh: VERTICAL DISPLACEMENT

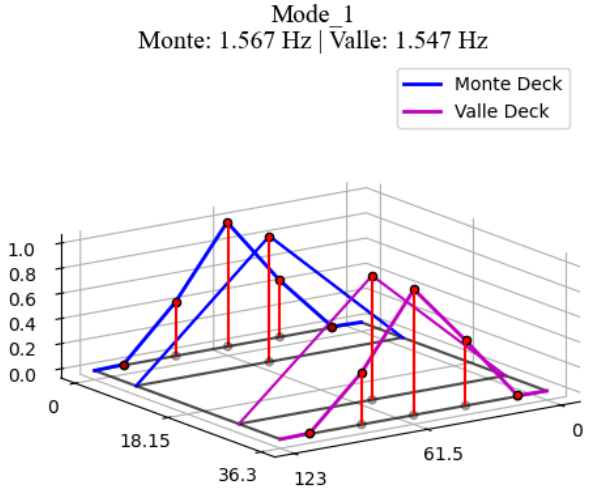




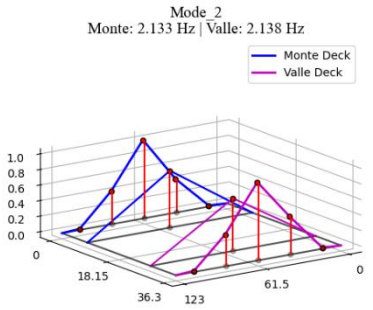
MODAL ANALYSIS: FEM CALIBRATED WITH ACCELEROMETERS DATA

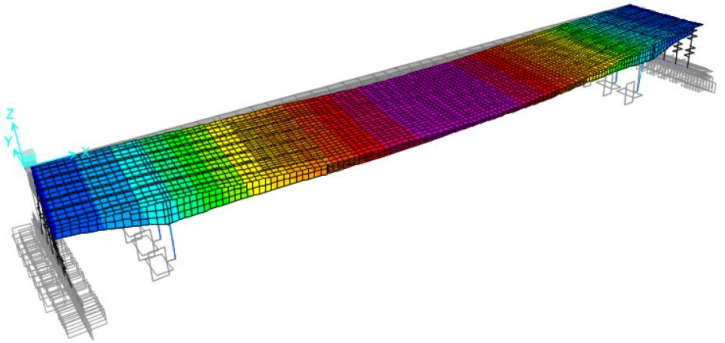
FEM – Mode 1 f = 1,559 Hz ; T = 0,641 s



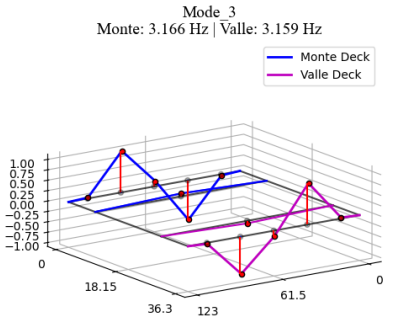


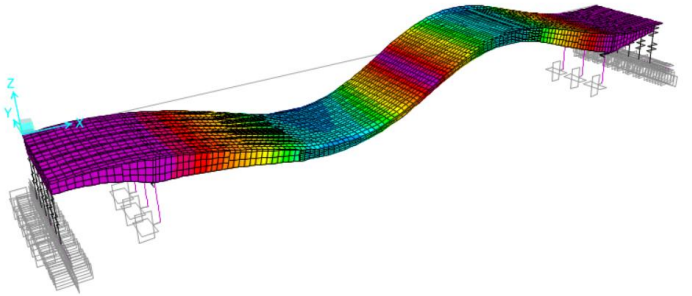
FEM – Mode 2 f = 3,153 Hz ; T = 0,317 s





FEM – Mode 3 f = 3,506 Hz ; T = 0,285 s





DISCUSSIONS

- **ISABHEL - ESA** founded project
- Continuous **structural health monitoring** and **smart asset management** of infrastructures (**two bridges in Tourin** - Italy)
- Datasets transmitted through **5G connection** to **processing/visualization platform**

- Ground deformations with **InSAR**
- Dynamic and Static behavior with **accelerometers and inclinometers**
- **Photomonitoring** for **change detection** and local **displacements**
- **FEM** of the bridges evaluated from projects and calibrated with collected data

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15 - 19 June 2026 | Auditorium Maximum of the Jagiellonian University, Kraków, Poland

FRINGE 2026

Thank you!

ID 205
DEM-EO Project
POSTER SESSION PO1
June 16 4:30pm – 7:00pm

ID 208
SGAM Project
POSTER SESSION PO2
June 18 4:30pm – 7:00pm

Booth

NHAZCA
NATURAL HAZARDS CONTROL AND ASSESSMENT

Emanuela Valerio - emanuela.Valerio@nhazca.com
Adriano Nobile - adriano.nobile@nhazca.com

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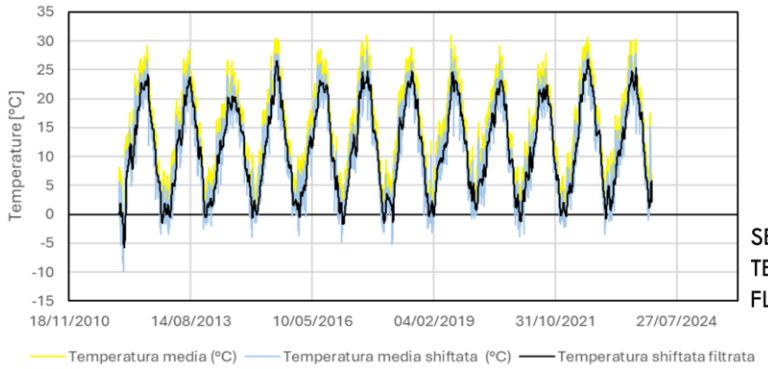
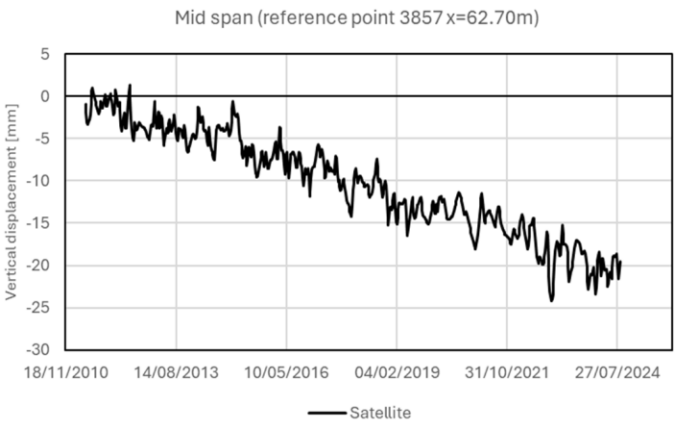
ANALYSIS OF THERMAL EFFECTS WITH SATELLITE DATA (SEASONAL VARIATIONS)

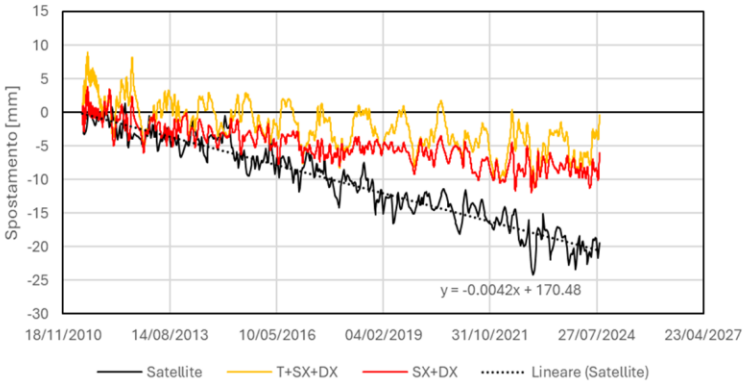


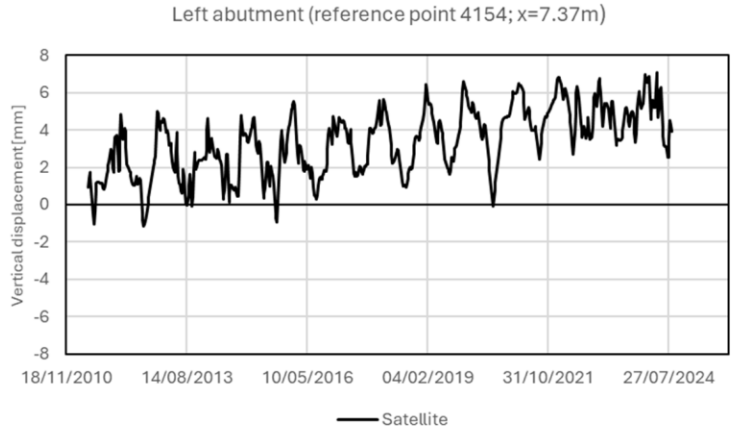
SEASONAL TEMPERATURE FLUCTUATION STUDY

SATELLITE DEFORMATION REGISTERED AT MIDSPAN

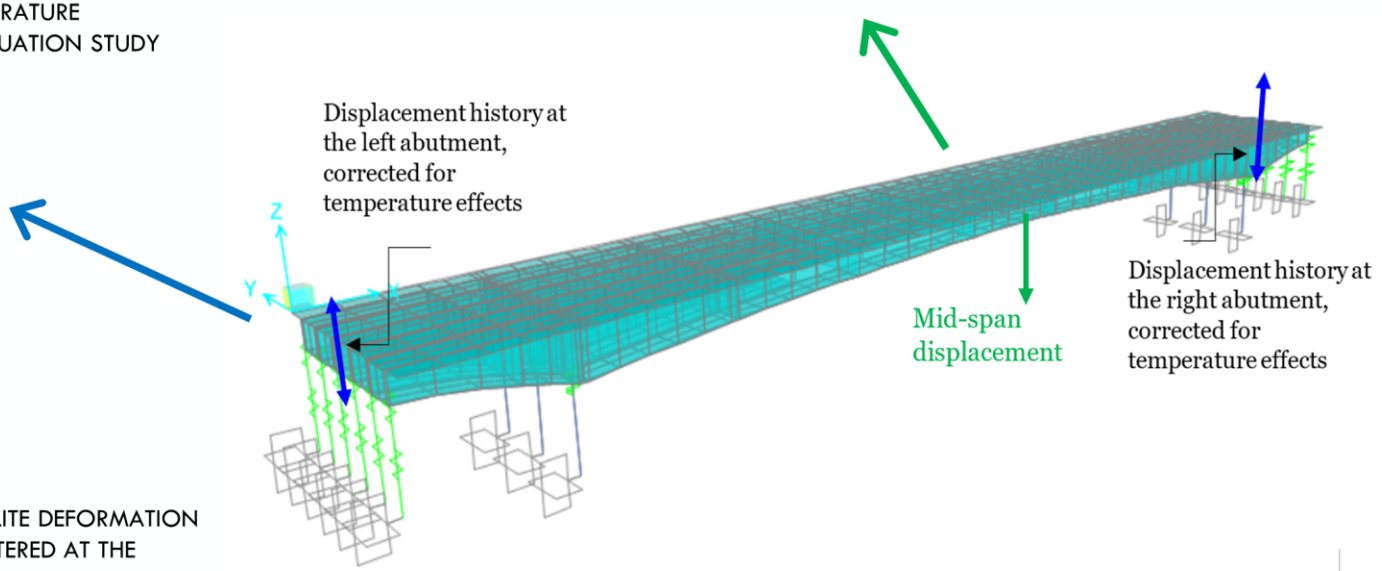


ΔT APPLICATION TO THE FEM MODEL





SATELLITE DEFORMATION REGISTERED AT THE ABUTMENTS



PHOTOMONITORING

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Processing time
(<1 min per analysis)

Image Registration Accuracy
(<1 pixel)

```
[10:06:44] - Change Detection started
[10:06:48] - Change Detection finished
[10:06:48] - Saving Change Detection Results
[10:06:58] - Analysis Completed
```

processing time for a single change-detection
~ 14 seconds

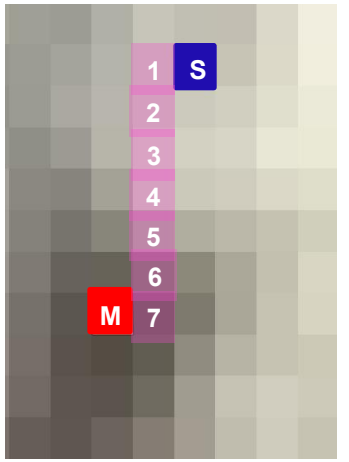
```
[10:12:16] - Analysis Started
[10:12:17] - Displacement Analysis started
[10:12:26] - Displacement Analysis finished
[10:12:27] - Saving Displacement Results
[10:12:42] - Analysis Completed
```

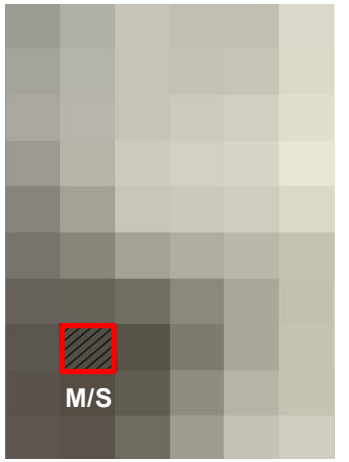
processing time for a displacement analysis
~ 26 seconds

STEP 1: Load two raw, non-coregistered images in QGIS and located easy to identify regions in both images

STEP.2: measure the offset between reference pixels

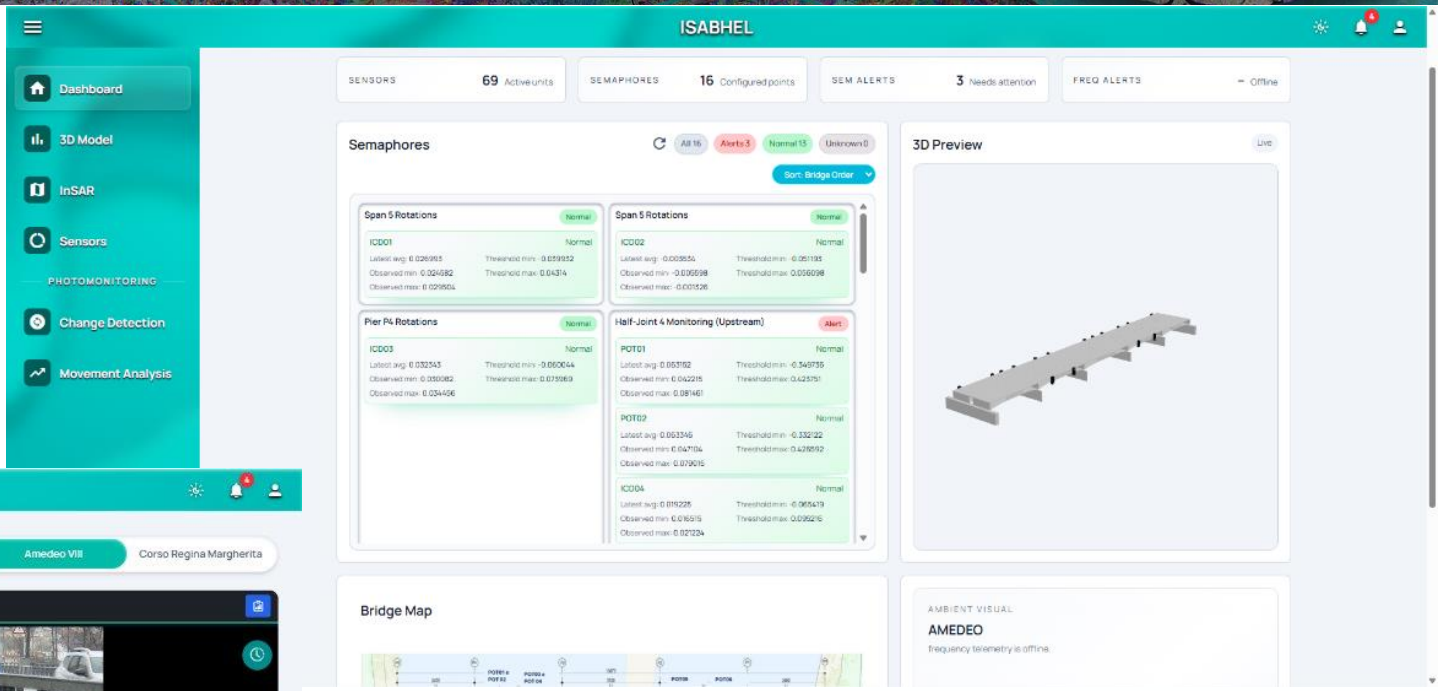
STEP.3: validate measurements with coregistered images

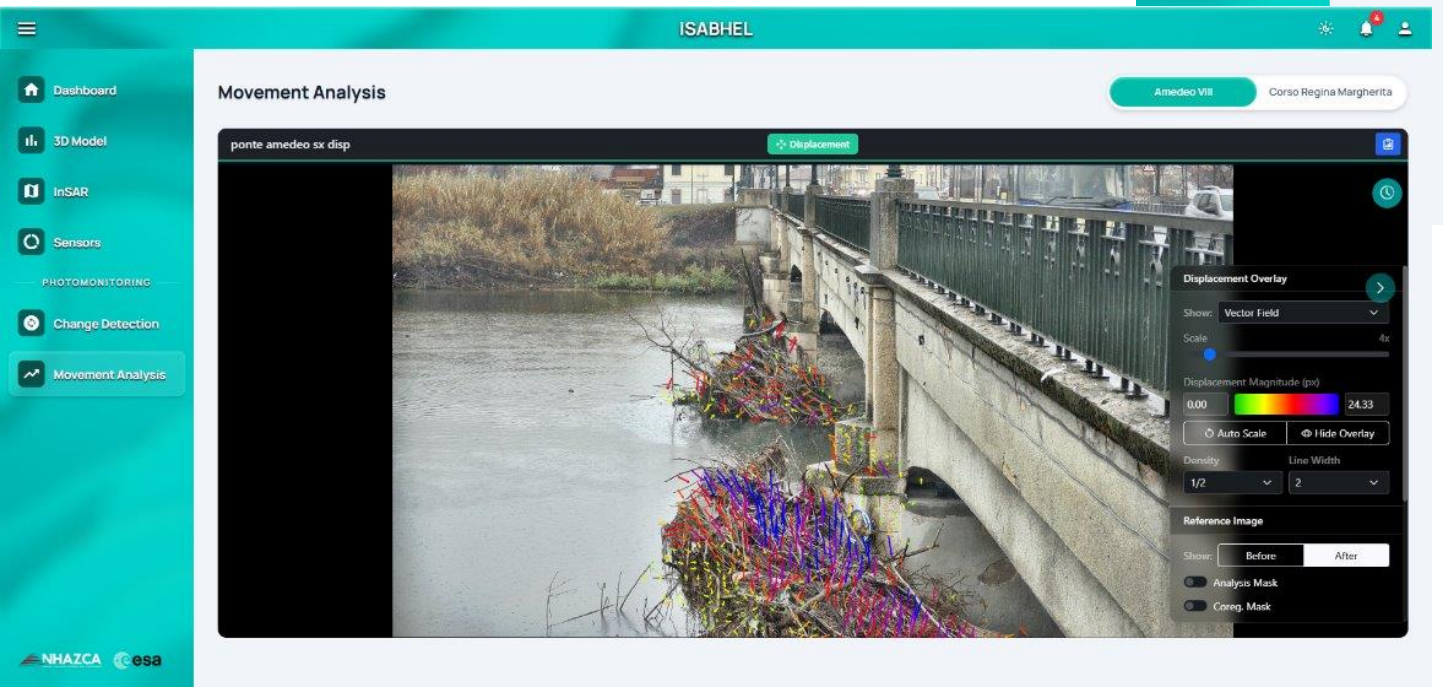




RESULTS: No discernible shift at the reference location indicates a residual offset below 1 pixel, confirming sub-pixel accuracy.

PLATFORM


ISABHEL
Dashboard
3D Model
InSAR
Sensors
PHOTOMONITORING
Change Detection
Movement Analysis
SENSORS 69 Active units
SEMAPHORES 16 Configured points
SEM ALERTS 3 Needs attention
FREQ ALERTS – Offline
Semaphores
3D Preview
Span 5 Rotations
Pier P4 Rotations
Half-Joint 4 Monitoring (Upstream)
Bridge Map
AMBIENT VISUAL
AMEDEO


ISABHEL
Dashboard
3D Model
InSAR
Sensors
PHOTOMONITORING
Change Detection
Movement Analysis
Movement Analysis
Amedeo VIII
Corso Regina Margherita
ponte amedeo sx disp
Displacement
Displacement Overlay
Show: Vector Field
Scale
Displacement Magnitude (px)
0.00
24.33
Auto Scale
Hide Overlay
Density
Line Width
1/2
2
Reference Image
Show: Before After
Analysis Mask
Coreg. Mask
NHAZCA
esa