ASECAP DAYS
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Celebrating 50 YEARS OF Successful TOLL ROAD PROJECTS

DIGITAL TECHNOLOGIES FOR BRIDGE DAMAGE DETECTION AND STRUCTURAL HEALTH MONITORING

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YAVUZ SULTAN SELIM BRIDGE AND NORTHERN RING MOTORWAY

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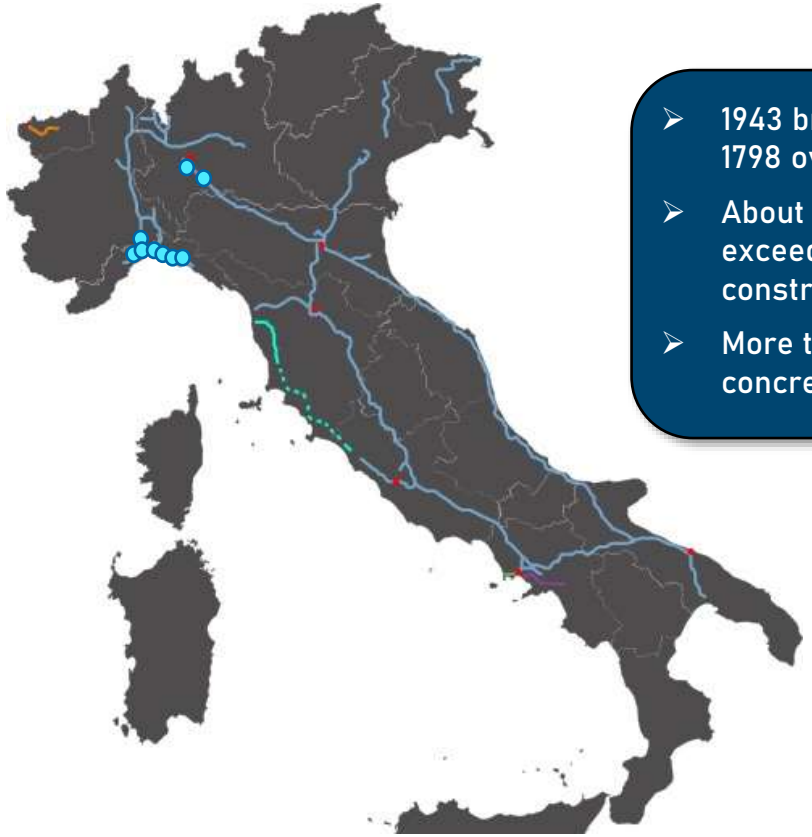
Bridges and overpasses: main challenges



- 1943 bridges and 1798 overpasses
- About 55% of bridges has exceeded 50 years since construction
- More than 90% of bridges are concrete bridges

Trends

Vulnerability of bridges to environmental actions - degradation of concrete and reinforcement corrosion

Current traffic loads higher than those foreseen in the design phase (dimensions, typologies and design speed of vehicles, etc.)

Average age of bridges increases: the heritage of national structures consists of bridges and viaducts built mainly between 1960-1980;

Exceptional actions can compromise the safety of bridges - earthquake, hydrogeological risk, landslide risk

For existing bridges, it is necessary to carry out an accurate phase of assessment of the health conditions

Integrating Structural Health Monitoring with Remote Visual Inspections

Visual inspections allow to observe the effect of damages on a structure

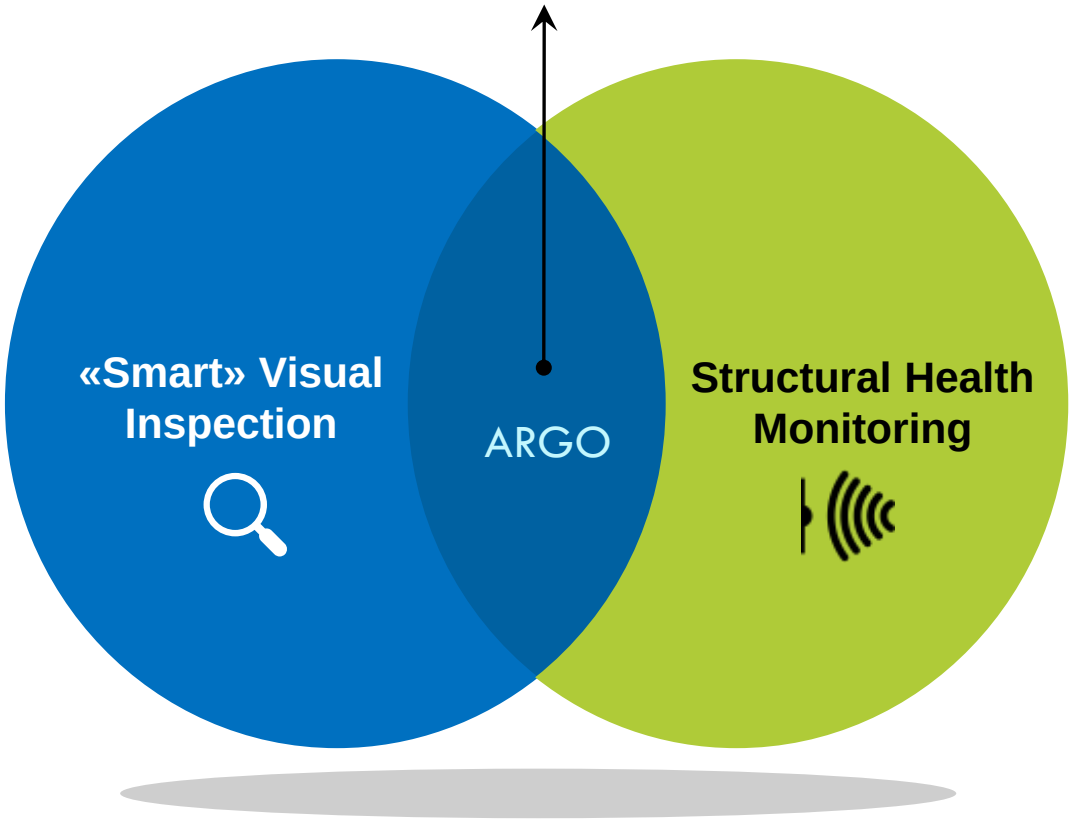
Visual inspections using drones can maximize damage identification quality and minimize costs as well as user safety

Visual inspections allow the detection of degradation phenomena on the external surface of the structure, which do not necessarily involve a change in the structural behavior

Visual inspections can be made more efficient through the use of drones and a digital twin of the bridge

Predictive Maintenance

Correlation of all information relating to a single structure (historical data, geometry ..) with those from other structures on the network



Monitoring systems allow to continuously analyze the behavior of the structure through the measurement of structural parameters detected by sensors

Structural monitoring can allow to identify variations in the behavior of the structure, which are not always easily found with visual inspection

Structural Monitoring allows the assessments of the health state of a structure based on measurable and objective parameters

SHM can allow an evaluation of the structural safety over time through the construction of lifetime curves

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Structural Health Monitoring

Goals and approaches

REDUCTION OF UNCERTAITIES

Installing a continuous monitoring systems allows to

- Increase the knowledge of the structures' operating conditions;
- Update risk estimation by using reduced safety coefficients in the assessment stages

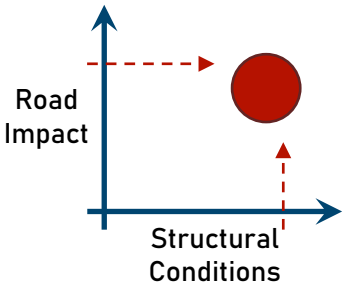
STRUCTURE CONDITION EVOLUTION OVER TIME

The installation of a continuous monitoring systems allows to record the structure's condition evolution over time (evolution of degradation, active loads,…), so to:

- Reduce the visual inspections frequency;
- Postpone interventions;
- Optimize maintenance cycles planning

PRIORITIZE MAINTENANCE INTERVENTIONS

Structural monitoring is used on selected structures according to their structural condition (defectiveness, age, structural typology,…) and the strategical relevance of the highway (traffic, accessibility,…), to optimize and prioritize local and global maintenance intervention.



Strategic goals are pursed by monitoring both DEMAND, which are the actions acting on the structure, and CAPACITY.

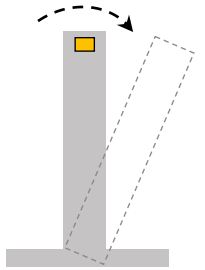
STRUCTURAL MONITORING

Monitoring Strategies

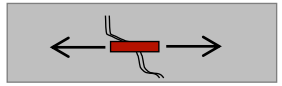
PRE-ASSESSMENT MONITORING, following visual inspections, using DATA-DRIVEN strategy

- ❑ No numerical model of the structure; monitoring relies on observing variations of the structural behavior starting from the system's installation moment.
- ❑ Monitoring of specific defects present in the structure (e.g., crack openings, ...).
- ❑ Monitoring aimed at reducing uncertainties regarding the functionality of the structure (types of constraints, functionality of supports, consistency of behavior).

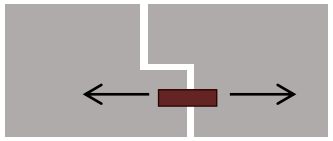
Pile rotation monitoring

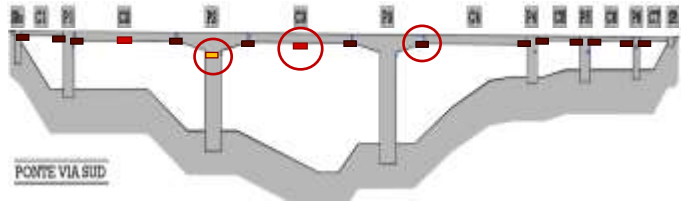


Crack monitoring



Joints or bearing monitoring

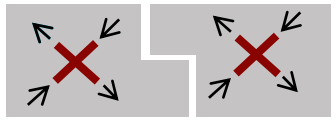




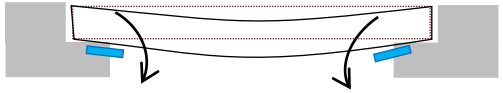
POST-ASSESSMENT MONITORING, following structural assessment, using MODEL-BASED strategy

- ❑ Numerical model of the structure available; comparison with the theoretical response.
- ❑ Monitoring, both local and global, to assess the structure's condition compared to possible limit states.
- ❑ Monitoring aimed at reducing uncertainties related to the interpretation model of the structure and the characteristics of materials.

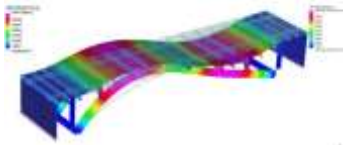
Strain monitoring

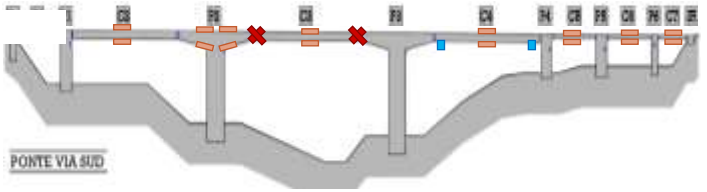


Displacement / rotation monitoring



Dynamic monitoring





The monitoring strategy aims to limit the number of collected data, which means easier information management and interpretation.

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STRUCTURAL MONITORING

ASPI monitoring approach

SENSORS ON STRUCTURES

- Bridges
- Tunnels

The ASPI's monitoring plan involves the installation of sensors for both static and dynamic monitoring of bridges and tunnels.

WEIGH IN MOTION

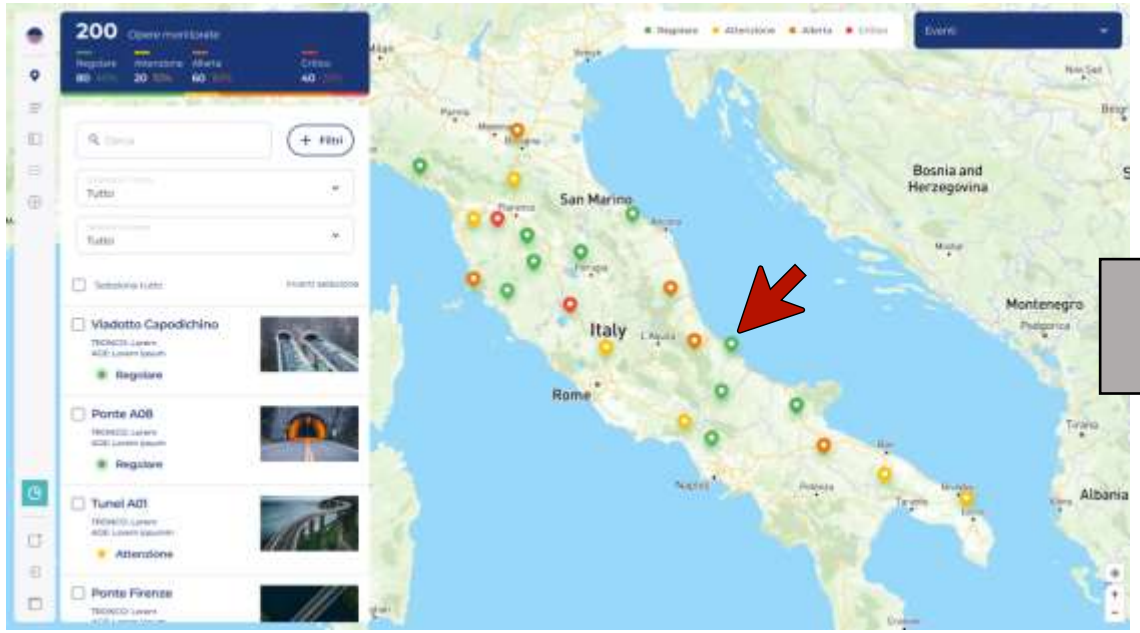
- Weigh-in-motion systems
- Integration with sensors on bridges

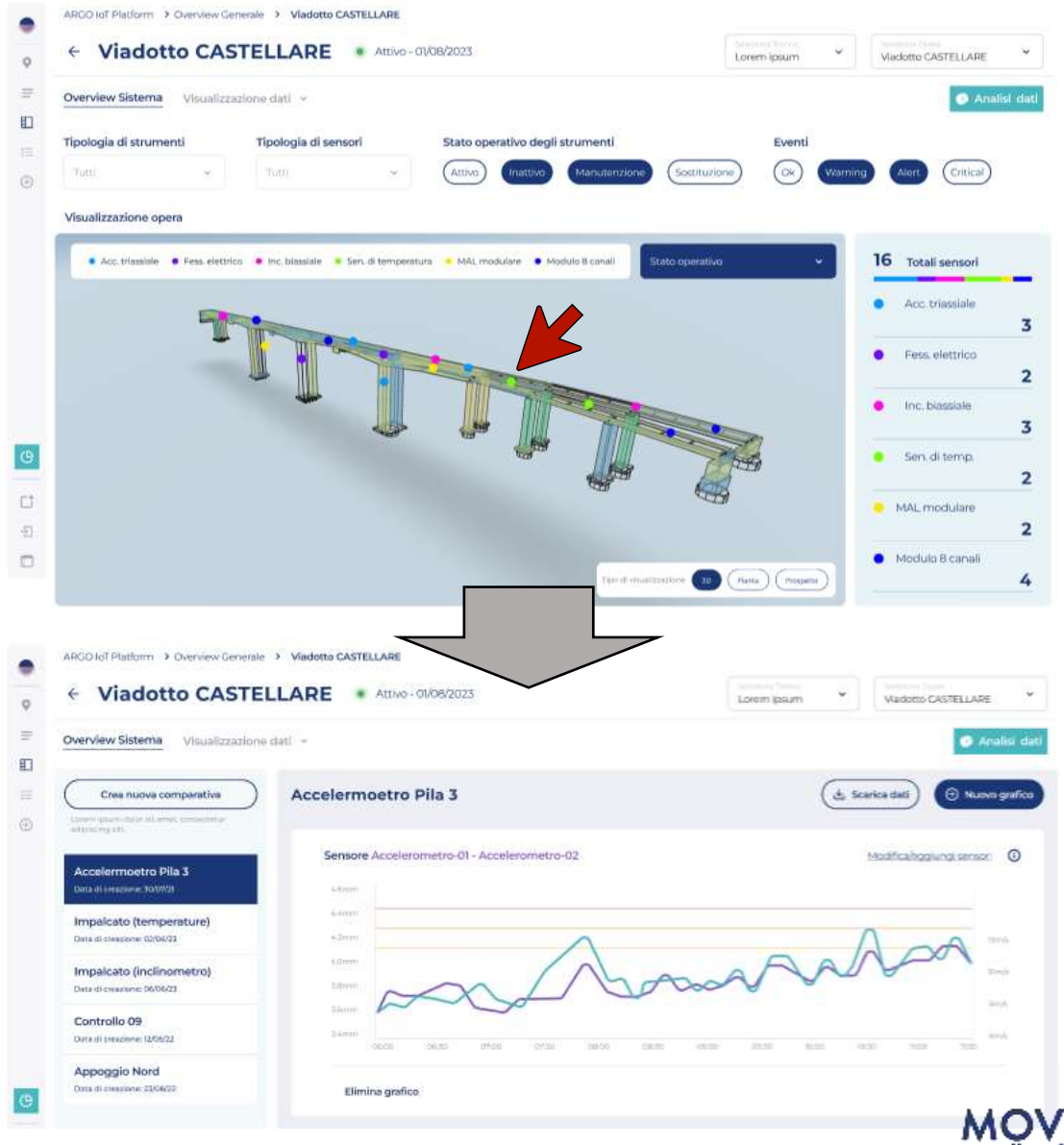
Installation along the network and near the monitored structures of weight in motion systems, for input-output correlation with monitoring data.

Weight in motion Monitored bridges

STRUCTURAL MONITORING

ARGO IoT Platform





- IoT monitoring platform which offers cost-effective end-to-end solution all the way from sensors on the bridge, which are continuous measuring, to high-speed data transfer to data lake for analytics, visualization and decision support.
- Well-designed user application for advanced visualizations, which allow a quick deep dive from general overview of the network to local analysis of each single sensor.

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Reimagining Bridge Inspection with Digital Twins and AI

Main Advantages

- Reimagine bridge inspections using a technology that allows to bring the bridge “into the office” and carry out remote and safe inspections
- Collect high-definition images of hard-to-reach bridge components and apply AI to support inspectors
- It is possible to observe and measure the evolution of defects over time
- Limited impacts on traffic, operations and a higher level of security.

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DRONES

Reimagining Bridge Inspection with Digital Twins and AI

DRONES

Reimagining Bridge Inspection with Digital Twins and AI

Creation of a structure's digital twin on which identify possible defects

- Visualize a high-resolution digital twin using multi-resolution technology
- Performing linear and areal measurements
- Insert notes directly on the 3D structure
- Visualize an initial set of defects suggested by an artificial intelligence

A sub-set of structures have been selected to be inspected cyclically with drones. The structures were chosen considering:

- Accessibly of the structure: particularly high structures
- Structural typology
- Defects: structures with the most recurrent defects on concrete, to be used to train AI algorithms
- Geographical context: clusters of structures in representative context

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THANK YOU

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