Autonomous Robot System for Monitoring and Cleaning of Bridges

iit InBot
ISTITUTO ITALIANO DI TECNOLOGIA

CAMOZZI GROUP

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UNIVERSITÀ POLITECNICA DELLE MARCHE

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UBISIVE

Autonomous Robot System for Monitoring and Cleaning of Bridges

F. Cannella G. **Marchello**

Industrial Robotics Facility
Italian Institute of Technology
Genoa - Italy


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Italian Institute of Technology

Autonomous Robot System for Monitoring and Cleaning of Bridges

NATIONAL BRIDGE PRESERVATION CONFERENCE 2024
BRIDGE PRESERVATION INNOVATION FOR INFRASTRUCTURE RESILIENCY
SEPTEMBER 9th-13th, 2024 GRAND AMERICA HOTEL SALT LAKE CITY, UTAH

Development and Deployment

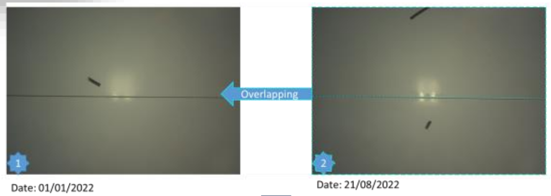
2018-2021

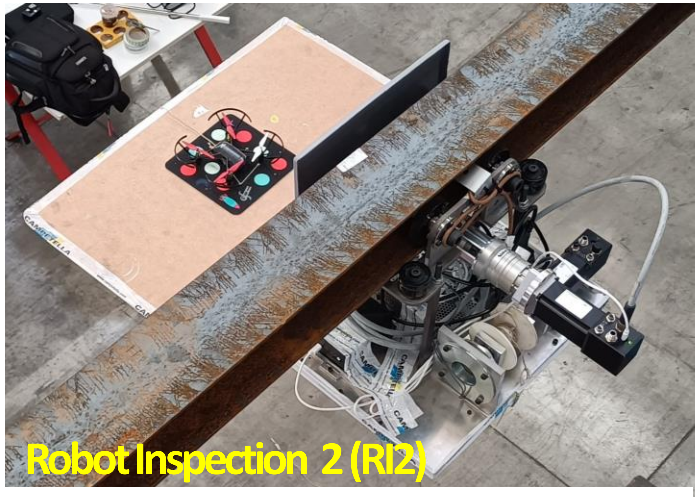
2021-ongoing

Mobile System

RINGHIO
(Robot for Inspection and Navigation to Generate Heritage and Infrastructures Observations)

Vision System





2021-2022 … …2023-ongoing (hope…A lot!!!)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Outline

- *Who we are*
- *Why these robots?*
- *Which robots' features?*
- *Who build them?*
- *How they work?*
- *How have been "smoothed" the mechanical and civil coupled?*
- *What will be the future perspectives?*


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Istituto Italiano di Tecnologia - IIT

Headquarter

Genoa (Italy)

- 32.000 sqm fully equipped
- approx. 1100 scientists and staff people
- one of the largest single site lab in Europe

Other Centers

(Genoa, Italy and USA)

- 17 centers
- approx. 1500 scientists and staff people

Source: https://www.iit.it/en/



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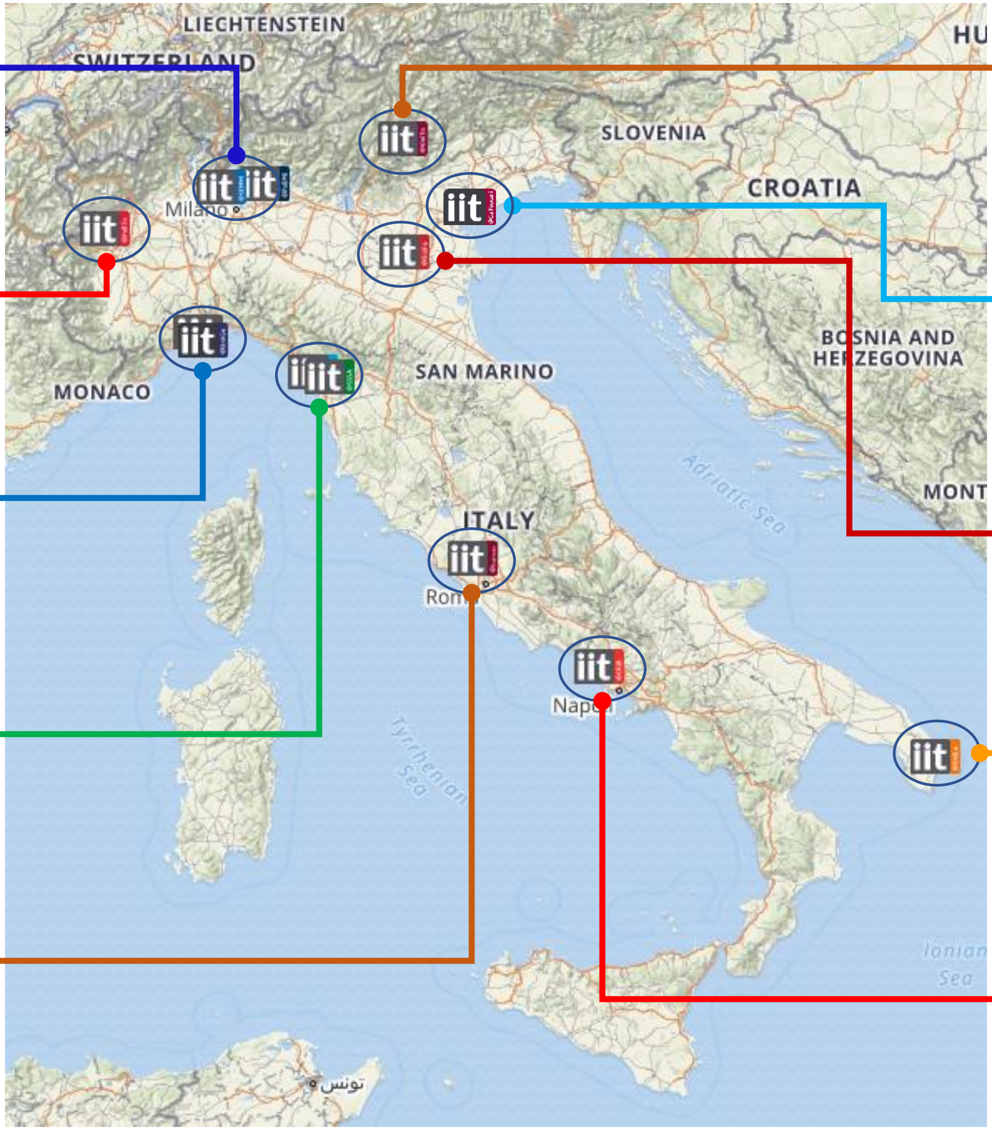
CGS@SEMM Milano
CNST@PoliMi Milano


CSFT@Polito Torino


CRIS, CHT@Erzelli, CJIR, NSYN@Unige Genova


CMBR@SSSA Pisa
CNI@NEST Pisa


CLNS@SAPIENZA Roma




CNCS@UniTn Trento


CCHT@Ca' Foscari Venezia


CTNSC@UniFe Ferrara


CBN@UniLe Lecce


CABHC@CRIB Napoli

Source: https://www.iit.it/en/web/guest/centers

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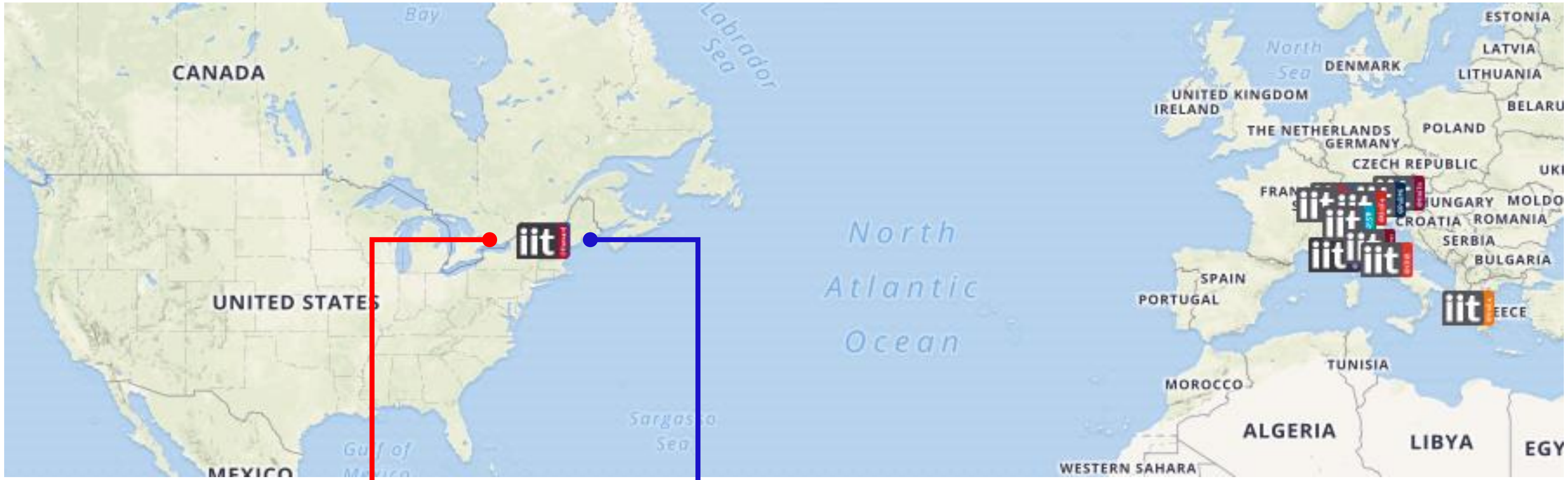

IIT@HARVARD USA

LCSL@MIT USA

Source: https://www.iit.it/en/web/guest/centers

 

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Istituto Italiano di Tecnologia - IIT

IIT's research results aim to benefit humanity and promote prosperity by transferring knowledge and technologies to society and industry
IIT overarching priority is to develop Human-Centered Science and Technology with a multidisciplinary approach that merges different skills and expertise.

20.2k+ Publications	66 ERC	1335 Patents	1817 Projects

Strategic plan

IIT's scientific activity is based on a strategic plan, updated every six years

The 2024-2029 Strategic Plan prioritizes **Artificial Intelligence for Healthcare and Earthcare**. It is organized into four research domains: Computational Science, Life Technologies (LifeTech), Nanomaterials, and Robotics. Each research domain consists of independent research units, each led by a principal investigator, and it is supported by state-of-the-art facilities.

Computational Sciences
Our focus is on massive simulations of physical systems, repeated to generate robust statistics, and mining vast datasets to identify explanatory patterns.

LifeTech
We are dedicated to developing advanced genetic, molecular, electrophysiological, computational, imaging, and perturbation tools aimed at dissecting the biological processes underlying brain function and RNA physiology.

Nanomaterials
Our research includes new sustainable/biodegradable materials, nanocomposites, 2D materials, nanofabrication technologies and nanodevices, and new colloidal chemistry approaches.

Robotics
We advance the state of the art by developing new robotic hardware and software in platforms for rehabilitation, prosthetics, surgery, agriculture, disaster recovery, industrial, and space applications.

Source: https://www.iit.it/en/web/guest/our-research


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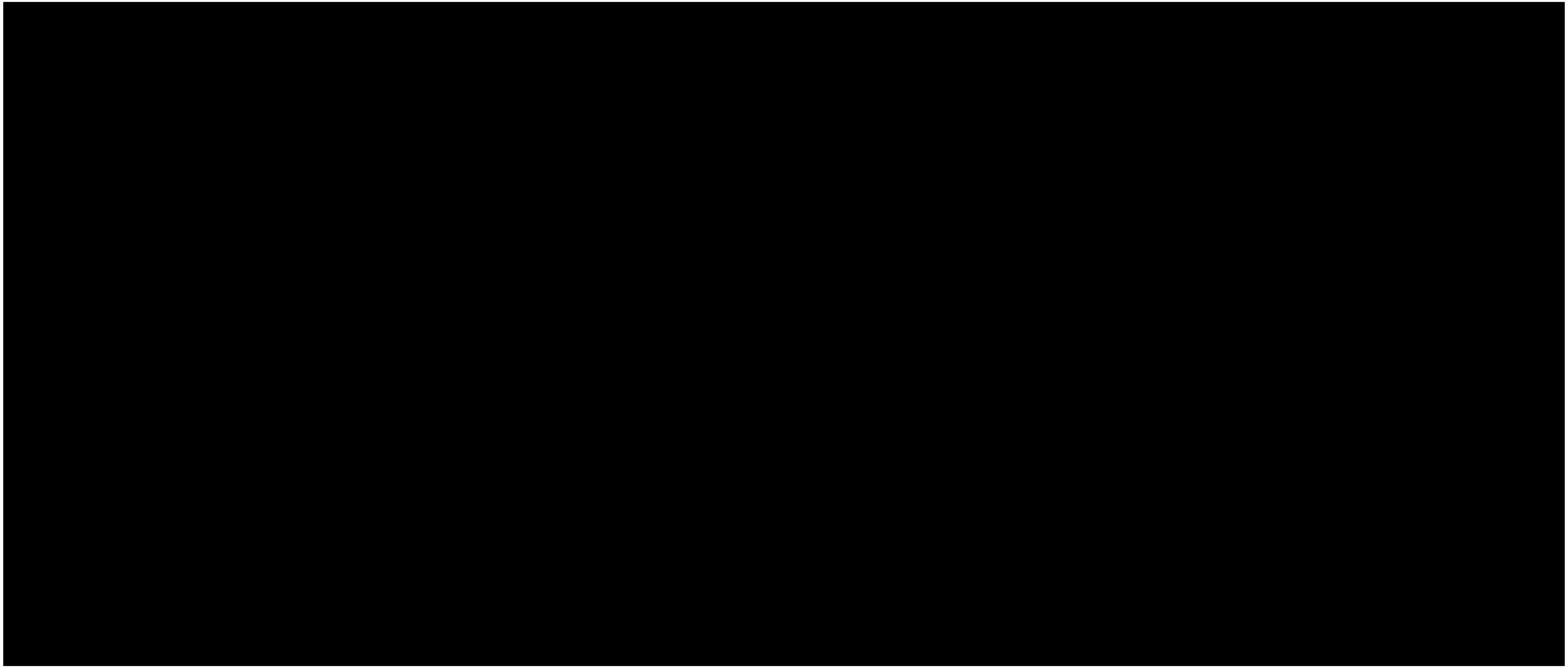
Research



Source: https://www.youtube.com/watch?v=OnikO_T_kEk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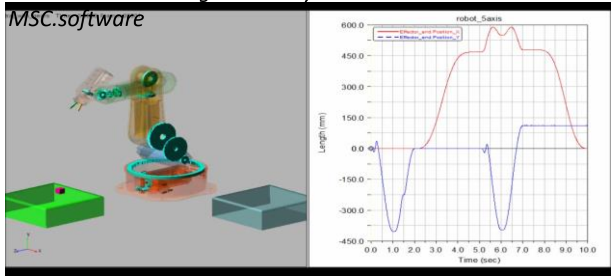
Industrial Robotics Facility (InBot – IIT)

Production Process TRL9 - Courtesy: Novacart

Numerical Modelling - Courtesy: MSC.software



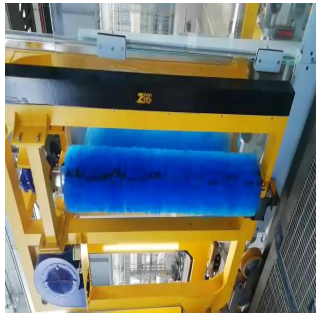
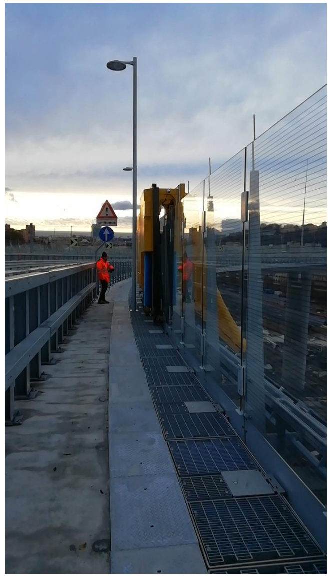
Robotic Manipulation

Industrial/Civil
Robotic/Automation
Research and Applications

Flexible Material Manipulation and Sewing

Archeolgical Site (Pompeiii) Autonomous Monitoring System


Monitoring Robots

Maintenance Robots

Source: https://inbot.iit.it/

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Why these Robots?


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Morandi's Bridge (Polcevera River Bridge) of Genoa – Open on 1967

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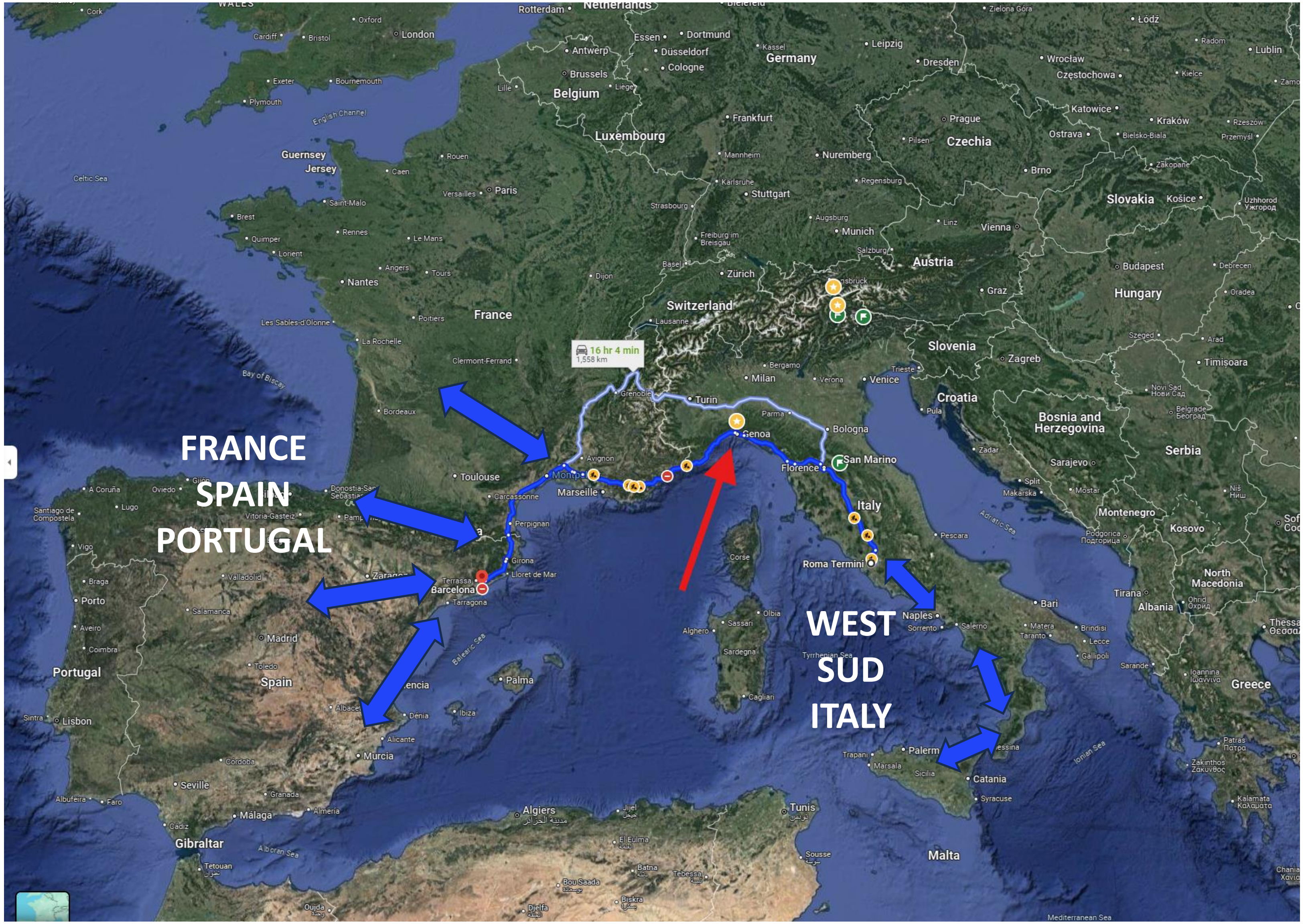

50.000 vehicles per day!
[Secolo XIX 8th.Aug.23]

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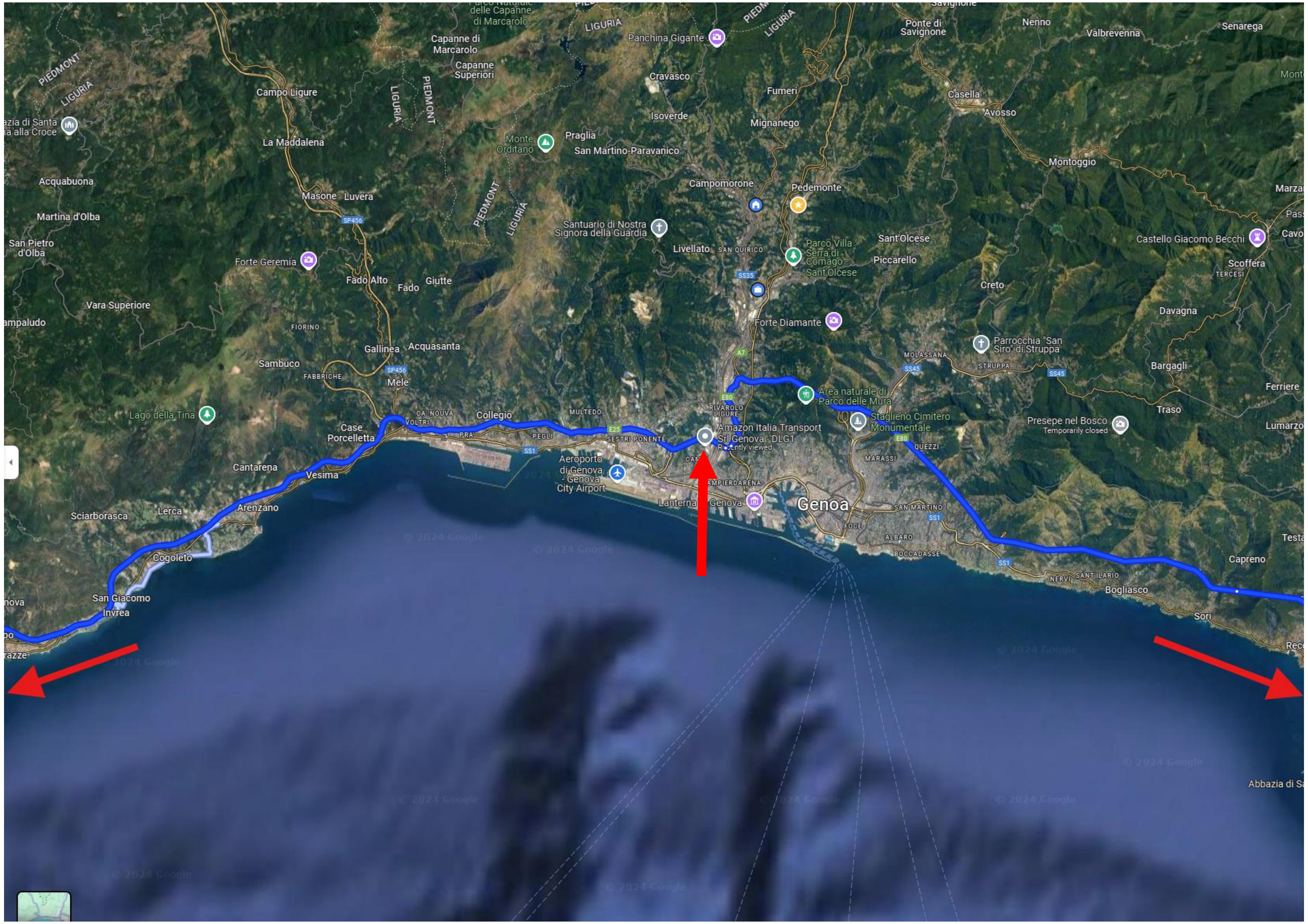

FRANCE
SPAIN
PORTUGAL

WEST
SOUTH
ITALY


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FRANCE
SPAIN
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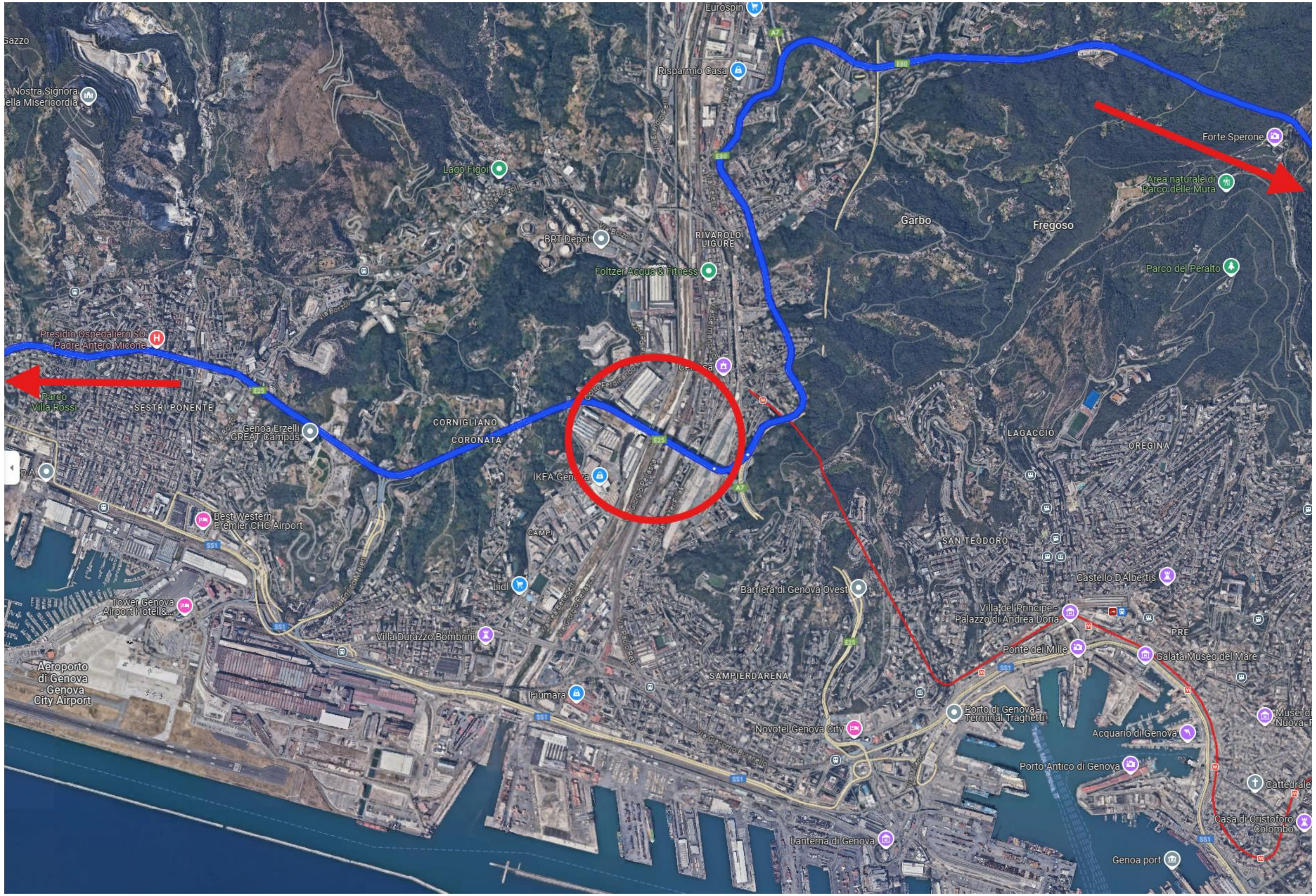


WEST
SOUTH
ITALY

Autonomous Robot System for Monitoring and Cleaning of Bridges

Pre-stressed concrete tendons to be applied to the bridges was the newest idea of Morandi's

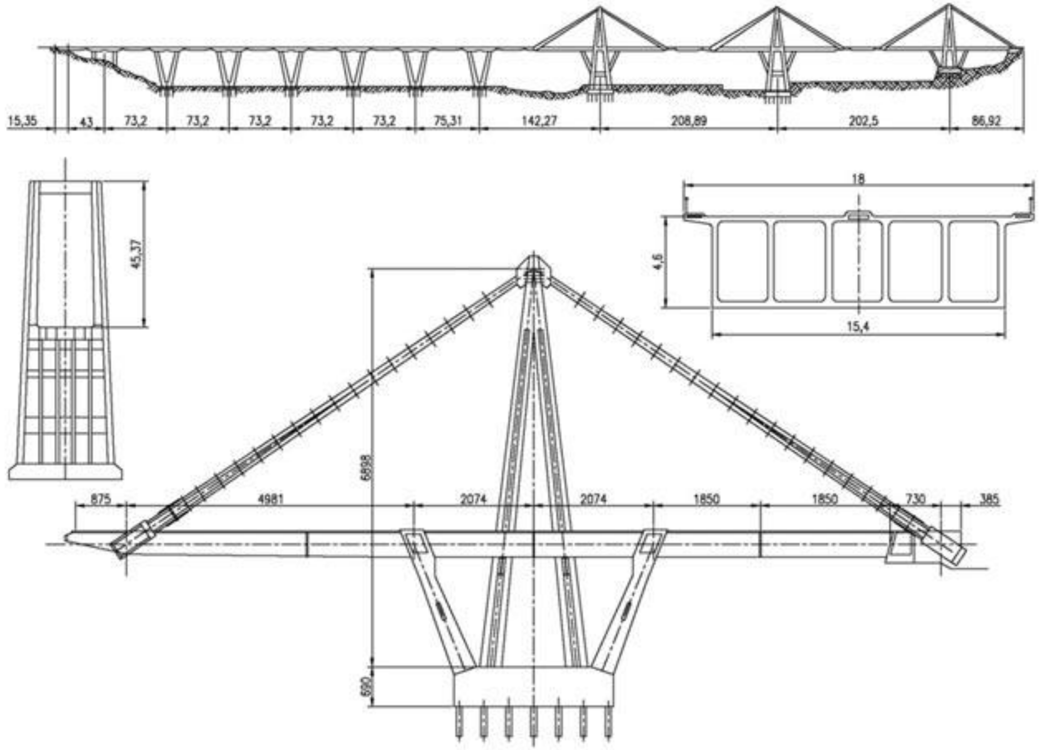
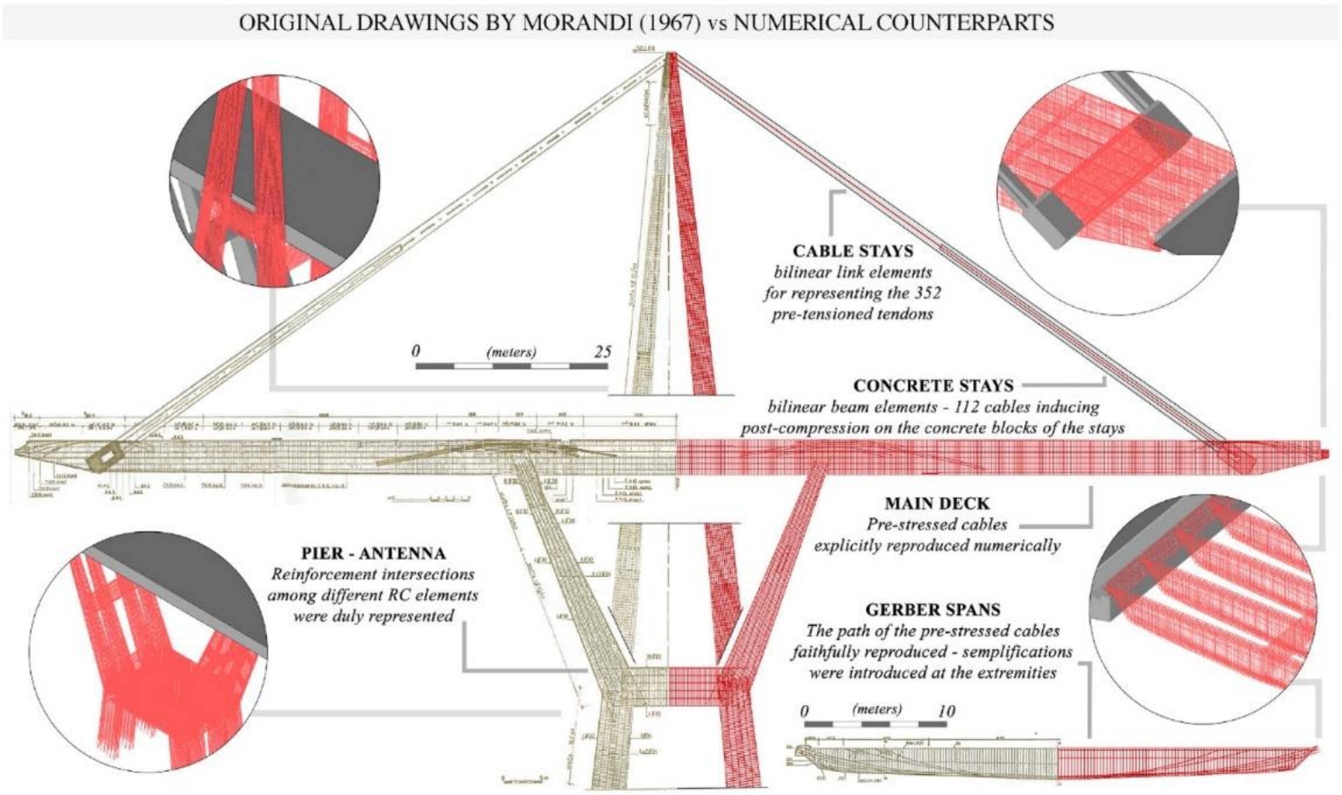


Figure 29. The Polcevera Bridge (1960–1964): general view of the bridge, an A-shaped frame, the antenna and the typical section of the deck.

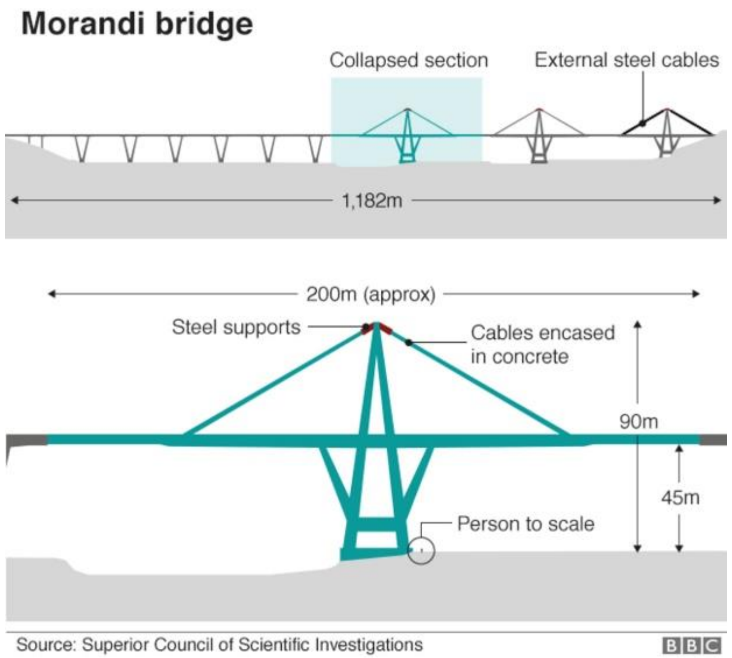


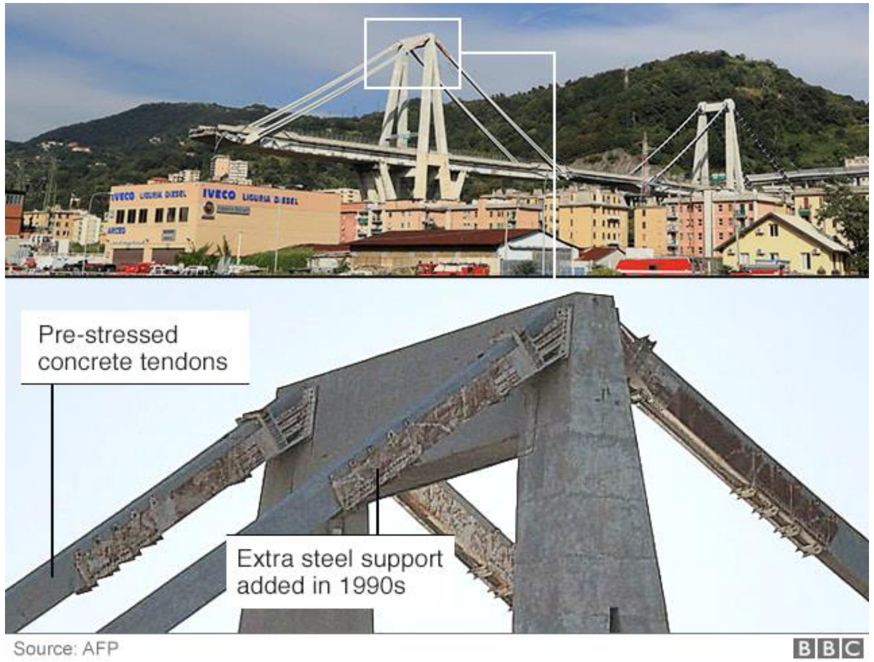
C. Gabriele - Terotechnologist expert in maintenance and road management 21/08/2018

D. Malomo et al., Numerical Study on the Collapse of the Morandi Bridge J. Performance of Constructed Facilities, 2020

Autonomous Robot System for Monitoring and Cleaning of Bridges

The final cause of collapse was the Southern Cable Failure of Pillar 9, but the Morandi's bridge was reportedly **undergoing maintenance** at the time of the collapse, including strengthening the road foundations





Pillar 9 cable reinforcement with extra steel support, to cope the damages of the concret

The black spots that <u>are believed</u> to be spot repairs to the concrete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Opened: September 4, 1967 (**Construction started:** 1963)
Total length: 1,012 m, (0.629 mi)
Width: 18 m (59 ft)
Height: Piers 90 metres (300 ft), Road Deck 45 metres (148 ft)
Engineer: Riccardo Morandi

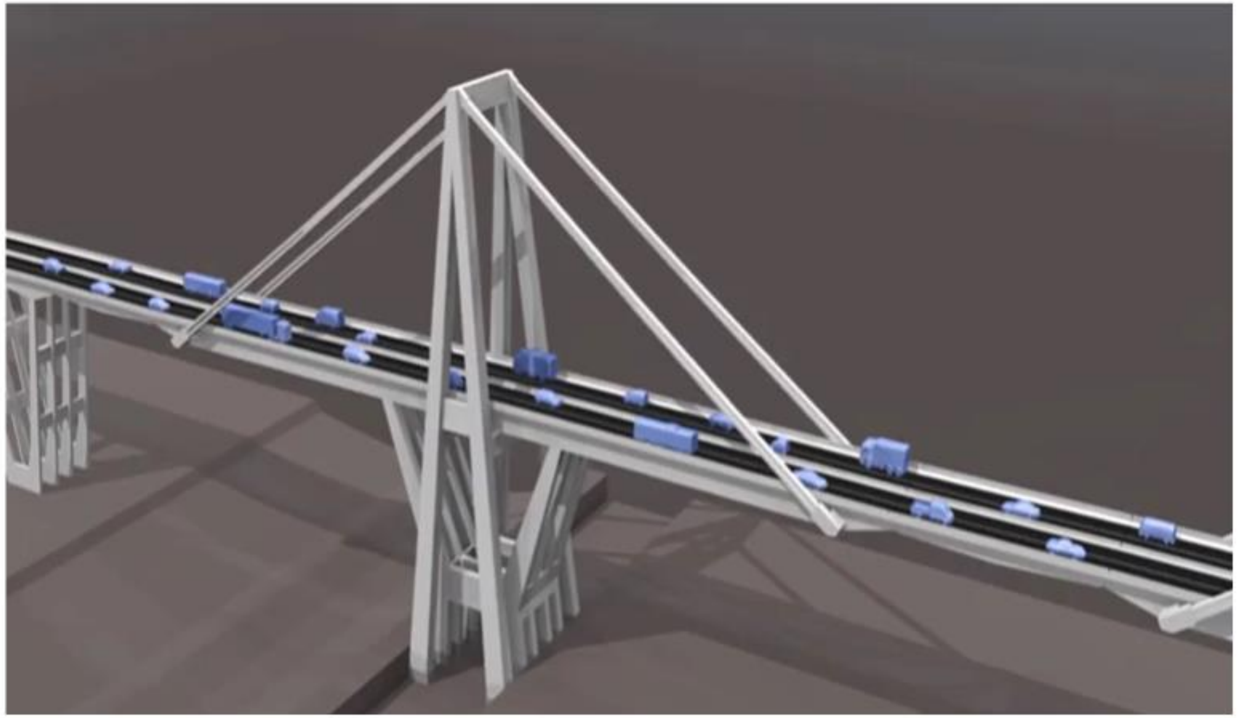
Morandi's bridge collapse


Morandi's Bridge before and after the collapse of the Pillar 9
(14th August 2018 at 11:36am with 43 victims and 16 injuries)

Autonomous Robot System for Monitoring and Cleaning of Bridges

The final cause of collapse was the Southern Cable Failure of Pillar 9, but the Morandi's bridge was reportedly **undergoing maintenance** at the time of the collapse, including strengthening the road foundations

Pillar 9 that collapsed



Numerical simulation
(there is not any clear recorded videos)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Opened: August 4, 2020 (**Construction started:** June 25, 2019)
Total length: 1,067 m, (0.663 mi)
Width: 36 m (118 ft) with solar panels
Height: Piers 45 metres (150 ft), Road Deck 50 metres (151 ft)
Architect: Renzo Piano

San Giorgio's bridge building

High Tech Structure: >240 sensors!!!

Very Efficiency in Building: <24 months!

"Simple but not trivial. A steel bridge, safe and durable. Because bridges do not have to collapse."
[Renzo Piano]

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State of the Art (up to 2018)

Articles About 17,000 results (0.04 sec)

Any time
Since 2024
Since 2023
Since 2020
Custom range...
1900 — 2018
Search

Sort by relevance
Sort by date

Any type
Review articles

include patents
include citations

Create alert

Review of **robotic infrastructure inspection** systems
D Lattanzi, G Miller - Journal of **Infrastructure** Systems, 2017 - ascelibrary.org
… This paper presents a survey of efforts in **infrastructure inspection robotics** over the past two decades. Technical considerations for the design of **robotic** systems are examined, followed …
Save Cite Cited by 244 Related articles All 4 versions

A multi-functional **inspection robot** for civil **infrastructure** evaluation and maintenance
S Gibb, T Le, HM La, R Schmid… - 2017 IEEE/RSJ …, 2017 - ieeexplore.ieee.org
… inspired several efforts to automate **inspection** processes and replace human … civil **infrastructure inspection** jobs. In this paper, we develop a multi-functional autonomous **inspection robot**…
Save Cite Cited by 31 Related articles All 3 versions

A mobile **robot** for automated civil **infrastructure inspection** and evaluation
L Van Nguyen, S Gibb, HX Pham… - … , and Rescue **Robotics** …, 2018 - ieeexplore.ieee.org
… on our **inspection robot** to automate the data collection and processing, which is a significant new addition to our **robotic inspection** system as it has not been deployed for **inspection** in …
Save Cite Cited by 19 Related articles All 3 versions

Autonomous **robot** system for **inspection** of defects in civil **infrastructures**
RG Lins, SN Givigi, ADM Freitas… - IEEE Systems …, 2016 - ieeexplore.ieee.org
… number of **robotic** systems that have been developed for **inspection**. In [12], a **robotic** system … to map abandoned mines and **inspect** hazardous environments was developed. In [13], …
Save Cite Cited by 54 Related articles All 3 versions

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Autonomous Robot System for Monitoring and Cleaning of Bridges

x5!!!!
6 years!!!

State of the Art (up to 2024)

Articles — About 93,200 results (0.15 sec)

Any time
Since 2024
Since 2023
Since 2020
Custom range...

Sort by relevance
Sort by date

Any type
Review articles

☐ include patents
☑ include citations

Create alert

Review of robotic infrastructure inspection systems
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Save Cite Cited by 244 Related articles All 4 versions

[HTML] Survey of robotics technologies for civil infrastructure inspection
AJ Lee, W Song, B Yu, D Choi, C Tirtawardhana... - Journal of Infrastructure ..., 2023 - Elsevier
... **infrastructure inspection**, including several **robot** systems and techniques. After reviewing the state-of-the art **infrastructure inspections**, ... **infrastructure inspections** in the following chapter. ...
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A multi-functional inspection robot for civil infrastructure evaluation and maintenance
S Gibb, T Le, HM La, R Schmid... - 2017 IEEE/RSJ ..., 2017 - ieeexplore.ieee.org
... inspired several efforts to automate **inspection** processes and replace human ... civil **infrastructure inspection** jobs. In this paper, we develop a multi-functional autonomous **inspection robot**...
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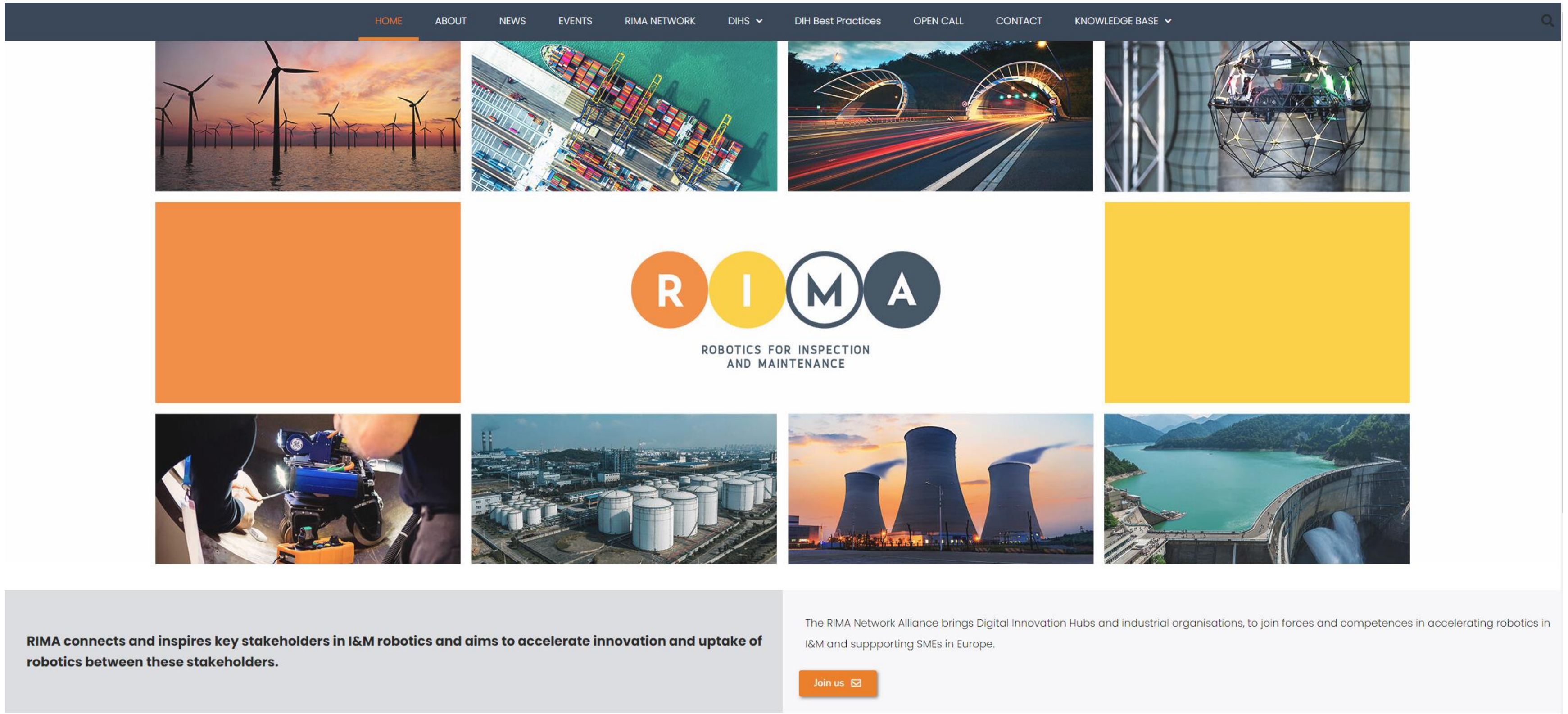
Europe - State of the Art (2019-23)



Project Information

RIMA
Grant agreement ID: 824990

DOI
10.3030/824990

Project closed

EC signature date
21 November 2018

Start date	**End date**
1 January 2019	30 June 2023

Funded under
INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial technologies - Information and Communication Technologies (ICT)

Total cost
€ 16 050 255,00

EU contribution
€ 16 048 605,00

Coordinated by
COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES
France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Europe - State of the Art (2021)

15 granted projects in 3 years!!!

Agenda

10:00-10:15 Welcome
10:15-10:30 Multidomain
10:15-10:30 PILOTING (https://piloting-project.eu/)
10:30-11:15 Ships and Ports
10:30-10:45 ROBINS (https://www.robins-project.eu/)
10:45-11:00 RAPID (https://rapid2020.eu/)
11:00-11:15 BUGWRIGHT2 (https://www.bugwright2.eu/)
11:15-11:30 Electrical distribution
11:15-11:30 AERIAL-CORE (https://aerial-core.eu/)
11:30-12:15 Civil Infrastructure
11:30-11:45 RESIST (https://www.resistproject.eu/)
11:45-12:00 PANOPTIS (http://www.panoptis.eu/)
12:00-12:15 OMICRON (https://cordis.europa.eu/project/id/955269)
12:15-12:30 Oil&Gas sector
12:15-12:30 HYFLIERS (https://www.oulu.fi/hyfliers/)
12:30-12:45 Airports
12:30-12:45 5DAEROSAFE (https://5d-aerosafe.eu/)
12:45-13:15 Renewable energy infrastructure
12:45-13:00 DURABLE (https://www.durableproject.eu/)
13:00-13:15 ATLANTIS (https://www.atlantis-h2020.eu/)
13:15-14:15 Promoting Robotics in I&M applications
13:15-13:30 RIMA (https://rimanetwork.eu/)
13:30-13:45 METRICS (https://metricsproject.eu/inspection-maintenance/)
13:45-14:00 AERO-TRAIN (https://www.aerotrain-etn.eu/)
14:00-14:15 ROBOTICS4EU (https://www.robotics4eu.eu)
14:15-14:30 Conclusions and farewell

Which Robots' features?


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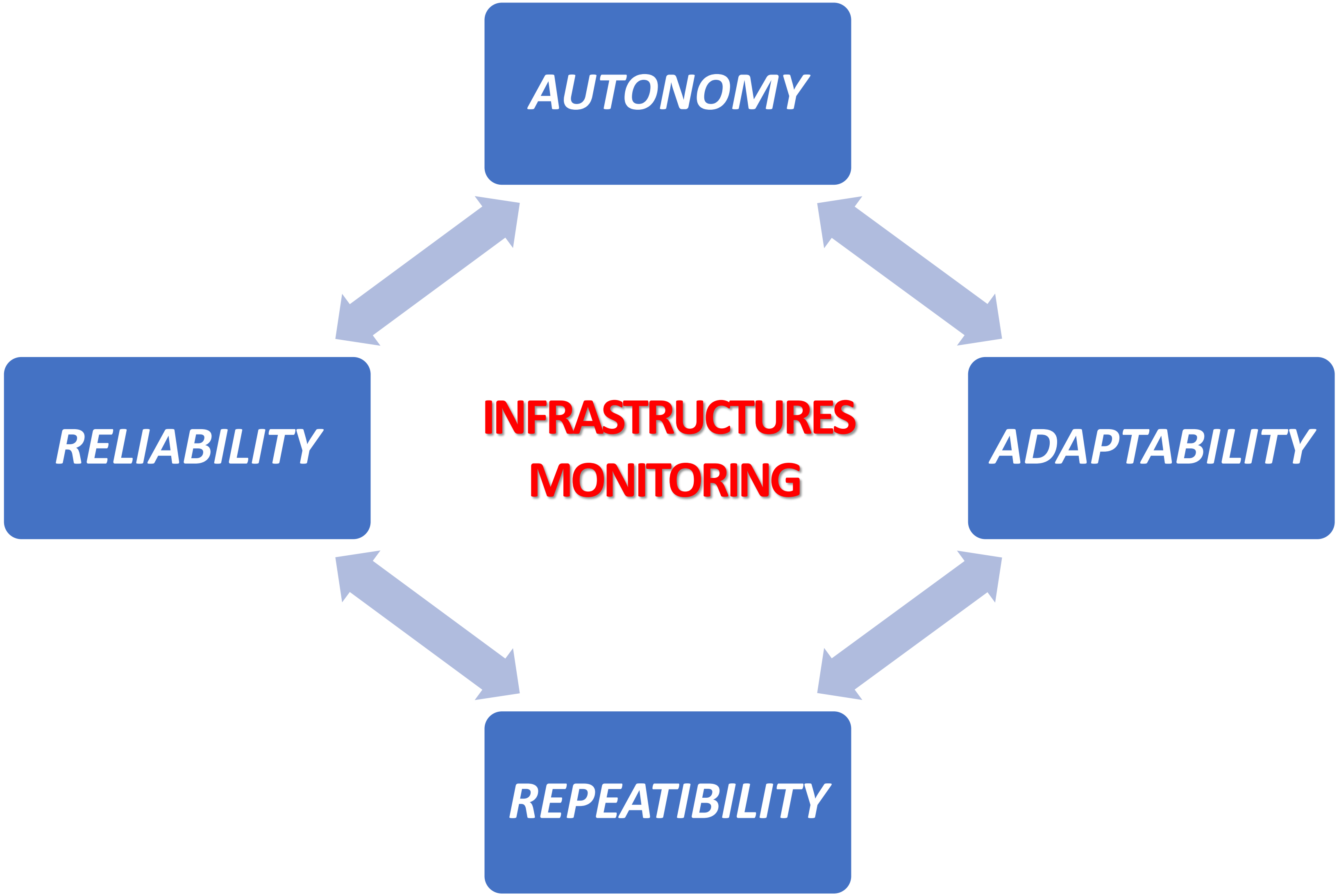


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The Partner's Roles

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INNSE BERARDI Machine Tools

INGERSOLL Machine Tools

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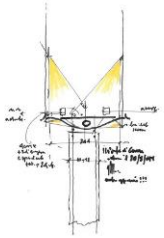

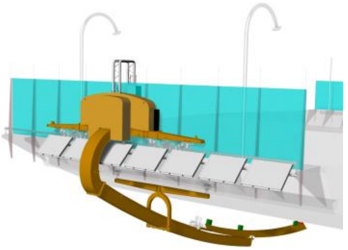

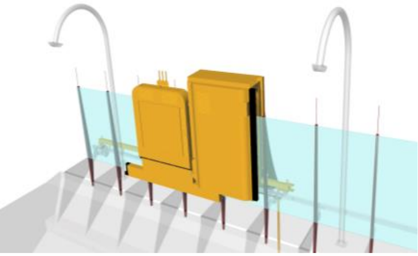

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autostrade per l'italia

MOVYON

autostrade per l'italia

MOVYON


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The CHALLENGE

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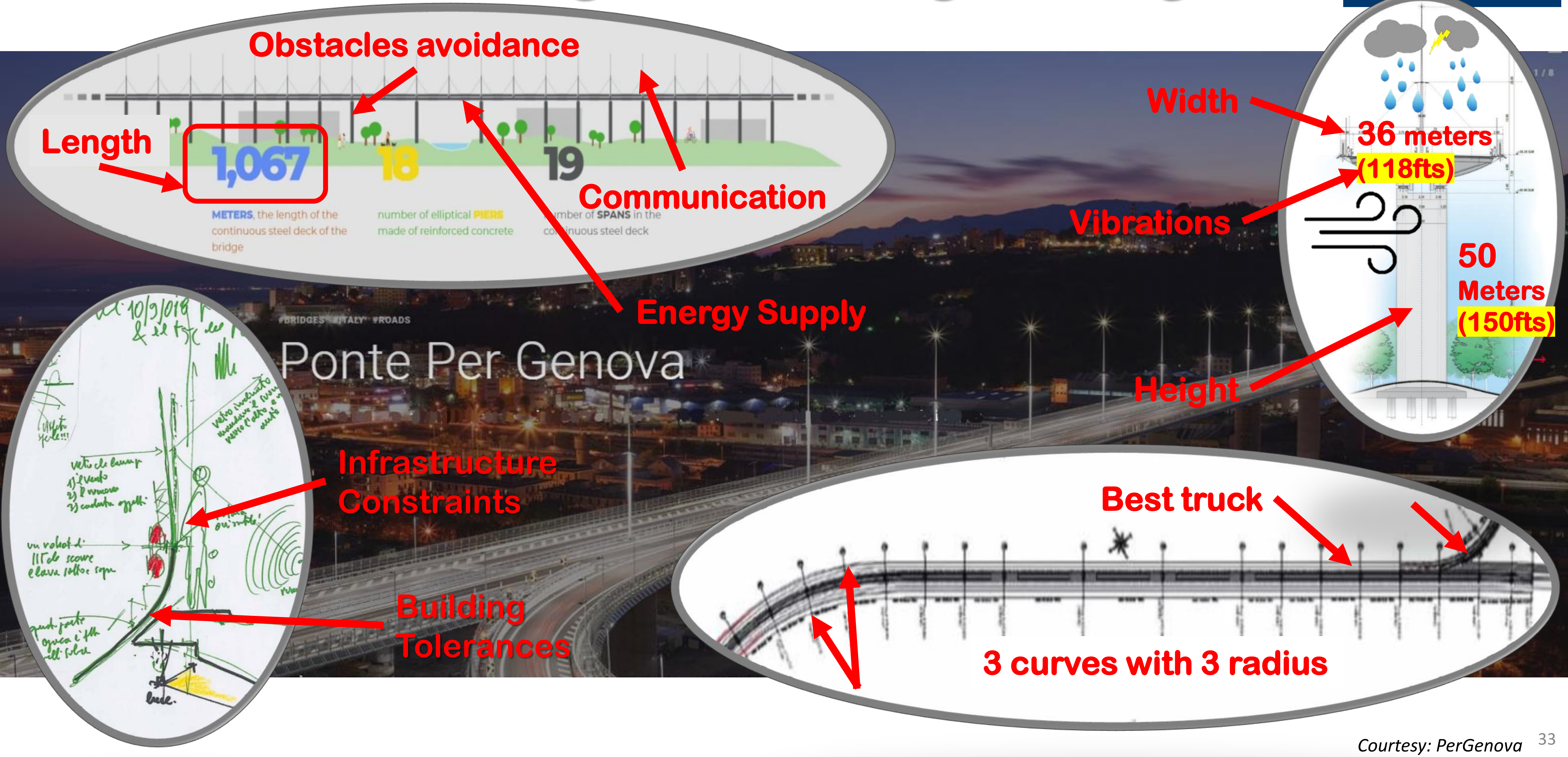

Courtesy: PerGenova


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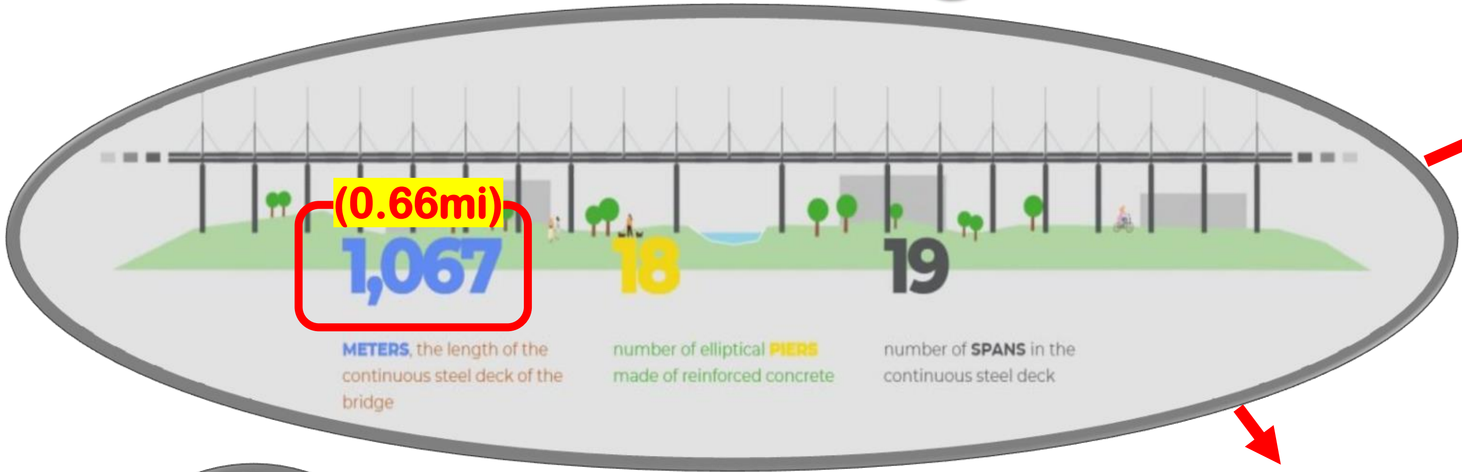
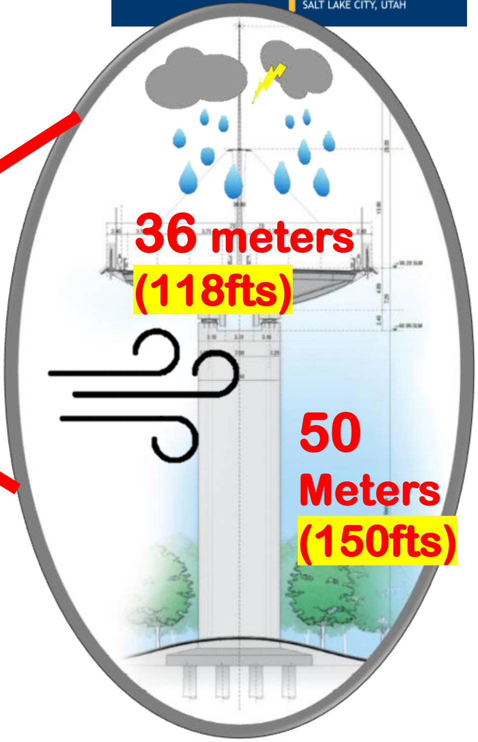


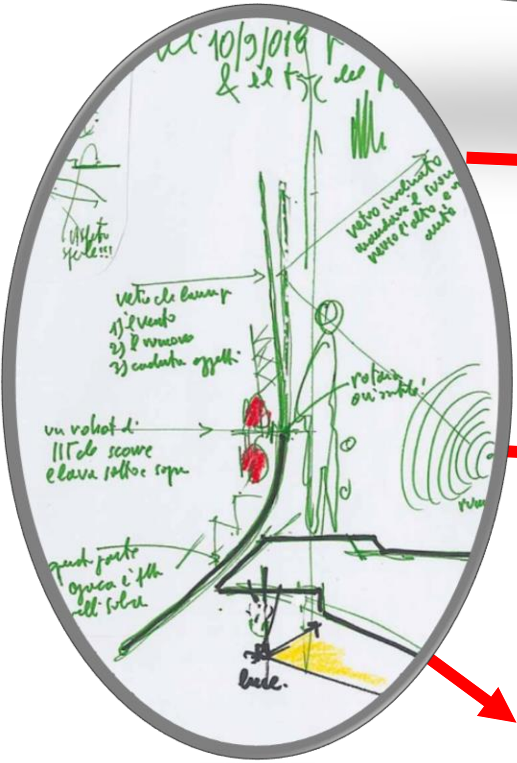


Vibrations

Obstacles avoidance

Energy Supply

Length Width Height



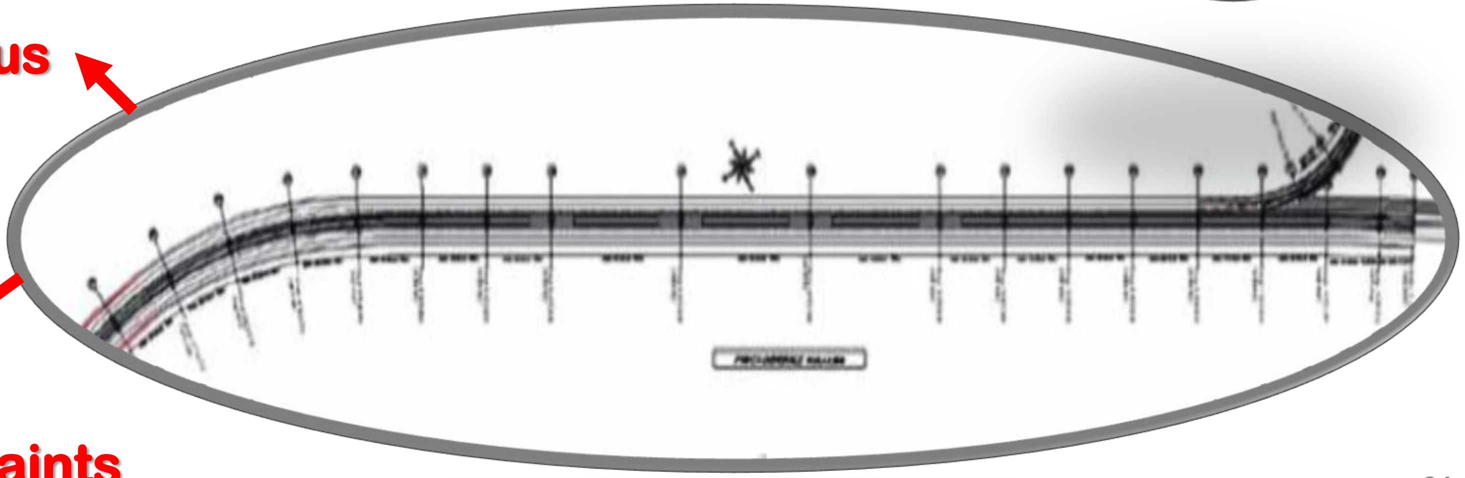
Building Tolerances

3 curves with 3 radius

Best truck

Communication

Infrastructure Constraints



Courtesy: PerGenova

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Autonomous Robot System for Monitoring and Cleaning of Bridges

Monitoring :
- Underside of the deck
- Head of piers

Maintenance:
- Sound barriers
- Solar panels

Contact: first tentative for a fully autonomous I&M robot to interact with the environment
- Sensors (ultra-sound, magneto-scope, etc.)
- Brushes for cleaning

Cognitive Mechatronics: be aware about the environmental parameters in order to make decisions
- Autonomy: batteries management
- Navigation: trajectories planner
- Self-Diagnosis: fault management


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Autonomous Robot System for Monitoring and Cleaning of Bridges

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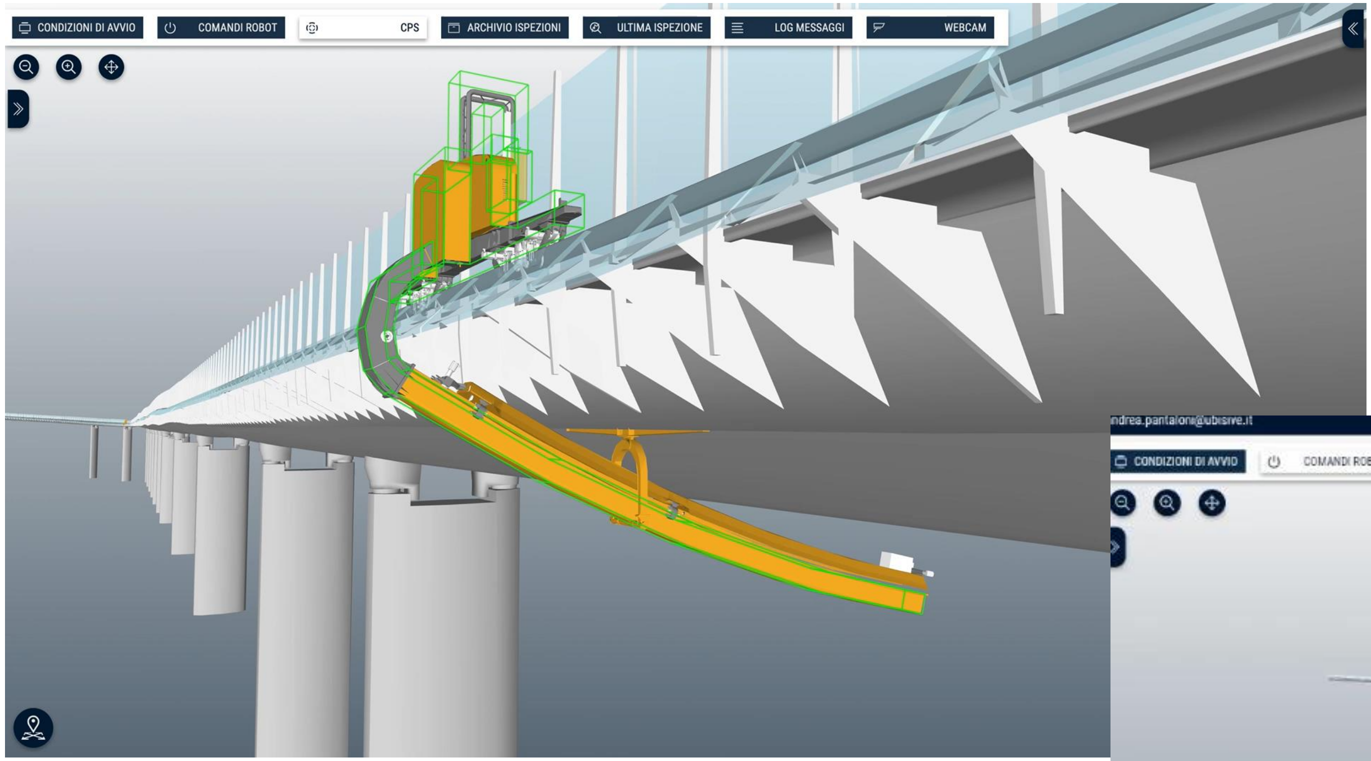
Remote Control

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The ROBOTS
(how do they work?)

 

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The ROBOTS

(how do they work?)

DESIGN & DYNAMICS

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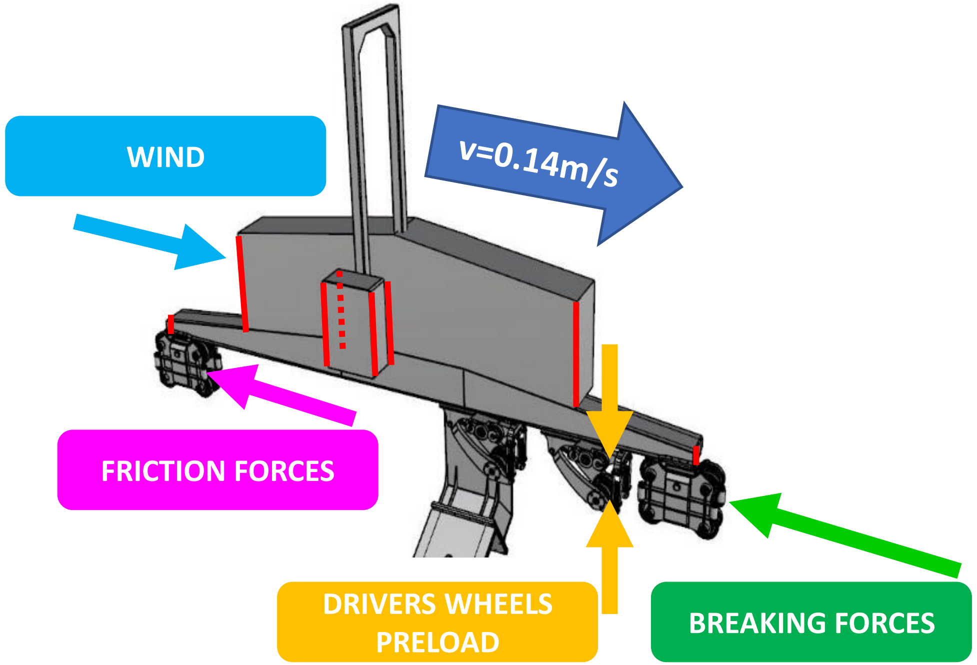
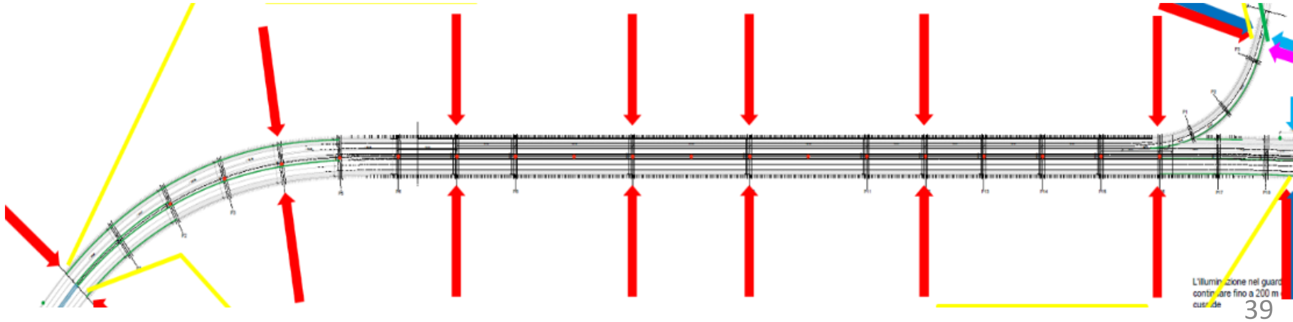
Robots Dynamics



- **Weight:** 2400kg/5300pounds
- **Motors:** 4 equipped 16 wheels
- **Trolleys**: 4 equipped 24 wheels
- **Beams**: 2 (10m/30fts each)
- **Width**: 7m/21fts
- **Dynamics:** the main forces will be the given by the wind (10m/s 20knots average), because the bridge crosses the Polcevera valley at around 45m (150fts) of quote
- **Running:** the robots will run (100-150mm/s, 0.46fts/s) along the rails installed along the bridge side
- **Actuation**: DC motors
- **Autonomy**: batteries that will be recharged in different charging stations (red arrows) along the 1067m (0.66mi) of the bridge



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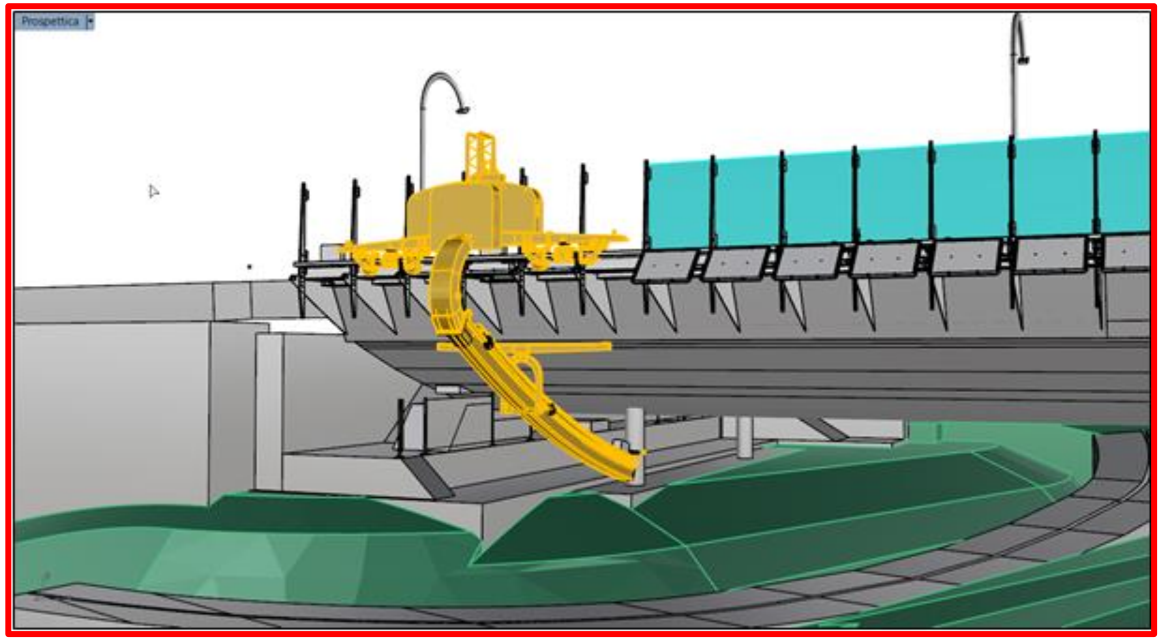
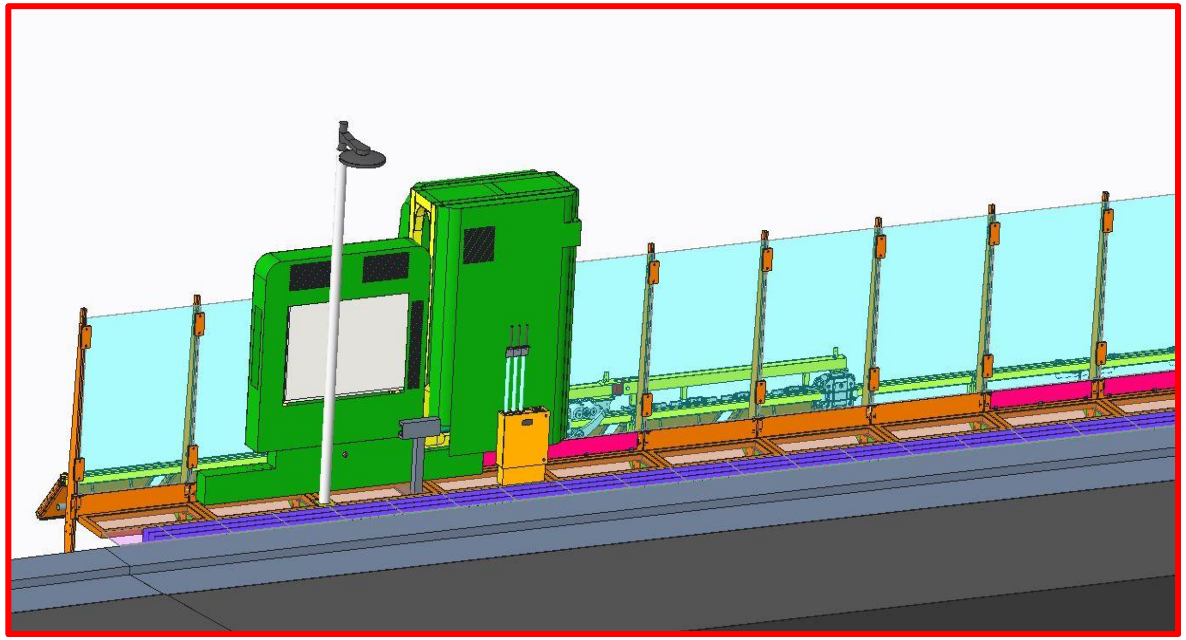
Autonomous Robot System for Monitoring and Cleaning of Bridges

Robot Typology





Two fully autonomous robotic systems will be installed on the bridge:

- **Robo-Wash** (n° 2) designed for cleaning the sound-barriers and solar panels (2-3 times per year, exploiting the rain water)
- **Robot-Inspection** (n° 2) designed to inspect (with contact/non-contact sensors) the underside of the bridge.

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Autonomous Robot System for Monitoring and Cleaning of Bridges

Robot Typology

Two fully autonomous robotic systems will be installed on the bridge:

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Autonomous Robot System for Monitoring and Cleaning of Bridges

Robot Typology

DATASHEET	
Bridge length	1060 m (~3500fts)
Running	On the rail(s)
Energy	Batteries
Control	Autonomous (on need: remote)
Connection	Wi-fi
ROBOT INSPECTION	
Database of imaging per fully inspection	30.000 about
Visual inspection	Pattern Analysis and Change Detection AI Algorithms
Defect detection	Color defects Depth Cracks
ROBOT WASH	
Sound barriers and Solar panels cleaning	Raining water
Traveling time end-to-end	3h about



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Autonomous Robot System for Monitoring and Cleaning of Bridges

Robot Inspection - Building

INGERSOLL
Machine Tools

MasterPrint®

CARBON LONG FIBERS BEAMS

 

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Autonomous Robot System for Monitoring and Cleaning of Bridges

Robot Inspection - Building

Assembled!

 

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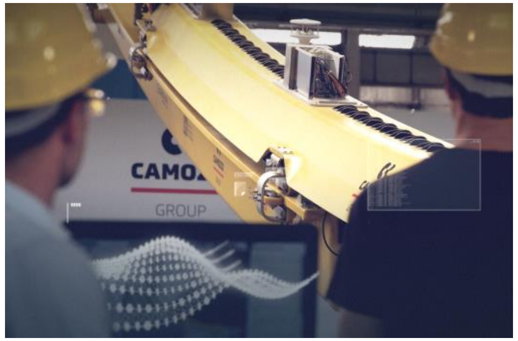
Autonomous Robot System for Monitoring and Cleaning of Bridges

Robot Inspection – Testing

CAMOZZI
Advanced Manufacturing



TESTS CONDUCTED IN THE CAMOZZI FACTORY IN MILAN ON A 1:1 SCALE BRIDGE MOCKUP

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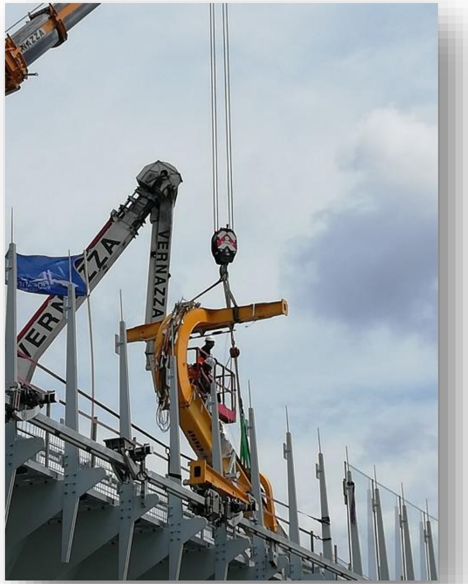
Robot Inspection Installation

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The ROBOTS
(how do they work?)

THE INSPECTION
(no contact sensors)


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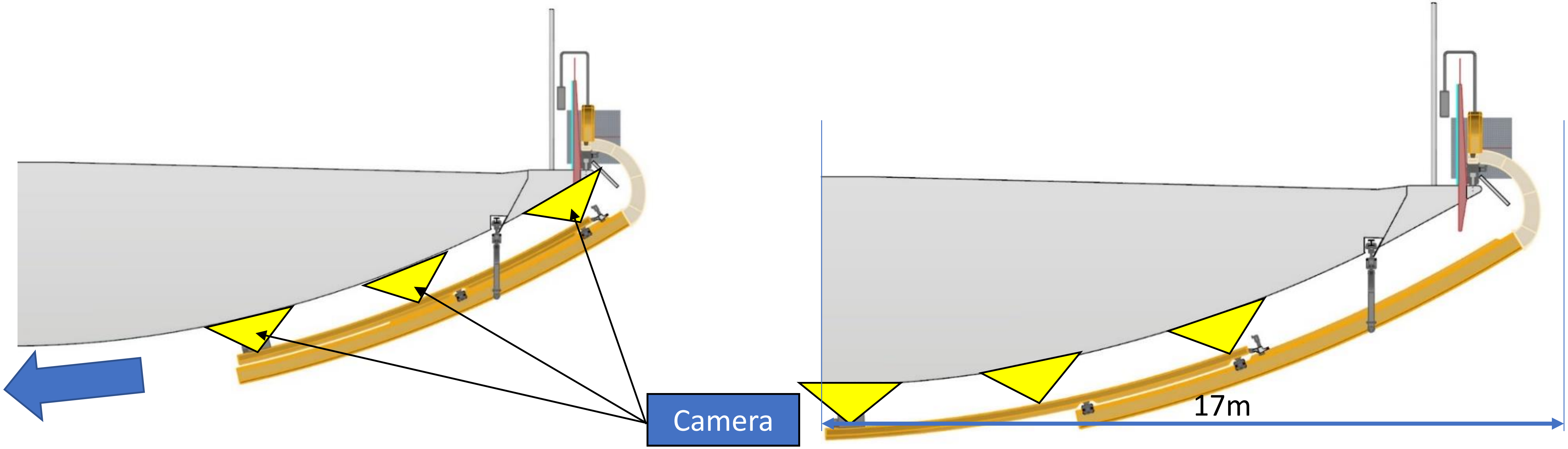
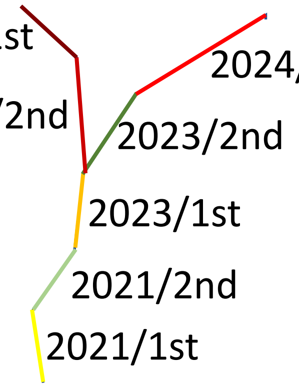


The vision will be moved by the sliding beam and the images will be processed with Pattern Analysis in order to detect potential «anomalies» that will be reported to the human operators.

The surface Monitoring will investigate:

1) Painting degrading
2) Corrosion of metallic parts
3) Joint status
4) Welded status
5) Crack detection

<u>Monitoring of the evolution along the months and years!</u>

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FULLY AUTONOMOUS Robot for inspecting the Genova San Giorgio bridge

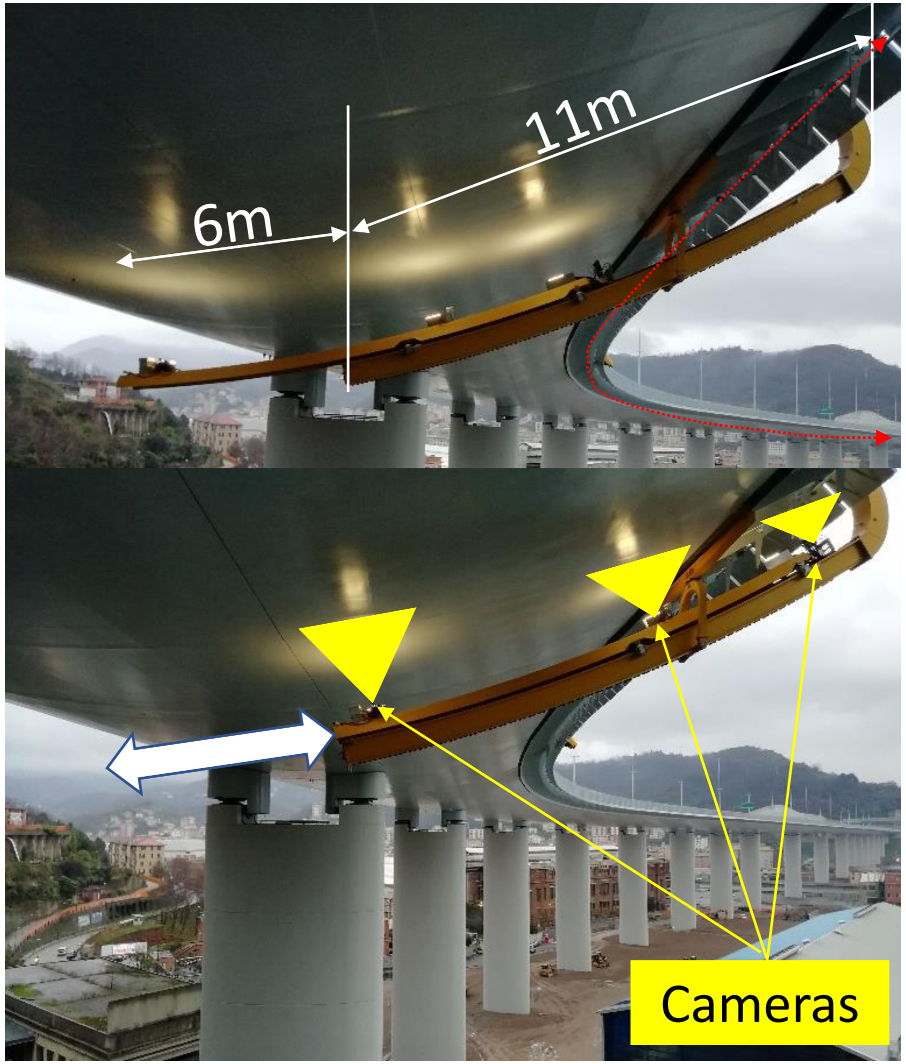
Weight: 2400kg (3500pounds)
(arm: 300kg of carbon fiber structure)

Payload of the arm:
On the tip: 80 kg (176pounds)
Distributed: 250 kg (552pounds)

Size:
Arm length: 11+6 m (36+20fts)
Length: 7 m (23fts)
High: 10 m (30fts)

Speed: 0.14 m/s (0.46fts/s)
Span: 1060 m (0.66mi)

± 25mm (0.98”) oscillation of the robot beam



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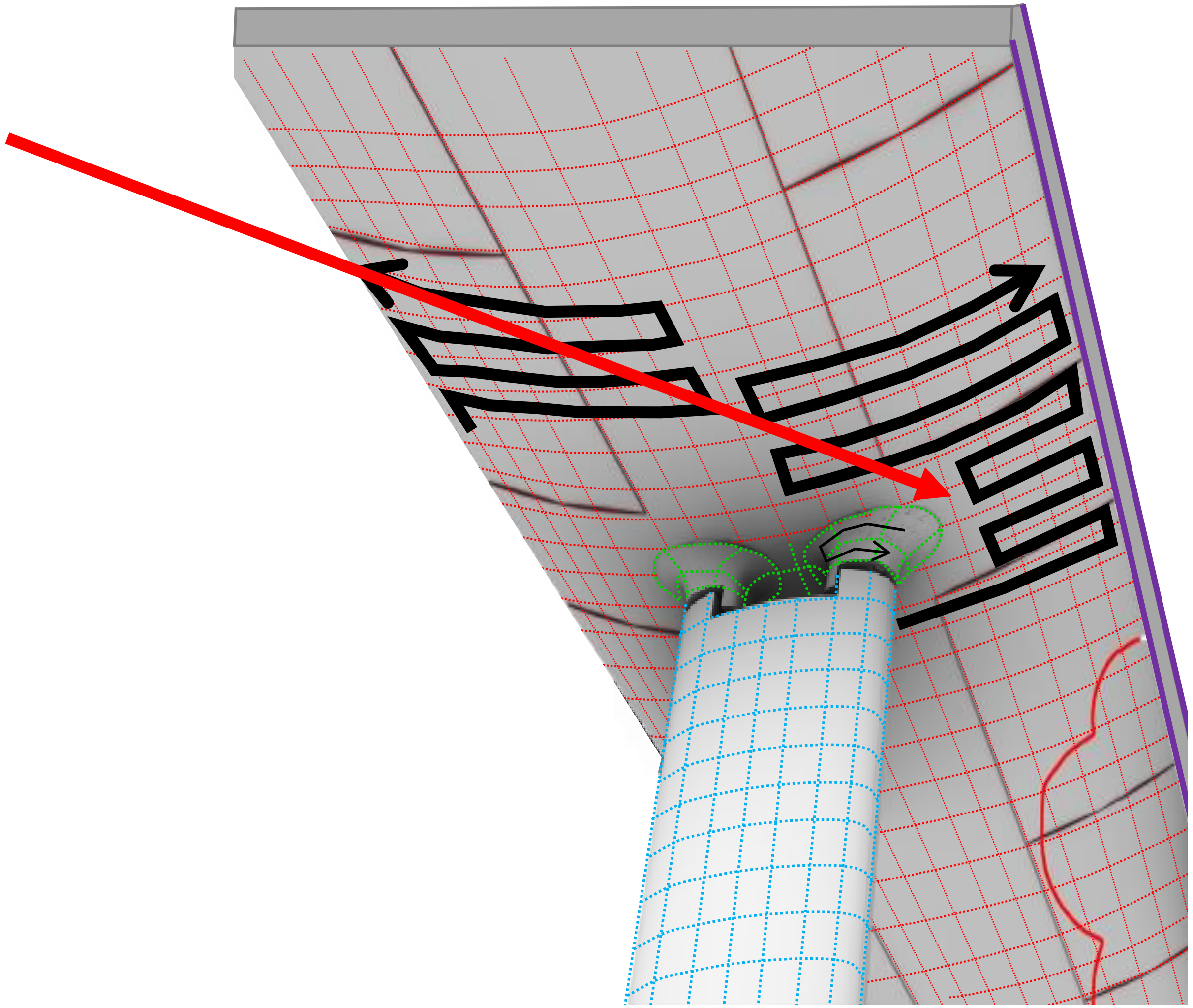
Bridge safety: INSPECTION <u>should be</u> reconfigurable for "jumping" the pillars



Inspection - Procedure

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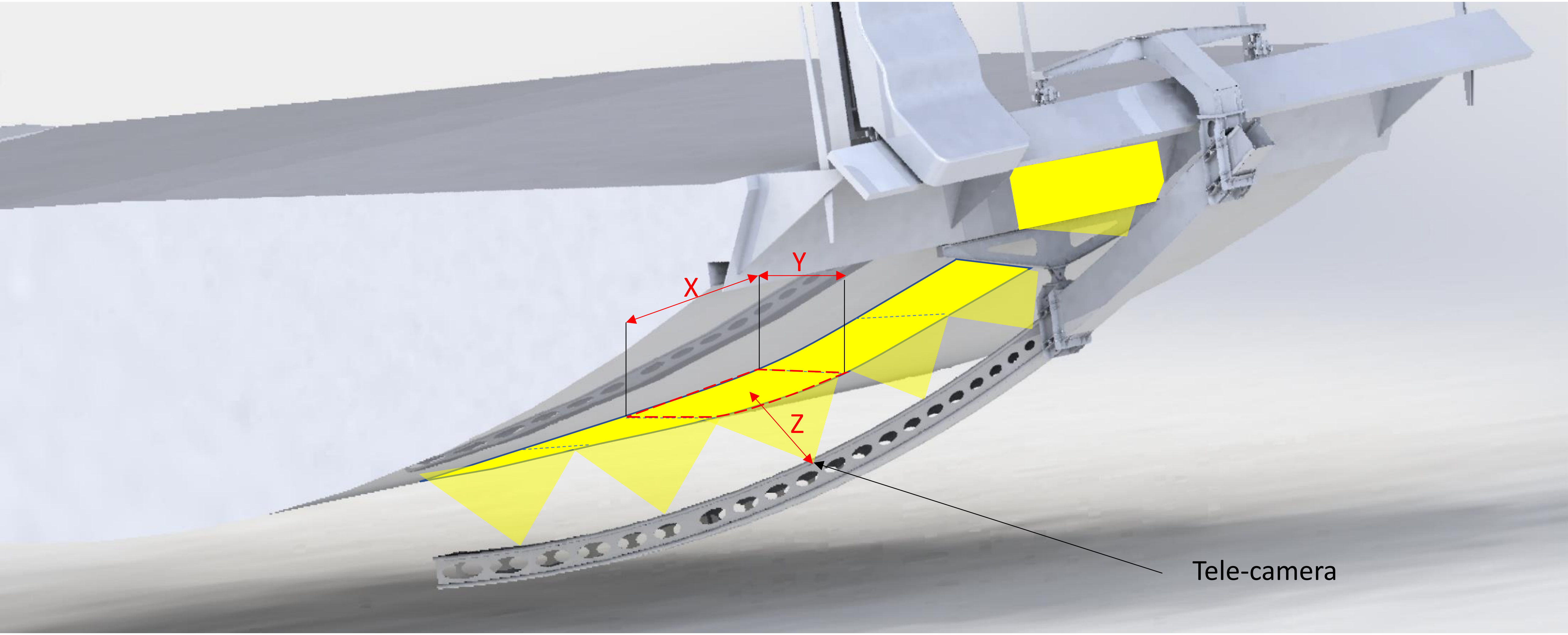
False Positive Avoidance – Pattern Analysis



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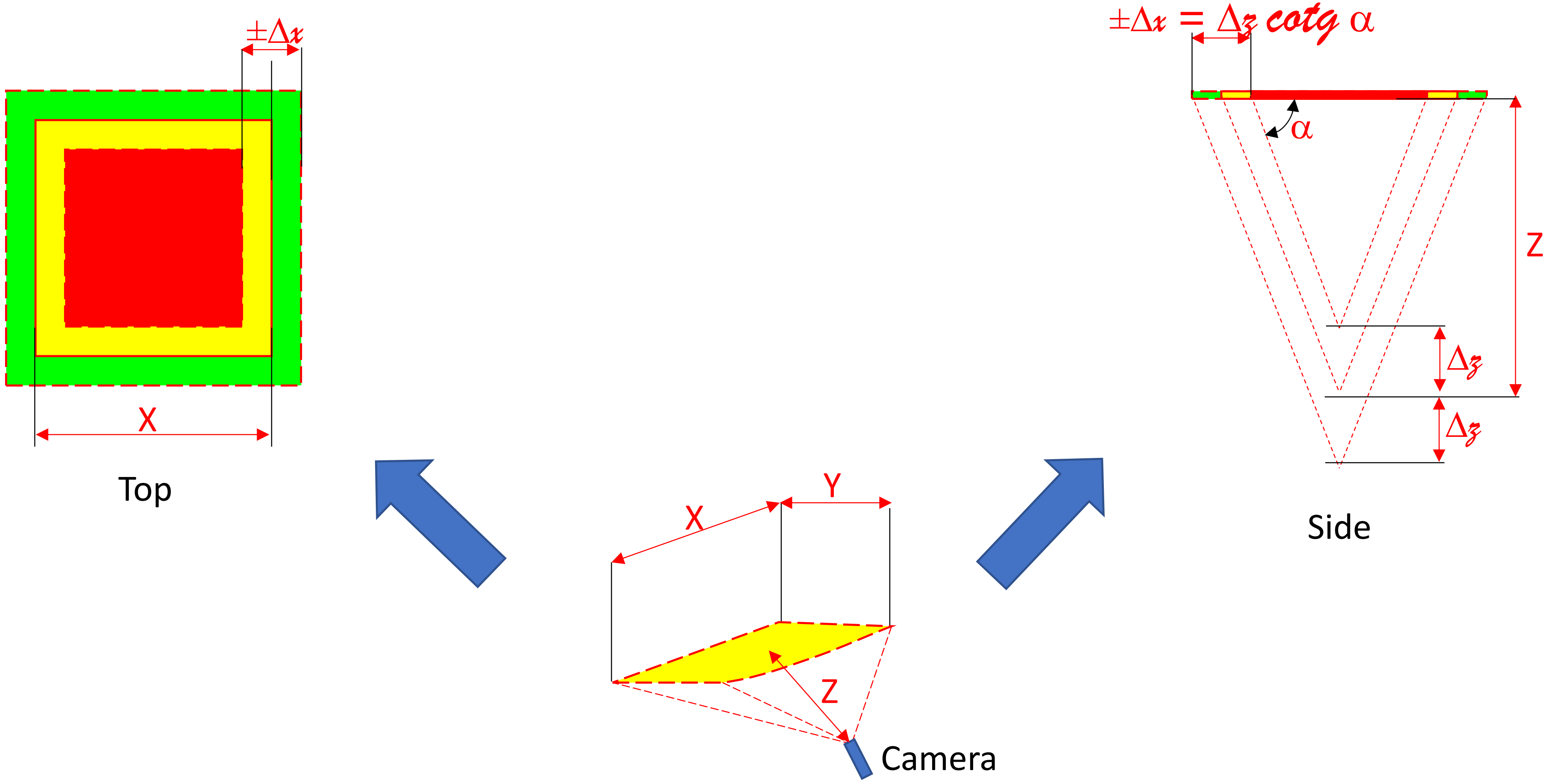


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The ROBOTS
(how do they work?)

THE INSPECTION
(contact sensors)

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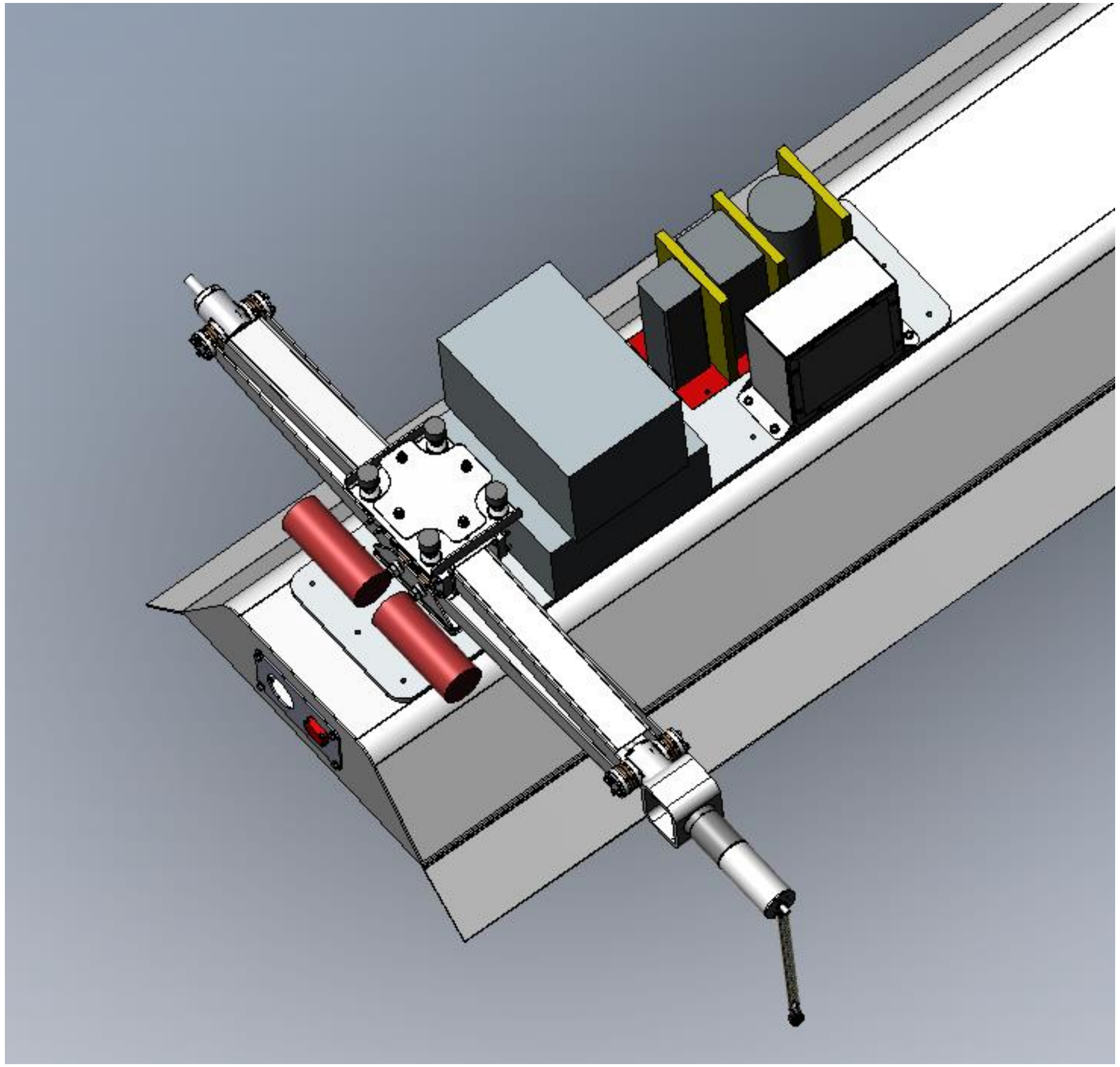

3RD Robot Arm for On Demand Detailed Investigation

The ROBOTS

(how do they work?)

THE CLEANING


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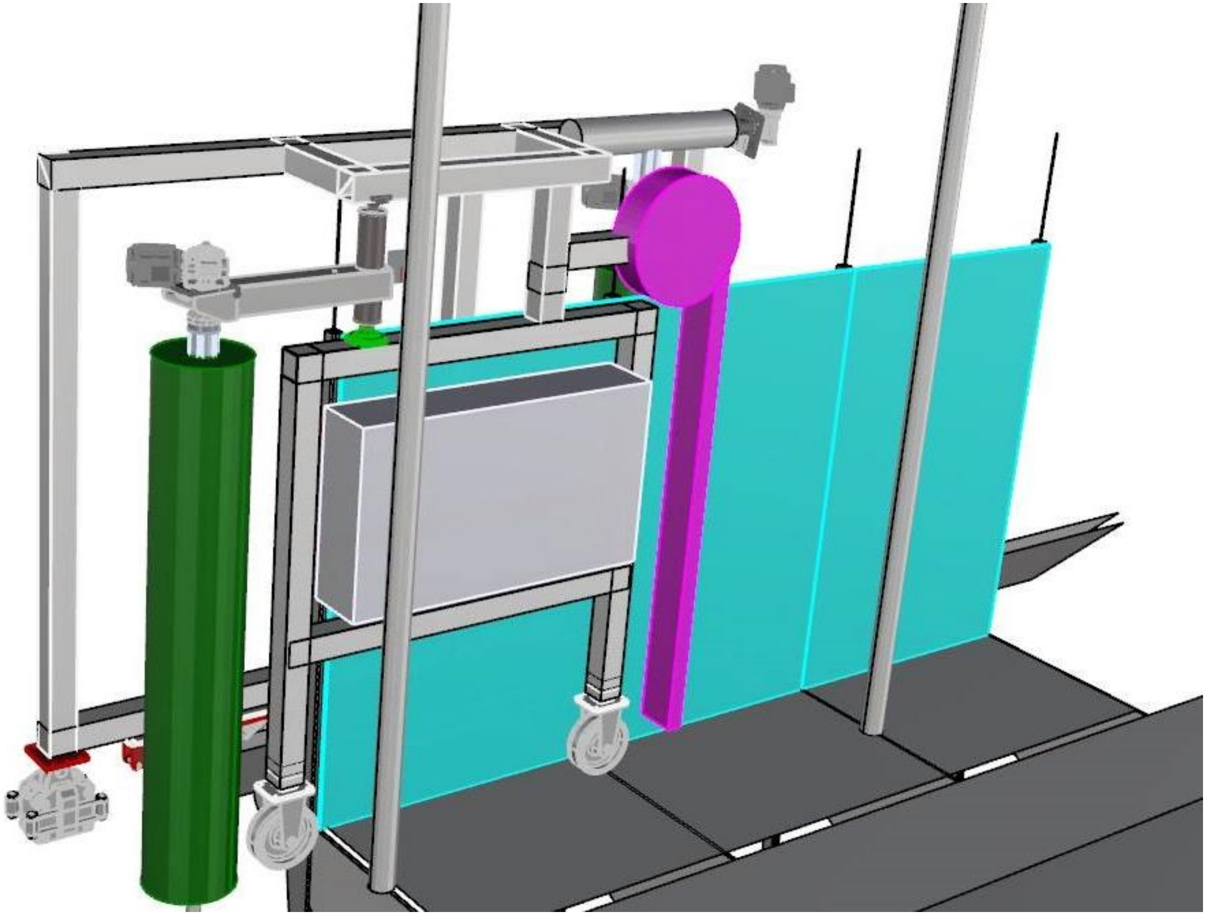
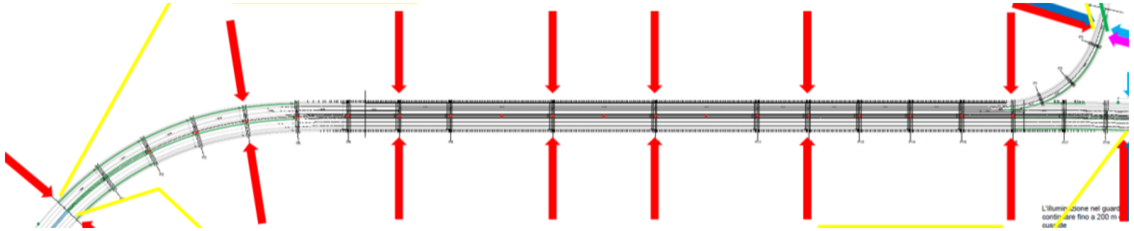
Autonomous Robot System for Monitoring and Cleaning of Bridges



Robot Wash

- **Weight:** 2200kg
- **Motors:** 3 equipped by 12 wheels
- **Trolleys**: 3 equipped by 36 wheels
- **Brushes**: 3 + Fan
- **Width**: 4+2.5m
- **Dynamics:** the main forces will be the given by the wind (12m/s average), because the bridge crosses the Polcevera valley at around 45m of quote
- **Running:** the robots will run (100-150mm/s) along the rails installed along the bridge side
- **Actuation**: DC motors
- **Autonomy**: batteries that will be recharged in different charging stations (red arrows) along the 1067m of the bridge



The cleaning deals with three surfaces: barriers (two sides) and solar panels (one side).
Moreover, in order to be a green system, the rotating brushes will exploit the rain water or the fans during the most dry season

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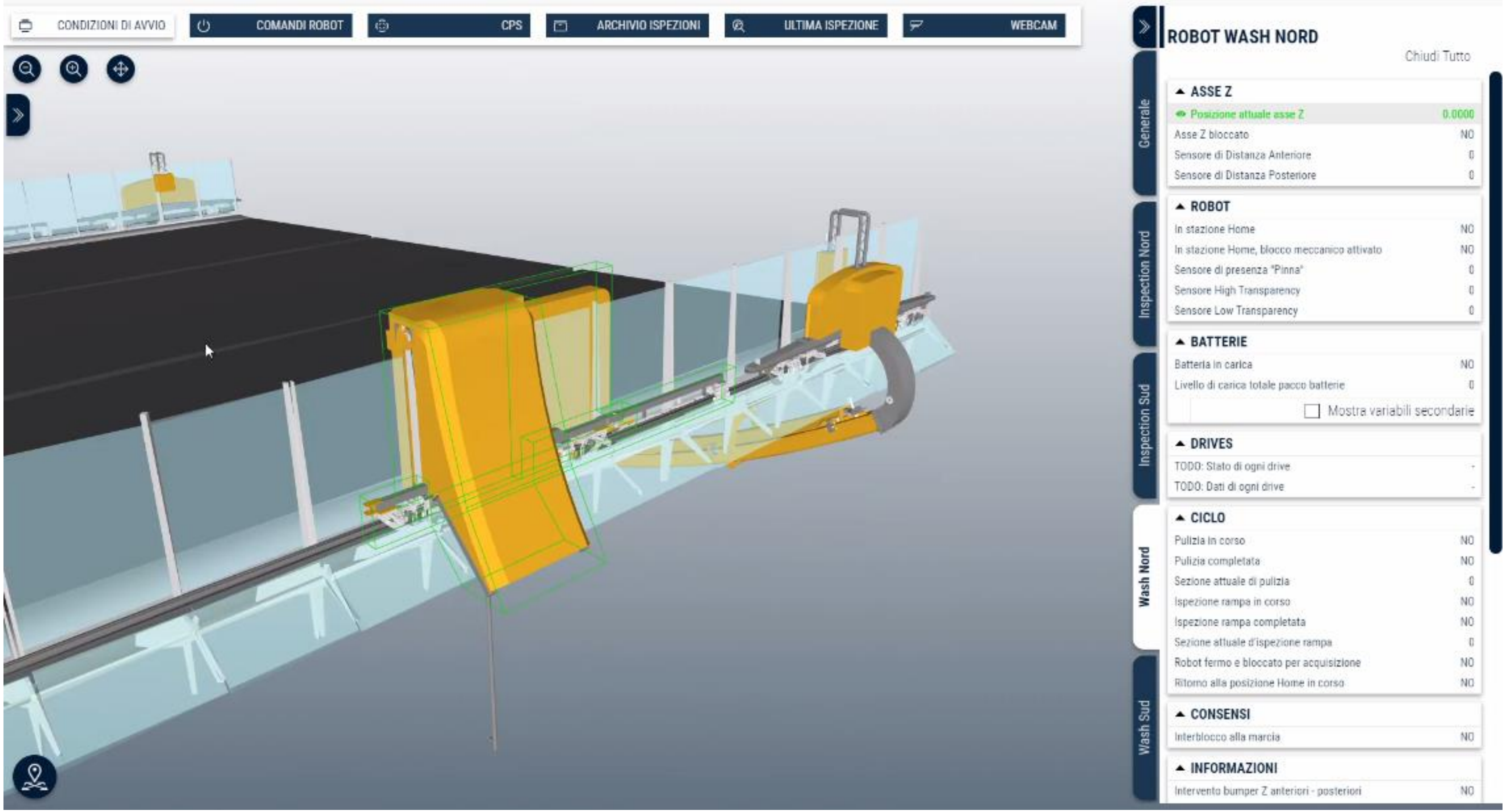


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Robot Wash Installation




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AT WORK!!!


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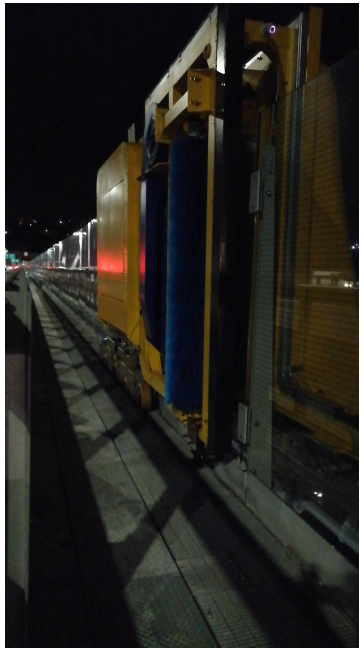
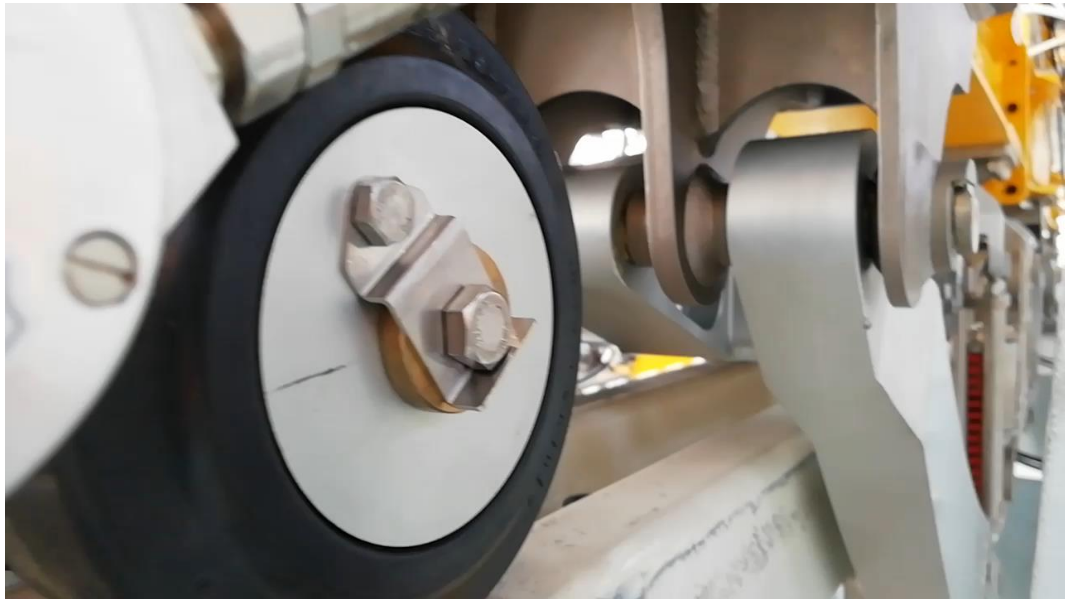
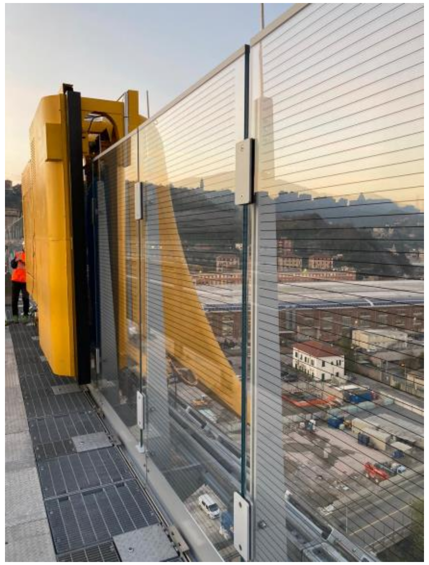
SOME DETAILS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AT WORK!

The ROBOTS
(how do they work?)

Vision and AI

 

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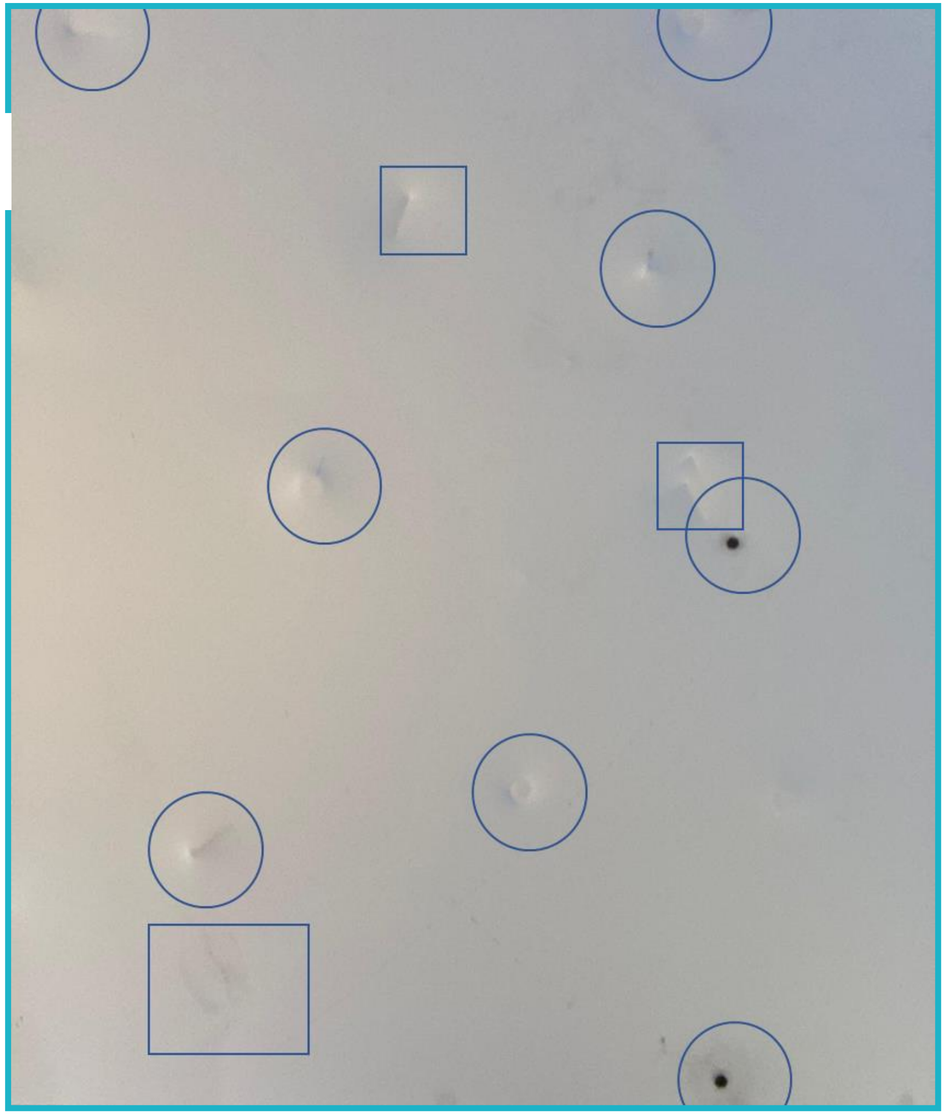
Inspection - Dataset Acquisition Challenge

- ✓ **IDENTIFIY CRACKS**
  - Ultra high resolution images [1]
  - Detection also by using CNN on tiles considering the high size of images (12Mpix)
- ✓ **IDENTIFIY BUMPS**
  - 3D and ultra high resolution images
- ✓ **IDENTIFIY ANAMOALOUS TESTURE**
  - Multi-spectral VIS + ultra high resolution
  - Evaluation of Spectral Indexes to put in evidence main defects
- ✓ **PROCESSING IS PERFORMED DURING THE ACQUISITION by using a queque mechanism**
- ✓ **MQTT messages are used to share detected defects to the HMI**



Mancini, A, et al. "Road pavement crack automatic detection by MMS images." *21st Mediterranean Conference on Control and Automation*. IEEE, 2013.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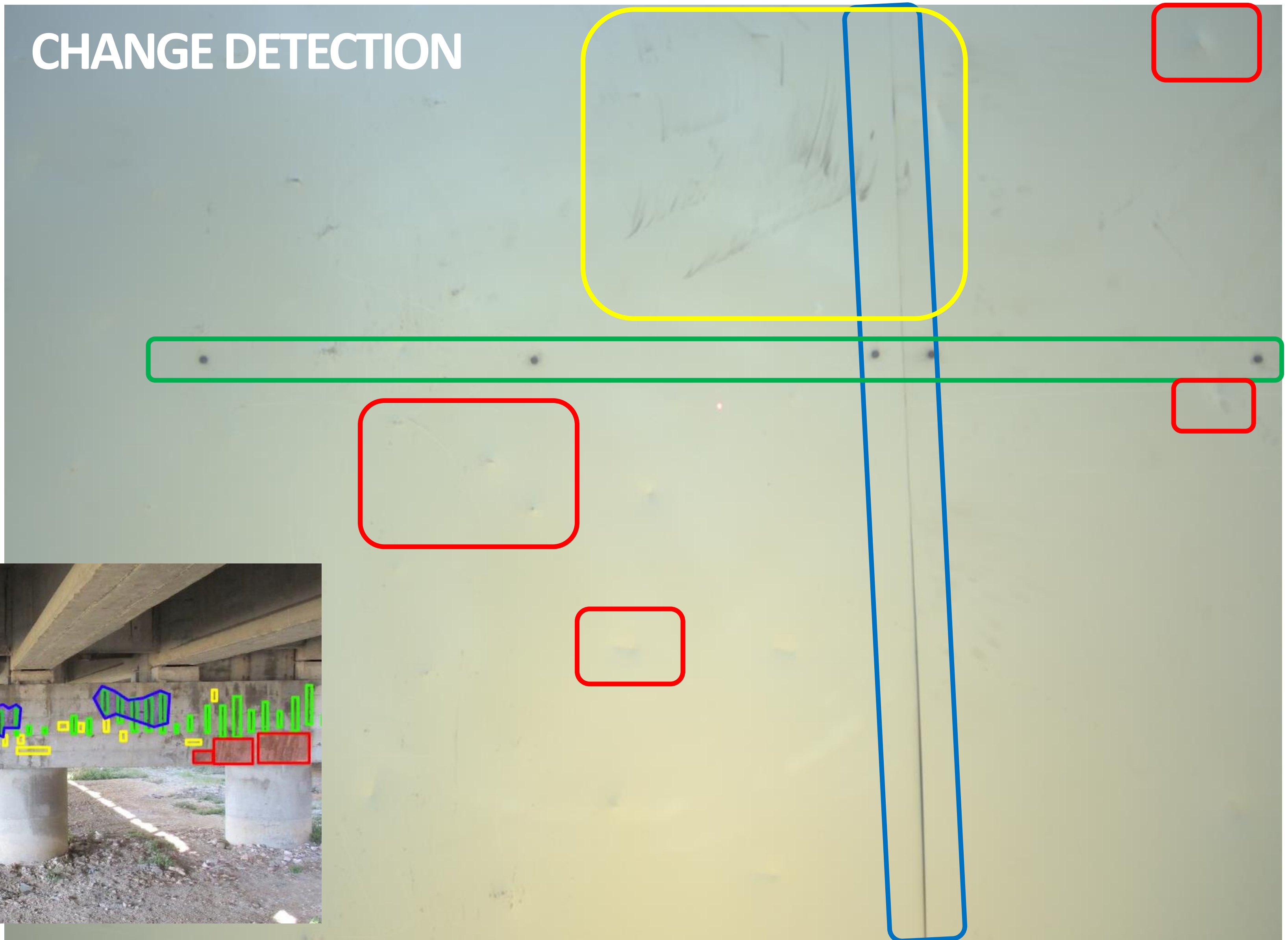

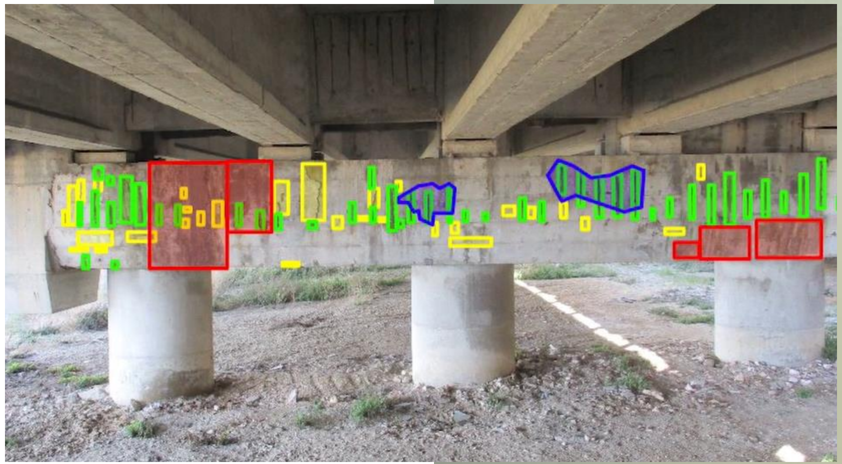

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INSPECTION ROBOT – Defect Detection (on site)


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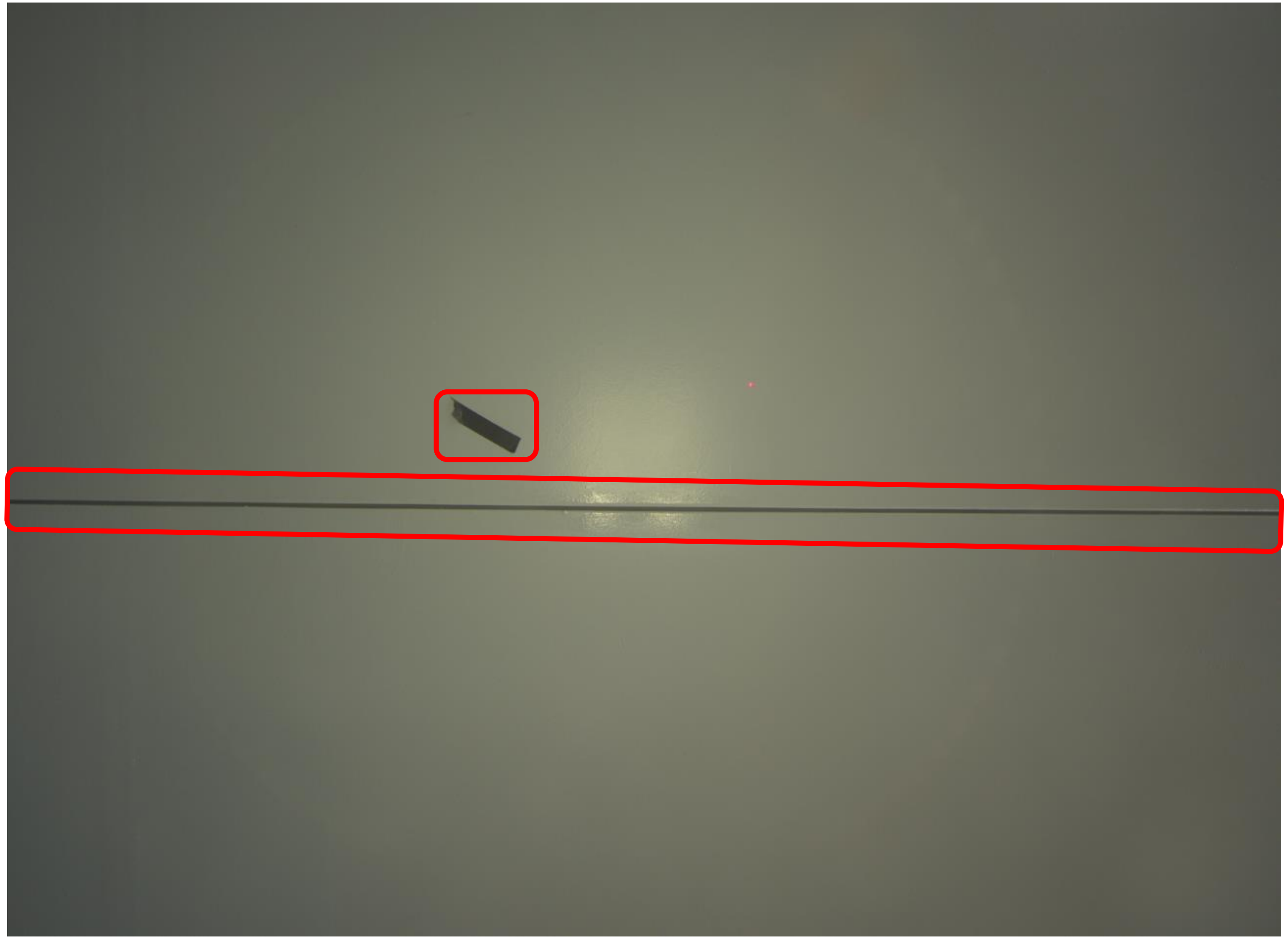
INSPECTION ROBOT – Defect Detection (on site)

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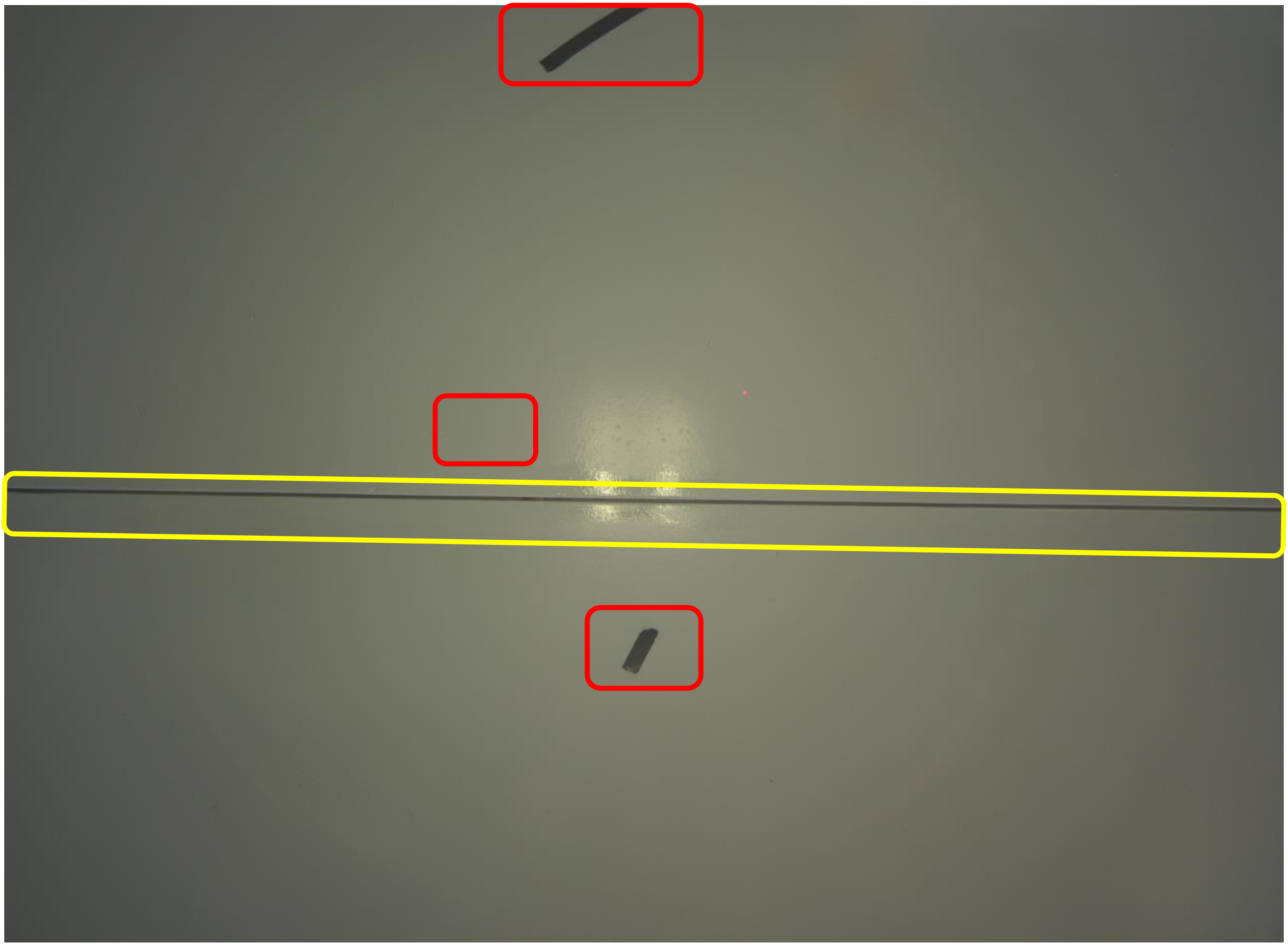
INSPECTION ROBOT – Defect Detection (on site)



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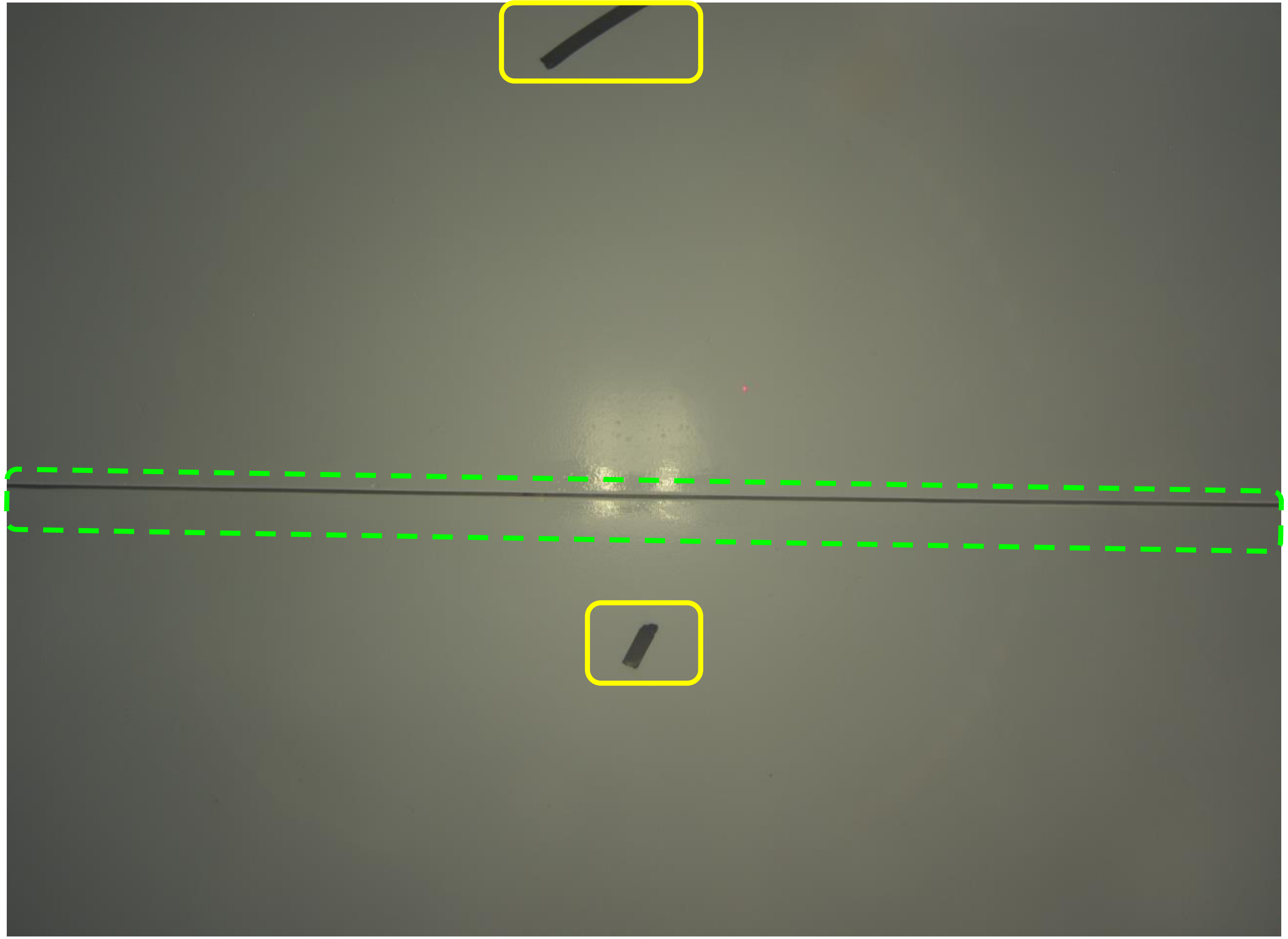
INSPECTION ROBOT – Defect Detection (on site)

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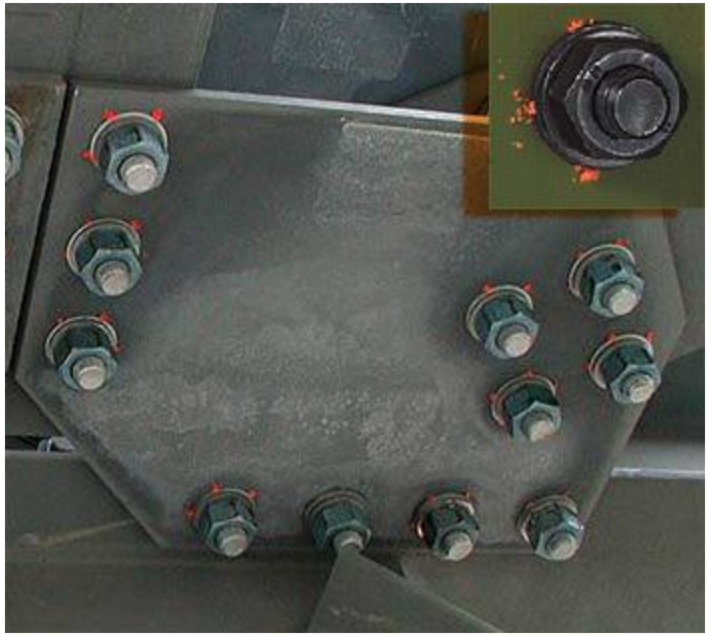

BRIDGE/BARRIERS – bolts – “standard approach”

The RESULTS


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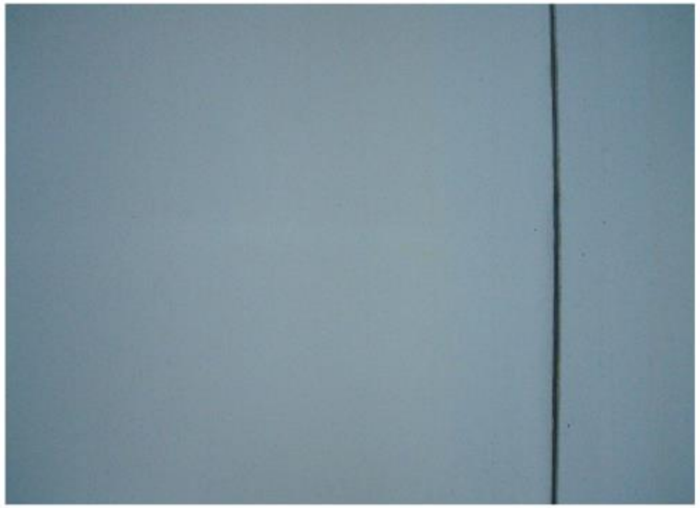
FIRST DEFECT DETECTION (2021, February)

The first scanning the whole bridge was covered and more than 30000 pictures were taken. A couple of them are shown in the following. THIS IS THE BRIDGE **SCAN «ZERO»**

IMAGES FROM SCAN «ZERO» (Feb 2021)

No defects DETECTED by the algorithm, because the bridge was new!



No defects DETECTED by the algorithm, because the bridge was new!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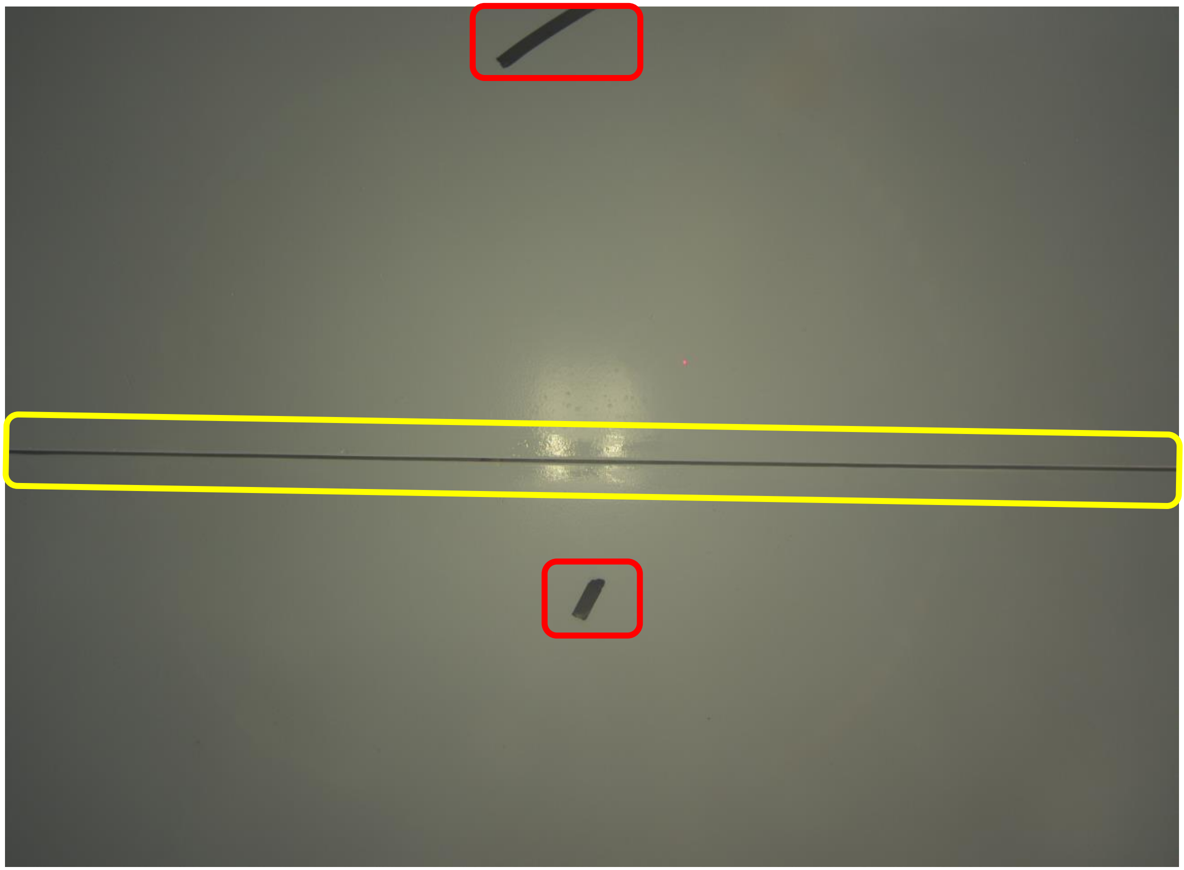
SECOND DEFECT DETECTION (2022, July)



Considering the bridge was detected just 1.5 year before, none was expeting any defect, an overall check up was carried on on the robots and only the cameras were tested around the robot parking areas with the artificial markers in order to check their functionalities after 18 months without being used.

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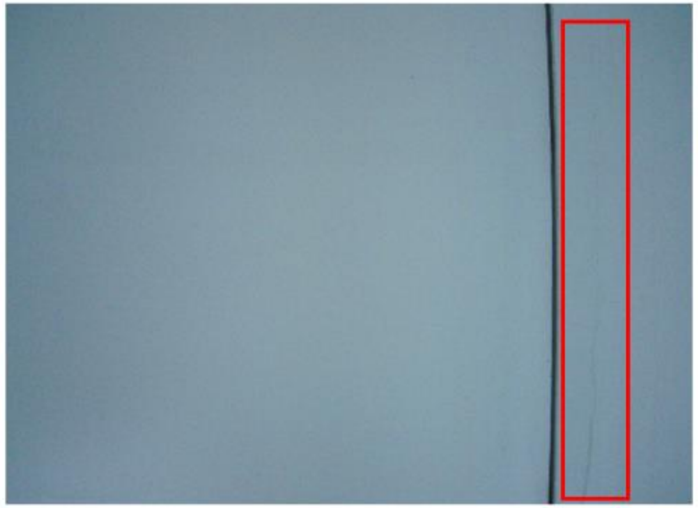
THIRD DEFECT DETECTION (2023, December)

IMAGES FROM SCAN «3» (Dec 2023)



The third inspection involved almost half bridge with around 1000 pictures (statistically detemined) to asses where same difects were come out: considering that only some dirty areas was found, the captured pictured were drastically reduced compared to 30000 for scanning the whole bridge.

Evident dirt zone EASILY DETECTED by the algorithm

Not Evident dirt zone NOT EASILY DETECTED by the algorithm (the ML needs to be trained about the dust and similaf defects)

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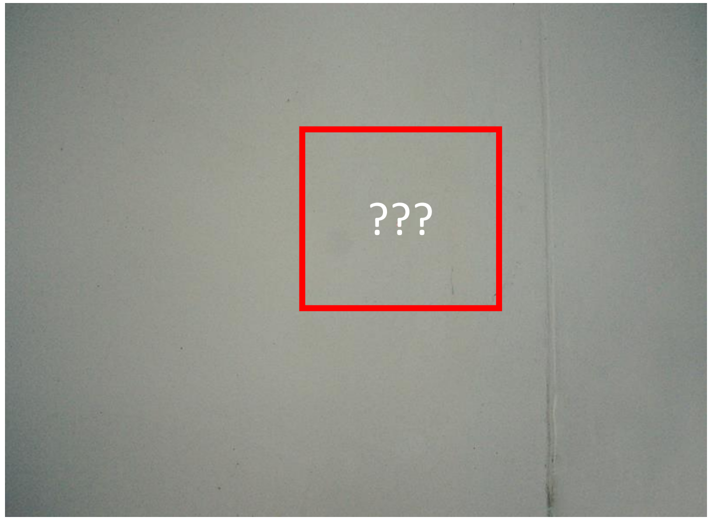
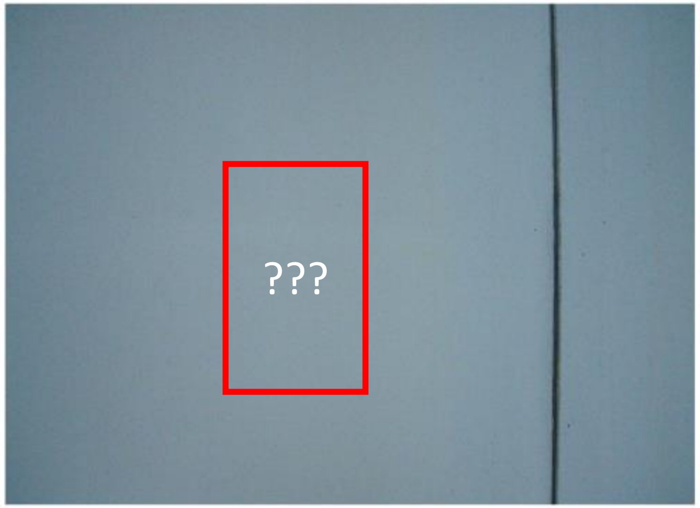
FOURTH DEFECT DETECTION (202?, ???)



????

????



???

Mechanical and Structural Interface
(tolerances differences between the mechanical and civil engineering)

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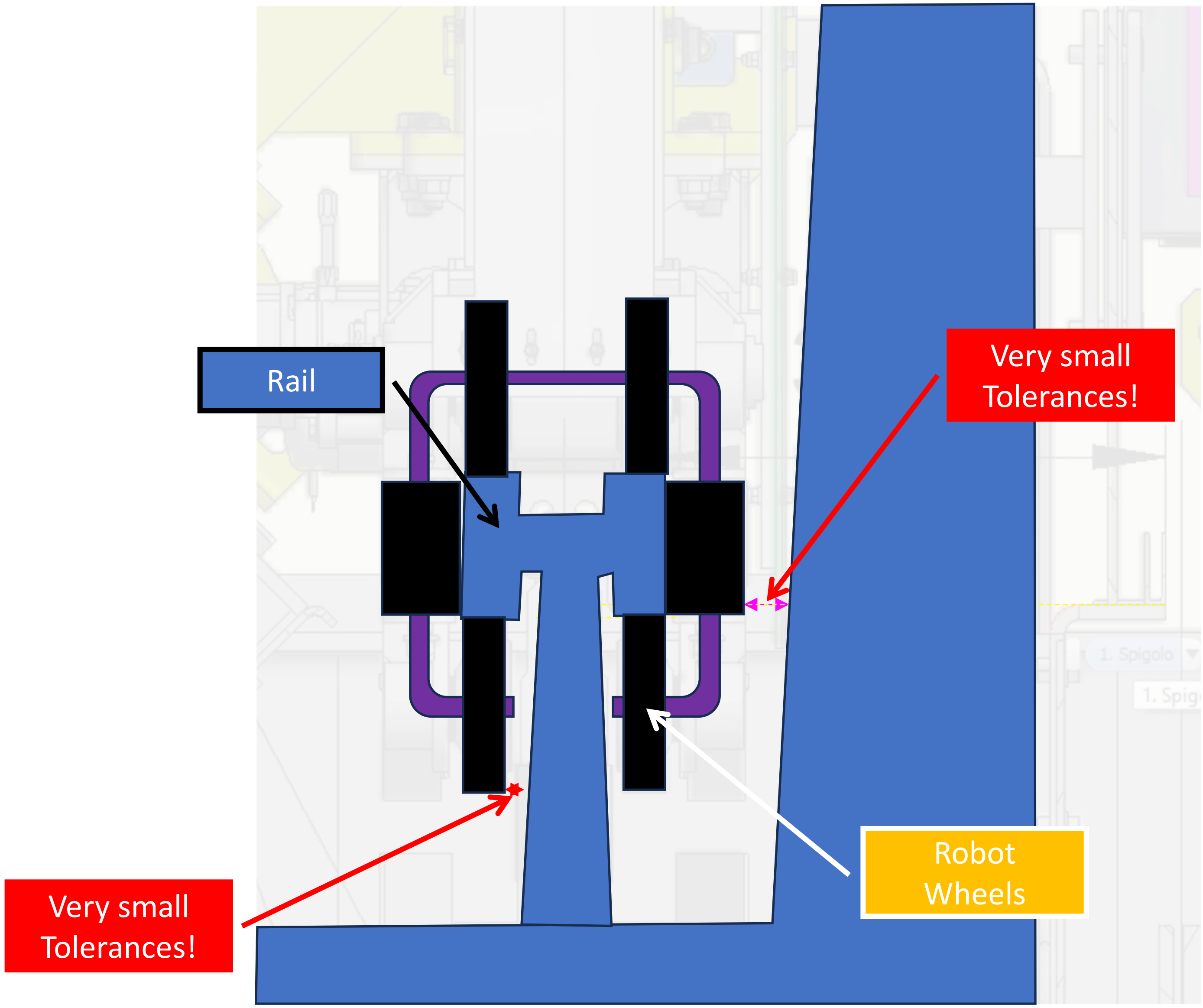
An example: the rail



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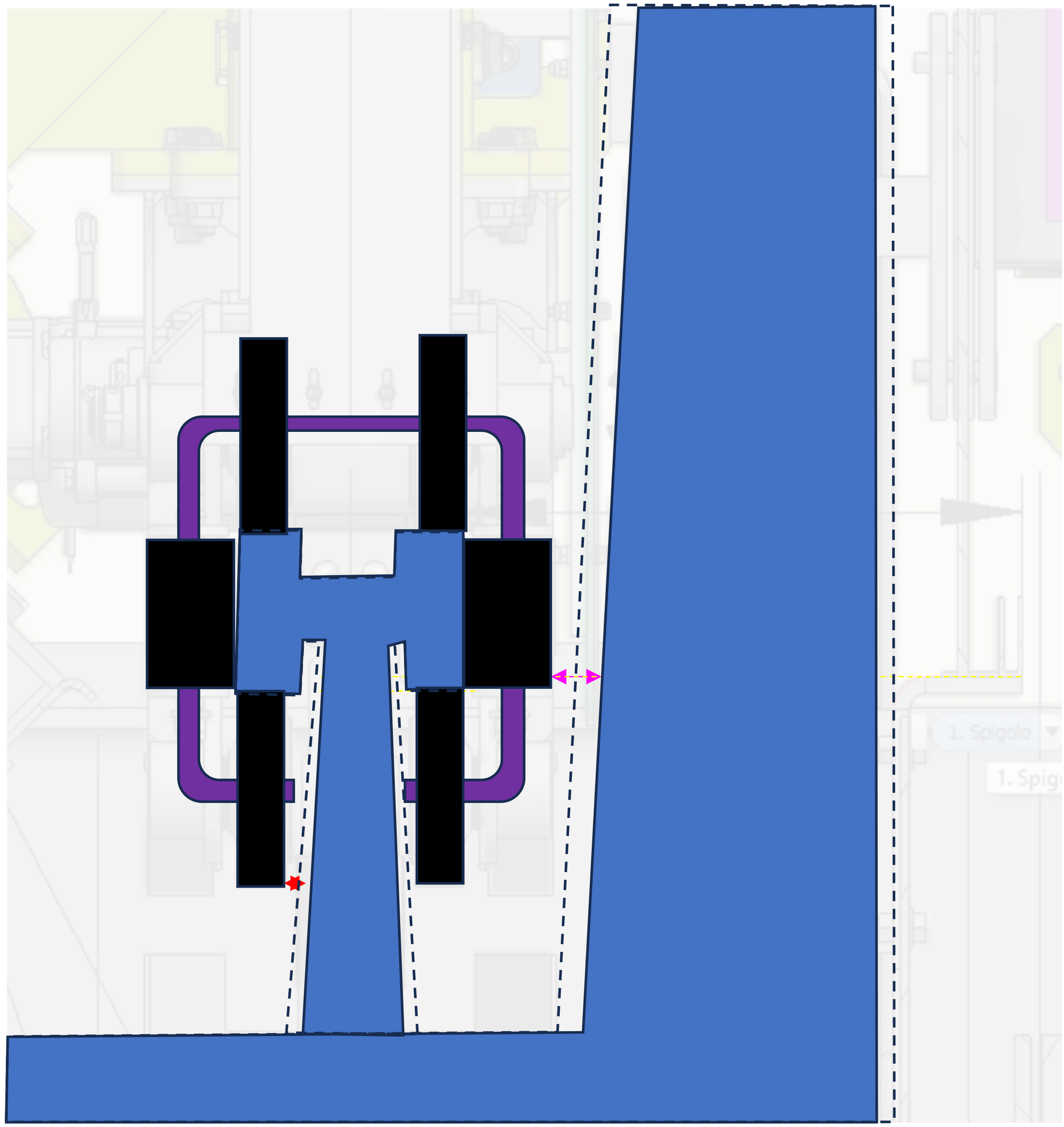
An example: the rail

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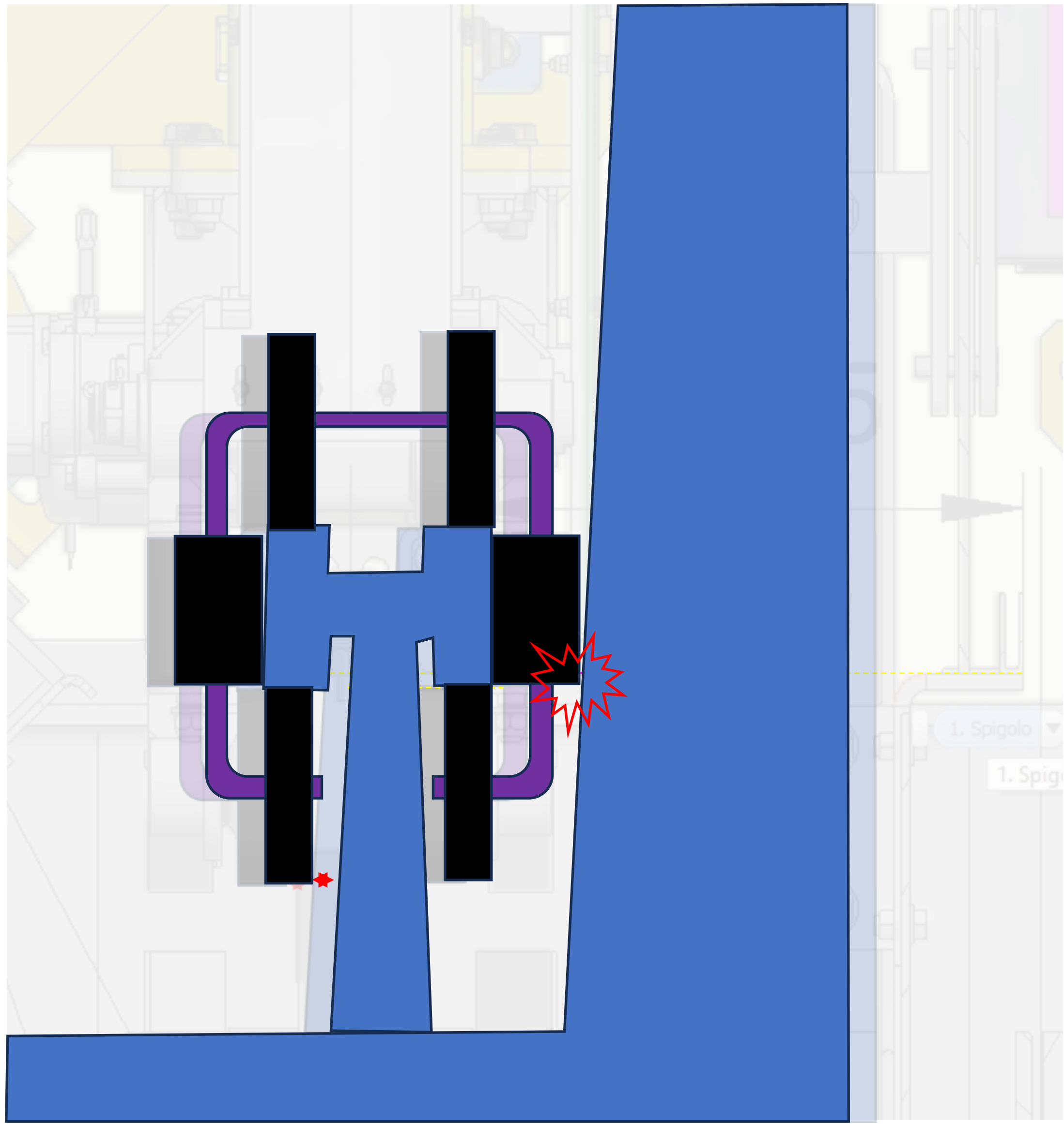
An example: the rail



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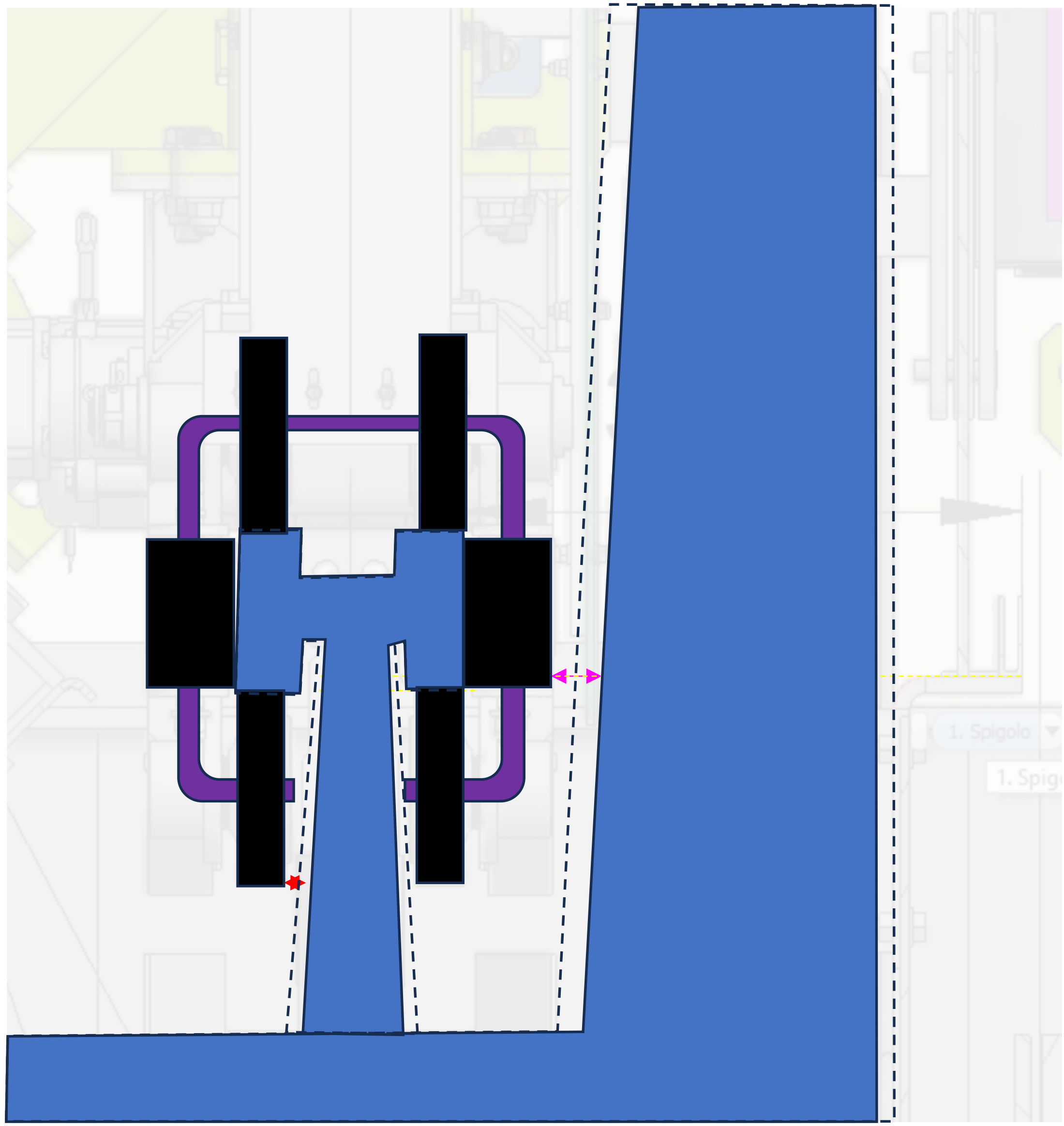
Autonomous Robot System for Monitoring and Cleaning of Bridges

An example: the rail

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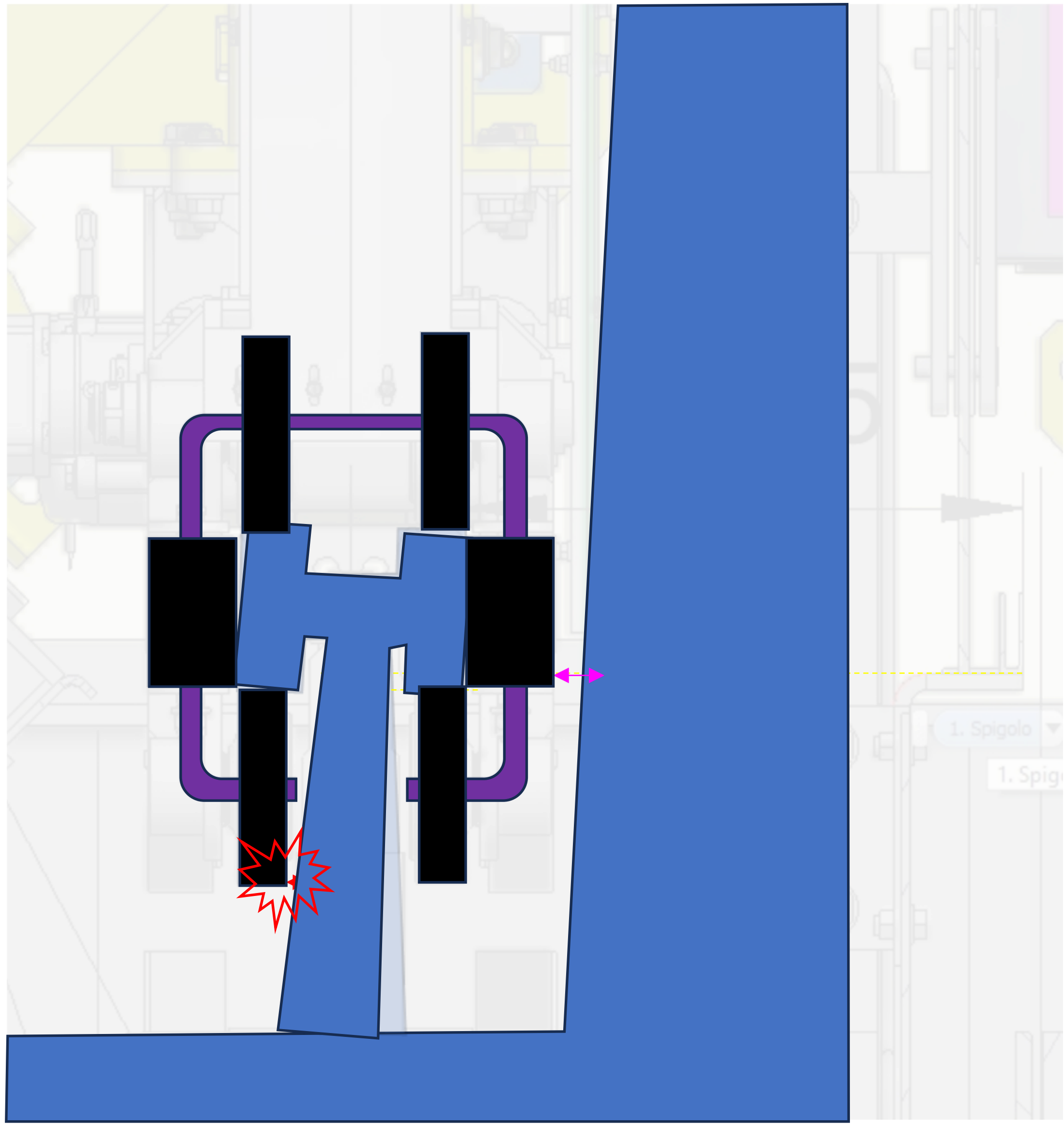
An example: the rail



...and so on...

Consequences…

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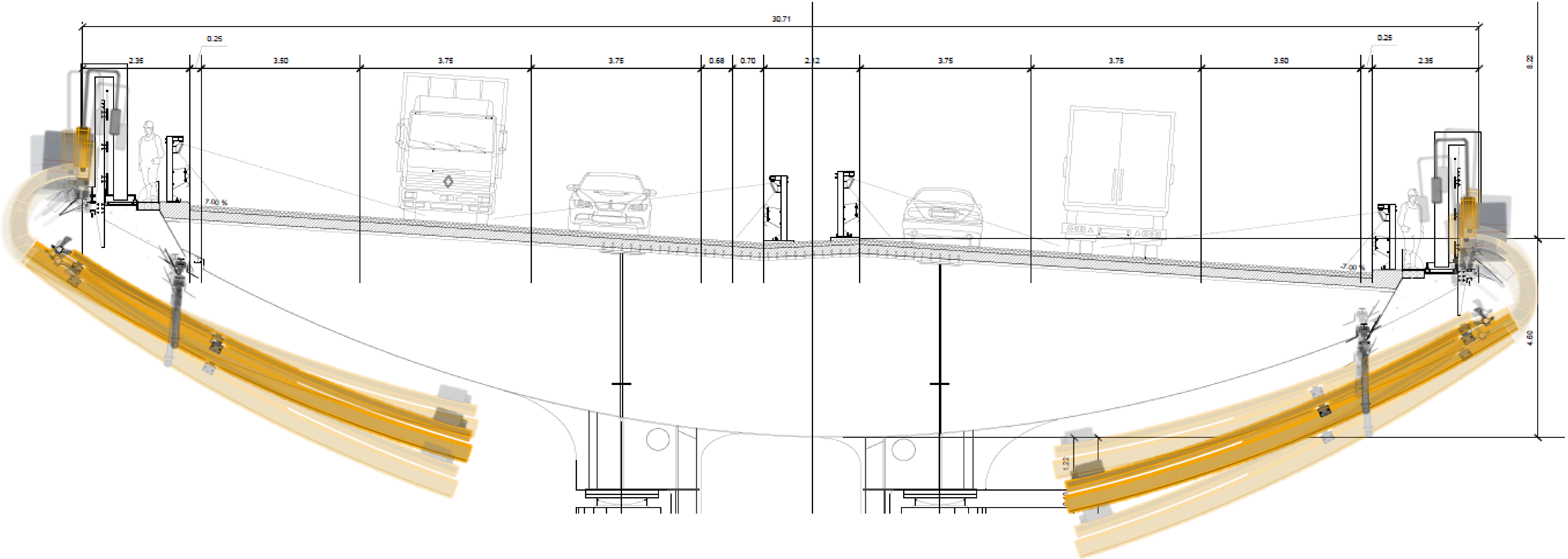
Tolerances differences on Robot Inspection Kinematics



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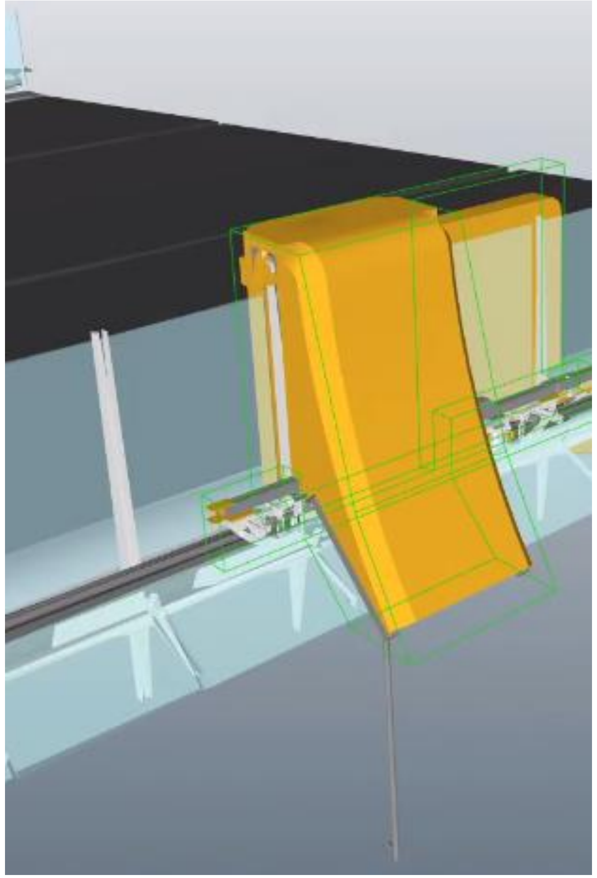
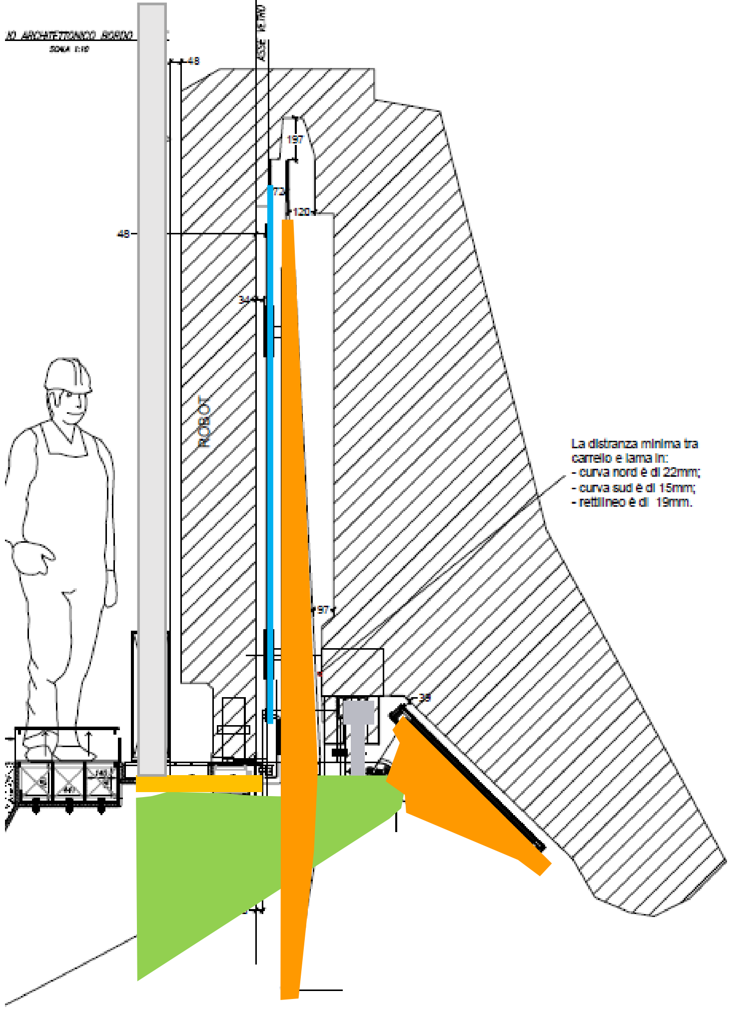
Tolerances differences on Robot Wash Kinematics





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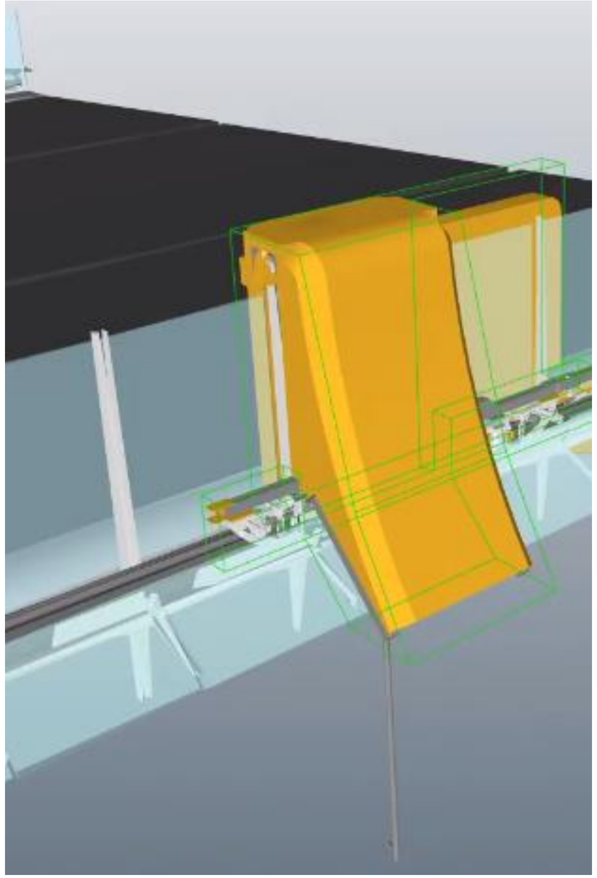
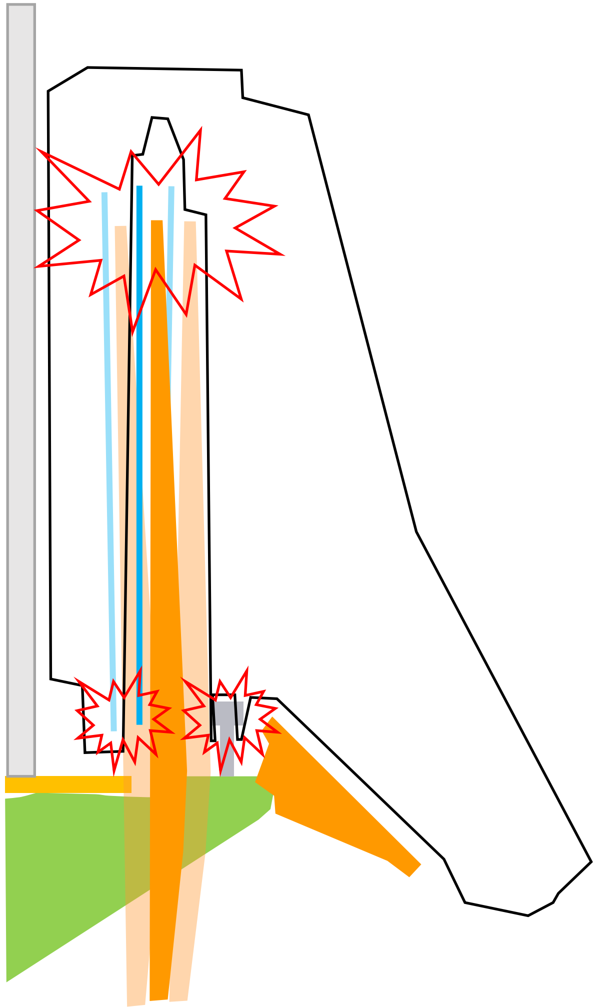
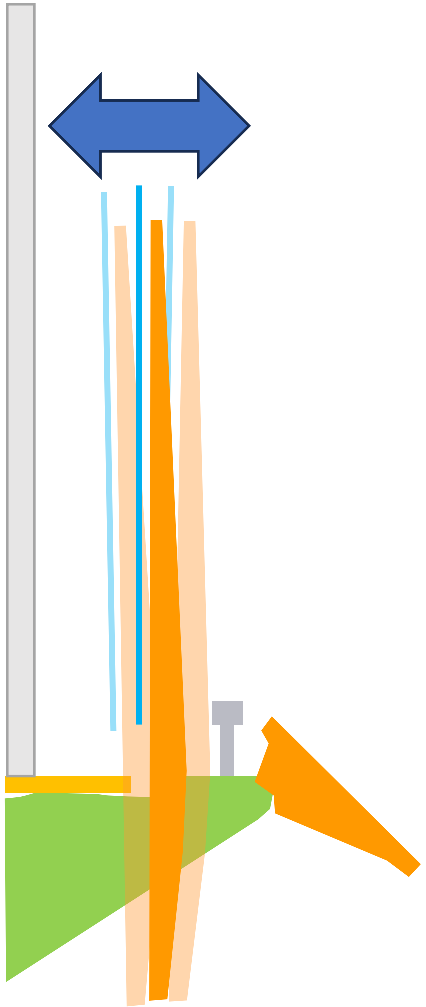
Tolerances differences on Robot Wash Kinematics







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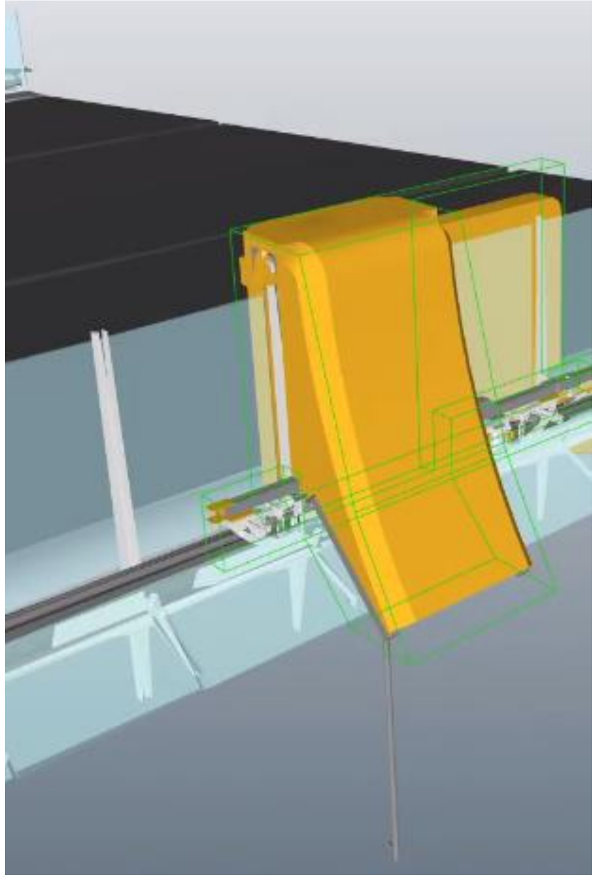

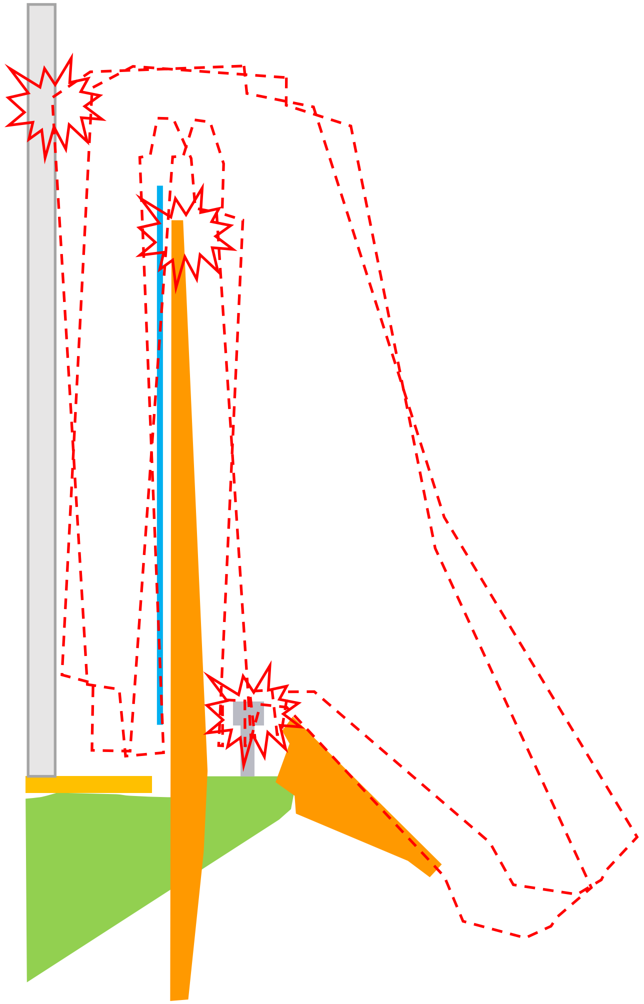


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How to face it?

The solution we have found was the improvement of the robot "awareness":

1) Improving the "environment perception": Cognitive Mechatronics to support the standard control
2) Increasing the degrees of freedoms of the robot: the robot is able to "adapt" to the "unstructured" environment



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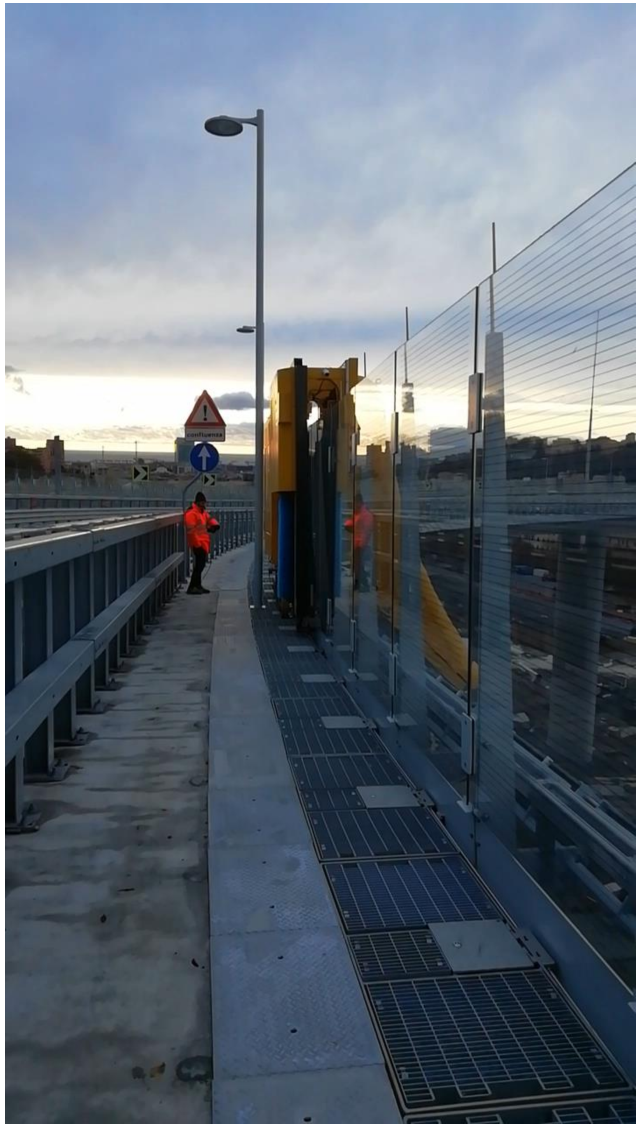
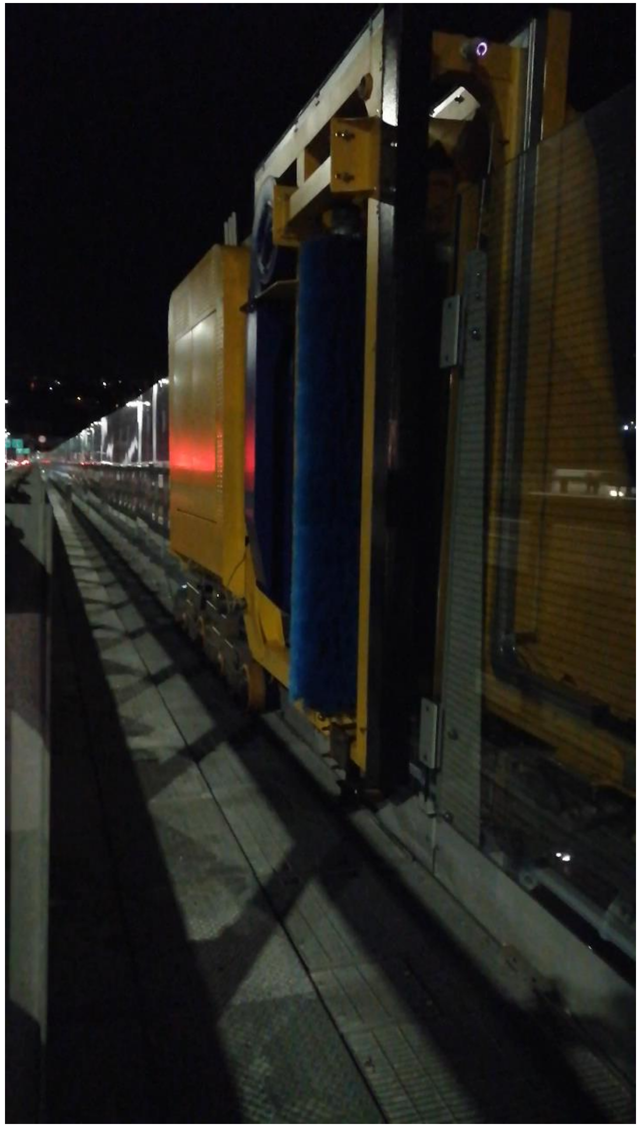
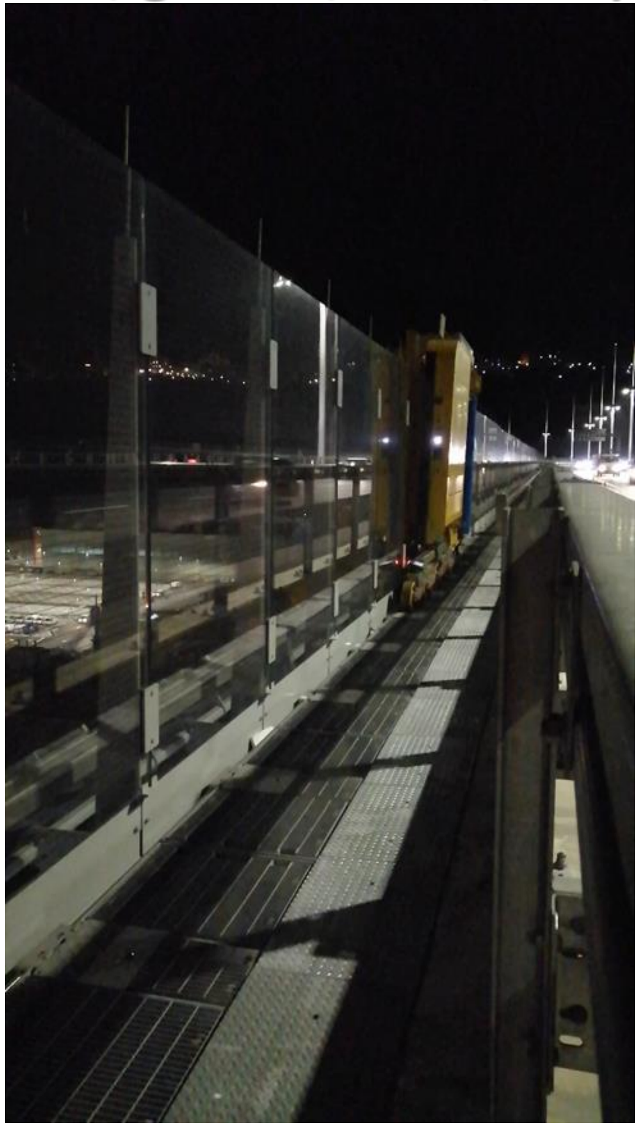
The transversal movement compensates the structure misalignments (rails, glasses, floor, etc.)





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Conclusions

The robot is Fully Autonomy and then can manage the:

- tasks without operators
- batteries
- wind, rain, etc. interferences
- running “into the wild” bridges
- etc…

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...but HOW TO USE A 2400KG (5300pouds), 17x7x6m (56x23x6fts) SIZE ROBOT?

Don't forget that this bridge had a lot of "architectural/aesthetic constraints":

- no rails under the deck for robot translation
- no conductor rails for robot energy suppliers
- no space outside the geometric envelope
- etc.

...HENCE, the robot inspection was shaped for a sort of "unique" bridge shape!

 

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…but HOW TO USE A 5300pouds, 56x23x6fts SIZE ROBOT?

- **Fully autonomy: no human operator is required. OK!!!**
- **Transportable?**
- **Deployable?**
- **Economic?**

 

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New FULLY Autonomous Robot Monitoring

- Fully autonomy: no human operator is required. OK!!!
- **Transportable**:
  - Size: smaller (2ft x 2ft x 3ft) than RI&RW on San Giorgio Bridge
  - Weight: smaller (20-30kg/60-90pounds) than RI&RW on San Giorgio Bridge
- **Deployable**:
  - multi-purposes
  - one “handle” as truck
- **Economic**:
  - commercial components
  - control and vision implementation
- Safe System:
  - no interaction with other infrastructures
  - all the components are mechanically under control
- Geometry Monitoring into details: obstacle avoidance
- Maintenance operations: can be in contact with surface

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Development and Deployment

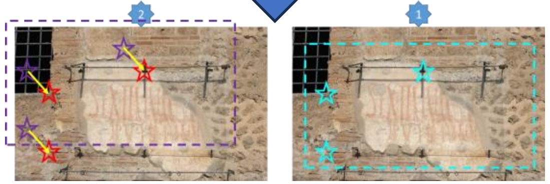
2018-2021

2021-ongoing

Mobile System

RINGHIO
(Robot for Inspection and Navigation to Generate Heritage and Infrastructures Observations)

Vision System



2021-2022 … …2023-ongoing (hope…A lot!!!)

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Use of eLoFTR matcher to align the two images

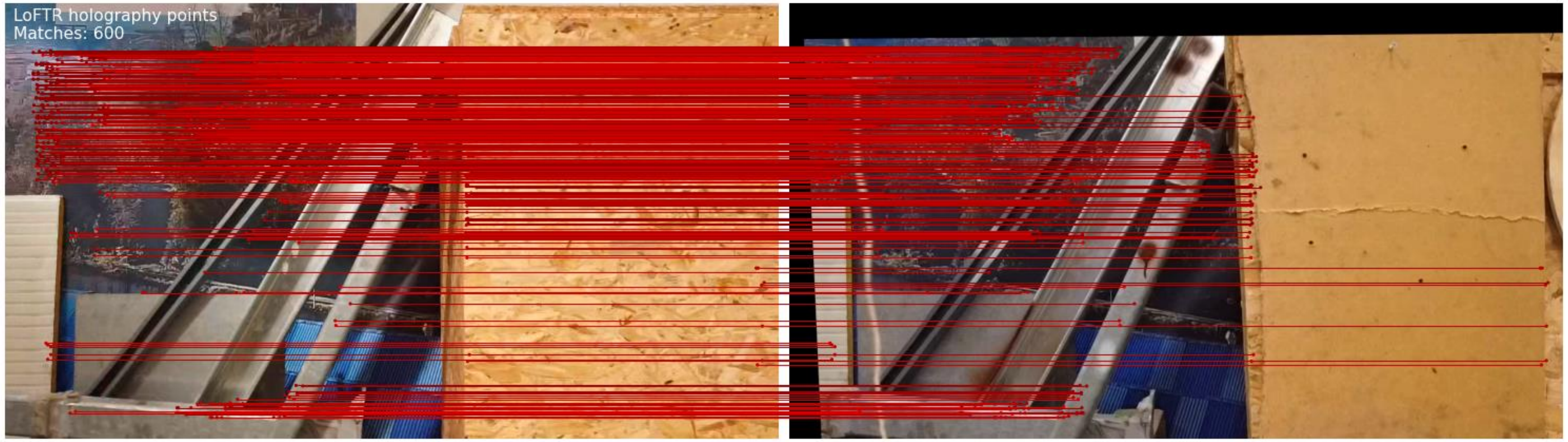

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Image alignment results

Image overlap **without** homography

Image Overlap **with** homography

 

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Take Home Message

Enhancements:

– fully autonomous system for standard inspection (and monitoring) and semi-autonomous system on-demand for ad-hoc inspection
– deployable for whatever infrastructure (new version is hundreds pounds!!!) and modular subsystems for being suitable for different applications
– open platform for future equipment (hw & sw) and database available for the other investigations

STEP-CHANGE:

- **RELIABLE: These robots are able to take into account the self-diagnosis, structure conditions, weather conditions, people presence and inspected/cleaned surface conditions!**
- **STANDARDS: First time autonomy machines are working on real civil structure (standards had to be ri-adapted!)**
- **ADAPTABLE: Successful match between the accuracy "less than millimetre" of the Roboticists and that "more than centimetre" of Civil Builders (mindset had to be changed!)….the robot could adapt to the design and building tollerances**
- **These robots will**
  - **optimize the (time and safety) human resources (M$!!!),**
  - **improve the structures safety**
  - **reduce the impact on traffic**


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InBot – USA links (2021/22)

BRIDGE PRESERVATION BLOG
A CONVERSATION ABOUT BRIDGE PRESERVATION

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Posted on December 14, 2021 by Bridge Blog ← Previous Next →

A Conversation with Ferdinando Cannella

By Lorella Angelini, Angelini Consulting Services, LLC

This post is dedicated to the innovative, robotic solutions for cleaning and inspection that were implemented in the new construction of the San Giorgio Bridge, in Genoa, Italy (see LINKS)

— Ferdinando Cannella, PhD, Head of the Industrial Robotic Unit at the Istituto Italiano di Tecnologia (Italian Institute of Technology)

This major urban bridge (Pics. #1 and #2) replaced the Morandi Bridge over the Polcevera river that dramatically collapsed on August 14, 2018 taking the lives of 43 people. The new San Giorgio bridge, which was inaugurated on August 3, 2020 with the Italian President, Sergio Mattarella, in attendance, was built in 13 months through a collective effort that encompassed the work of 330 companies and 1000+ people.

drones or by inspections carried out by individuals, whose reporting always contains subjective elements of evaluation. Even if inspections are carried out by the same individual, this individual cannot guarantee that two or more reports will not be somehow affected by his, or her, subjectivity.

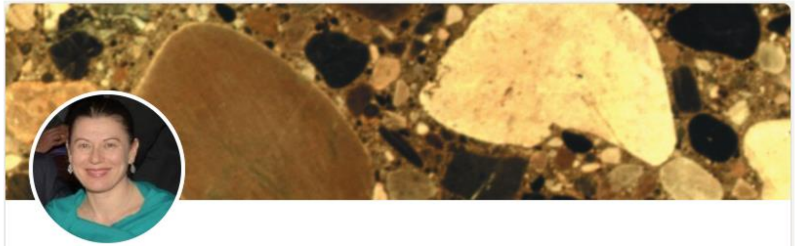
— Pic #8: Cameras on the Retractable Beam of the RobotInspection (from Camozzi)

Does the RobotInspection have other functions in addition to scanning the outer bottom of the steel girder?

Yes, the RobotInspection can be equipped with an additional retractable beam that is connected to the retractable section of the main beam. The main beam is a huge structure (see Pic #9) that can carry up to 80 kg (176 lbs.) on its end. The additional beam has the ability of moving toward the surface of the steel girder to the point of touching it. It is designed to carry specialized instruments, such as 3D camera and ultrasound sensors that can provide in-depth information of steel imperfections. Ideally, in the future, the additional beam could also be equipped with instruments for painting and touching up.

The additional beam is designed to be used ad hoc. For example, if pictures taken by the main beam show 3 or 4 anomalies in the girder's steel surface, then the owner has the capability of using the additional beam to evaluate these anomalies. If one of these anomalies remains questionable after the second inspection, then it is time to send an inspector. As a result, the robot has reduced the use of inspectors to a bare minimum, thus lowering costs and risks.

— Pic #9: Size of the Transversal Beams of the RobotInspection (from Building CuE)



Lorella Angelini · 3°
Principal at Angelini Consulting Services, LLC
Minneapolis, Minnesota, Stati Uniti d'America · Informazioni di contatto
482 collegamenti

Angelini Consulting Services, LLC
Università Politecnica delle Marche, Ancona, Italy

Messaggio + Segui Altro

Collegati se vi conoscete Collegati

Informazioni

I am a civil engineer with knowledge of materials and technologies for the construction industry, especially the repair and maintenance of concrete bridges and commercial buildings. Having 25 years of business-to-business marketing experience in Europe and the USA with ICI and BASF, my consulting activity focuses on supporting companies in finding market opportunities for growth and designing the marketing plan to take advantage of these opportunities. Due to my technical knowledge, I am able to implement specialized actions of the marketing plan, such as getting product certifications and approvals that meet the requirements of specific market segments. I am the writer of the Blog for AASHTO TSP2 Bridge Preservation.

In primo piano

Link

A Conversation with Sarah Sondag, Principal Engineer with Minnesota DOT
Bridge Preservation Blog
By Lorella Angelini, Angelini Consulting Services, LLC A registered Professional Engineer in the State of Minnesota, Sarah Sondag is the Bridge Operations Support Engineer with the Bridge Office at Minnesota DOT. She is a prominent advocate for bridge...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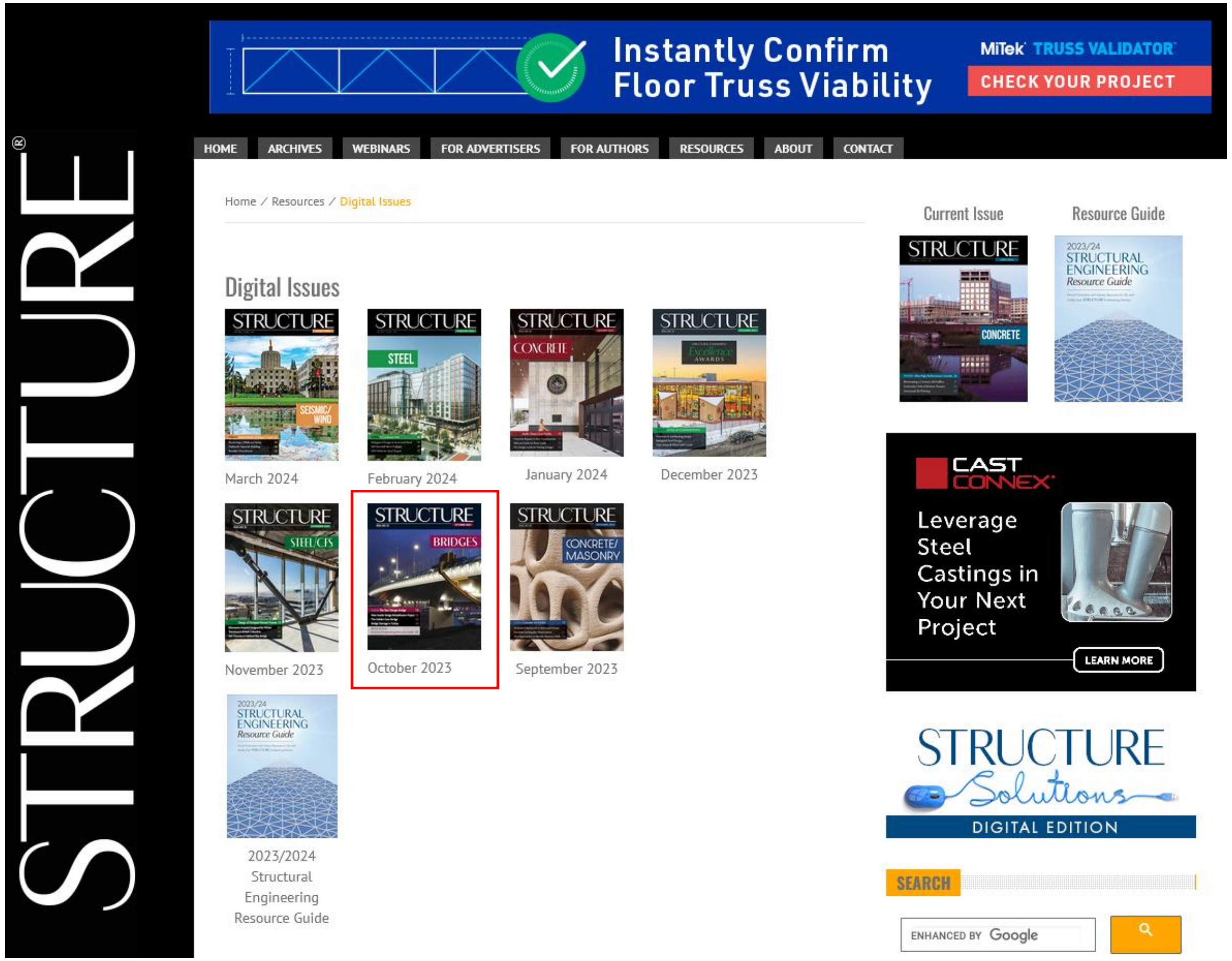
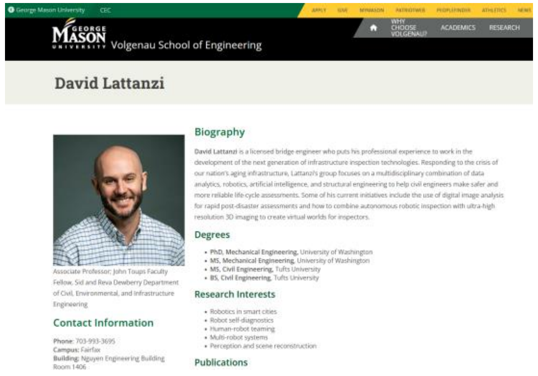
InBot – USA links (2023)



Source: https://www.structuremag.org/?p=25413



Source: https://volgenau.gmu.edu/profiles/dlattanz

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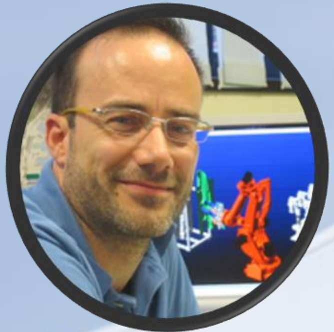
Thank you for the attention!



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