Roberto Galeazzi

Head of DTU Centre for Collaborative Autonomous Systems

Jochen Teizer

Professor @ Department of Civil and Mechanical Engineering

# AI and Robotics for the Construction Industry

Agenda of the talk

- DTU Centre for Collaborative Autonomous Systems (CCAS)
- Why Robotics and AI for the construction industry
- Highlights of DTU research on robotics, AI and digital technologies in support of the construction industry
  - Aerial robotics
  - Ground robotics
  - Marine robotics
  - Digital Twins
- Conclusions

DTU Centre for Collaborative Autonomous Systems

Vision

Towards a sustainable and resilient world powered by the seamless collaboration of humans with autonomous systems.

World class R&I Centre

DTU AUTONOMOUS SYSTEMS

World class Testing Facilities

MSc Programme
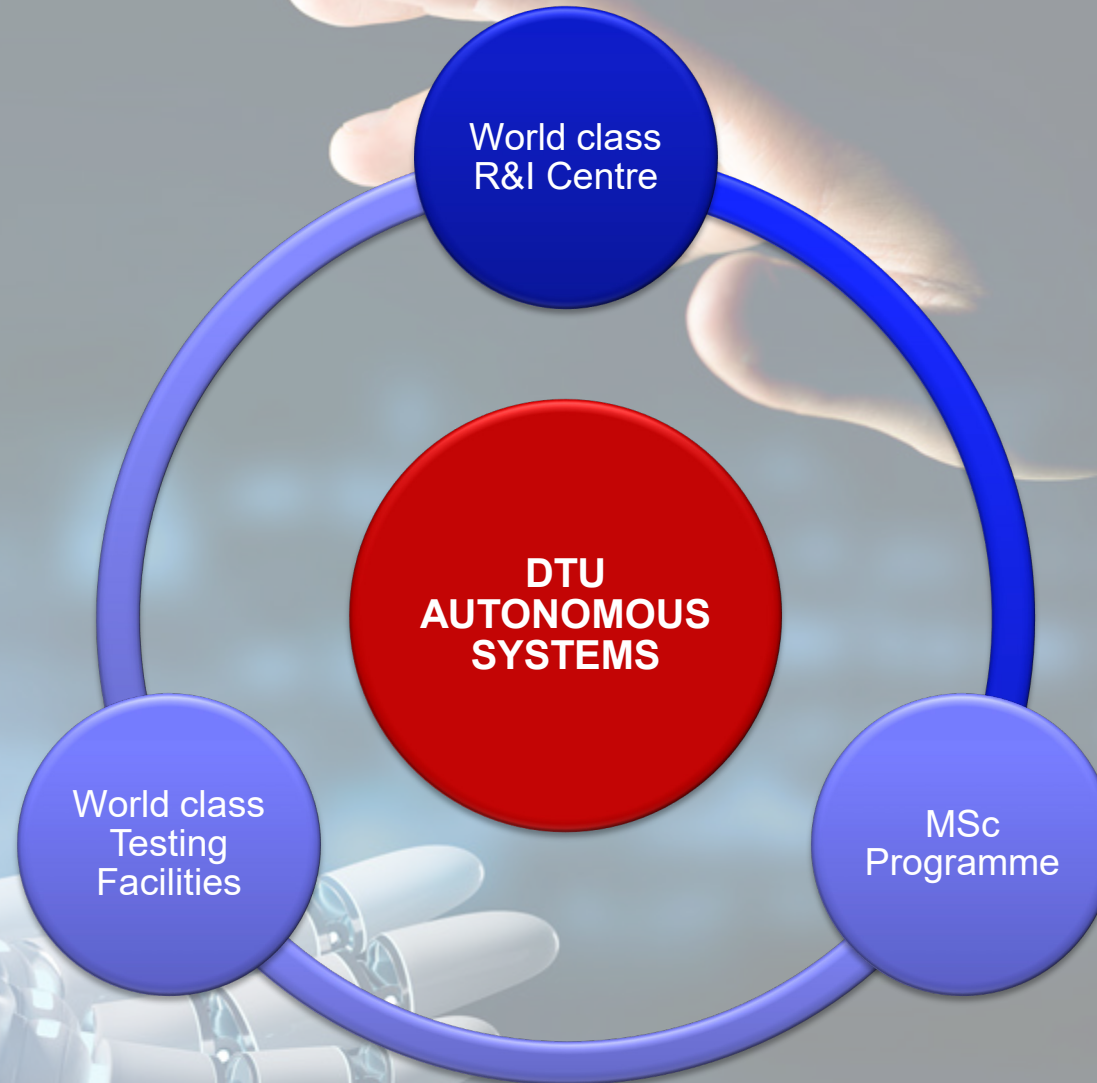
DTU Autonomous Systems
What there is in it for YOU?

- **CCAS offers YOUR COMPANY**
  - *Interaction with leading experts* on artificial intelligence, automation, digital technologies, human-machine interaction, robotics and space technology
  - *Access to cutting-edge knowledge and competences* in design, development, verification and validation of autonomous systems
  - *Help to drive YOUR next technological innovation* in home automation, process supervision, transport systems, delivery systems, energy production, precision farming, infrastructure maintenance, assisted living, environment monitoring and many more areas
- **MScAS offers YOUR COMPANY**
  - *Direct engagement with YOUR future workforce* by giving guest lectures and proposing MSc projects tailored to YOUR technological needs
- **ASTA offers YOUR COMPANY**
  - *Direct access to state-of-the-art testing facilities* where to verify and validate your XUV technologies

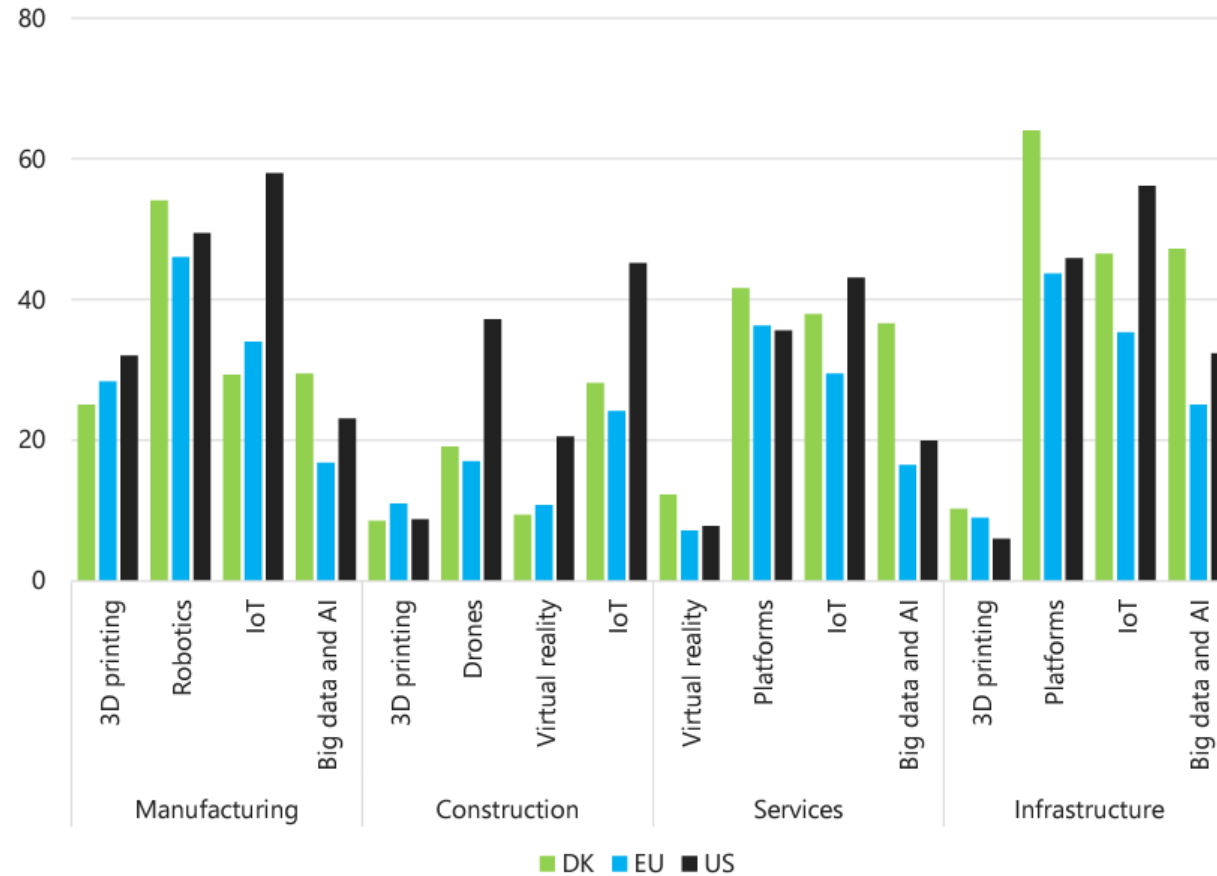# Why Robotics & AI & Digital Technologies in the construction industry?
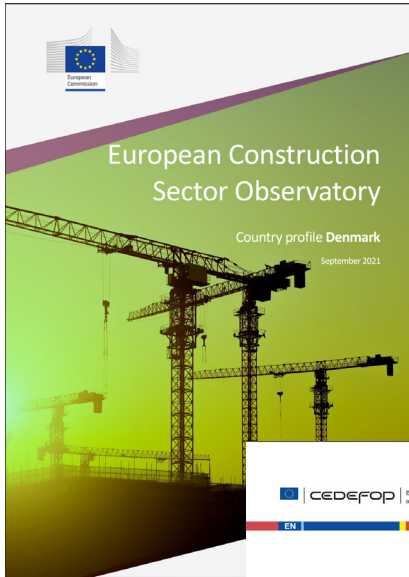
- **Specific challenges**
  - Lack of holistic innovation with systemic approach and life cycle perspective
  - High carbon and environmental footprint of the built environment and construction
  - Low uptake of innovation
- **Barriers** (among others)
  - The construction sector faces an acute **shortage of skilled workers**.
  - The limited level of **innovation activity** in the construction sector
  - **Digital adoption rates in the EU are lower than in the US**. The difference is particularly large in the construction sector ,where the share of digital firms is 40% in the EU and 61% in the US.
  - The **cost of equipment and software, lack of skilled workforce, and lack of awareness and understanding are the three main factors hindering a faster and broader digitalisation of the European construction sector**.
- **Enablers of change** (among others)
  - **Use of robotic systems** (including those used for 3D printing) and automation for construction and deep renovation
  - **Use digitally assisted design** to improve resource efficiency and safety, reduce waste, and reduce construction time
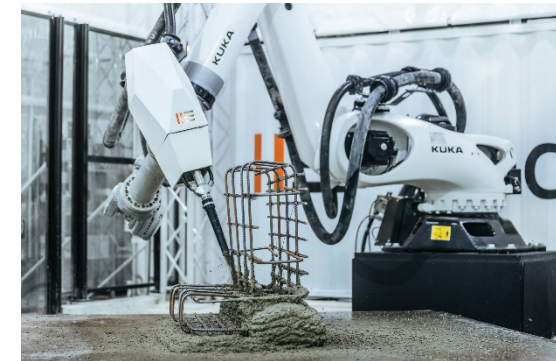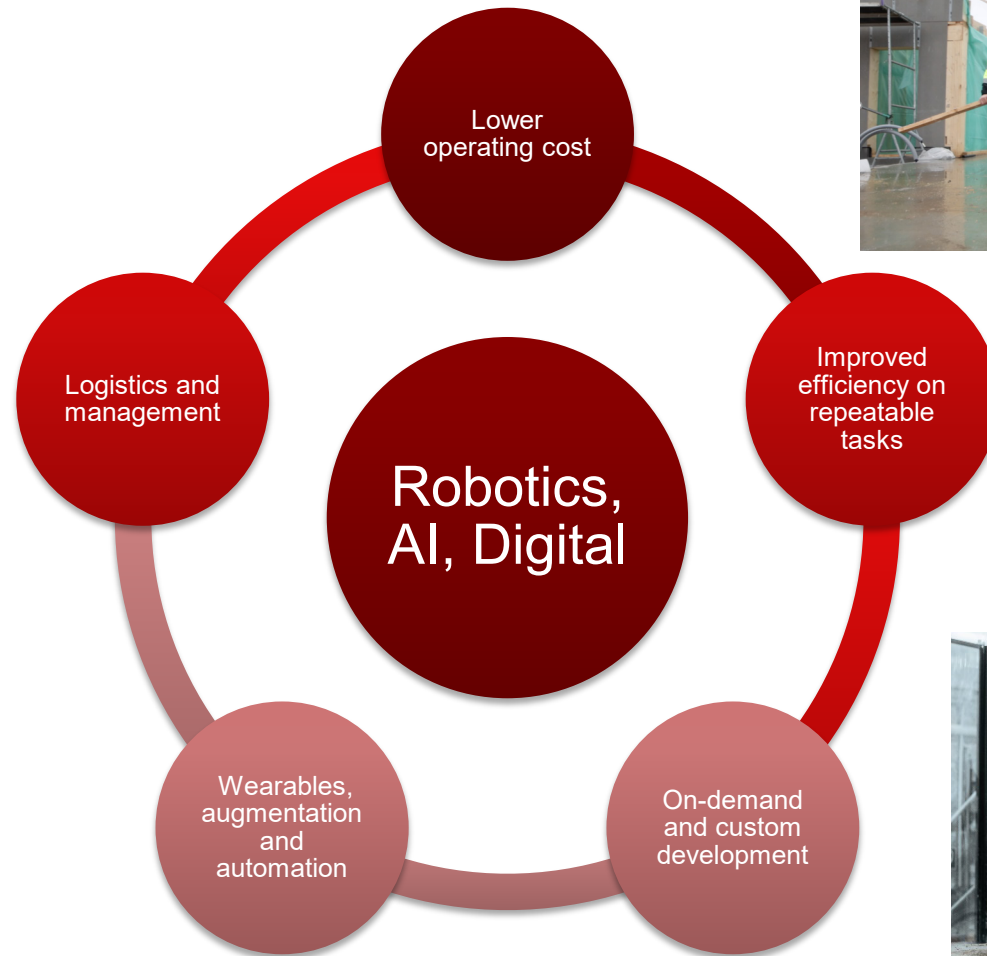
Why Robotics & AI & Digital Technologies in the construction industry?

Adoption of different digital technologies (in % of all firms), by sector

# Five ways Robotics & AI & Digital Technologies can disrupt the Construction Industry

- Lower operating cost
- Improved efficiency on repeatable tasks
- On-demand and custom development
- Wearables, augmentation and automation
- Logistics and management

Robotics, AI, Digital

Jochen Teizer

Professor, Department of Civil and Mechanical Engineering
Technical University of Denmark

Digital Twins in Construction

Digital Twins concept
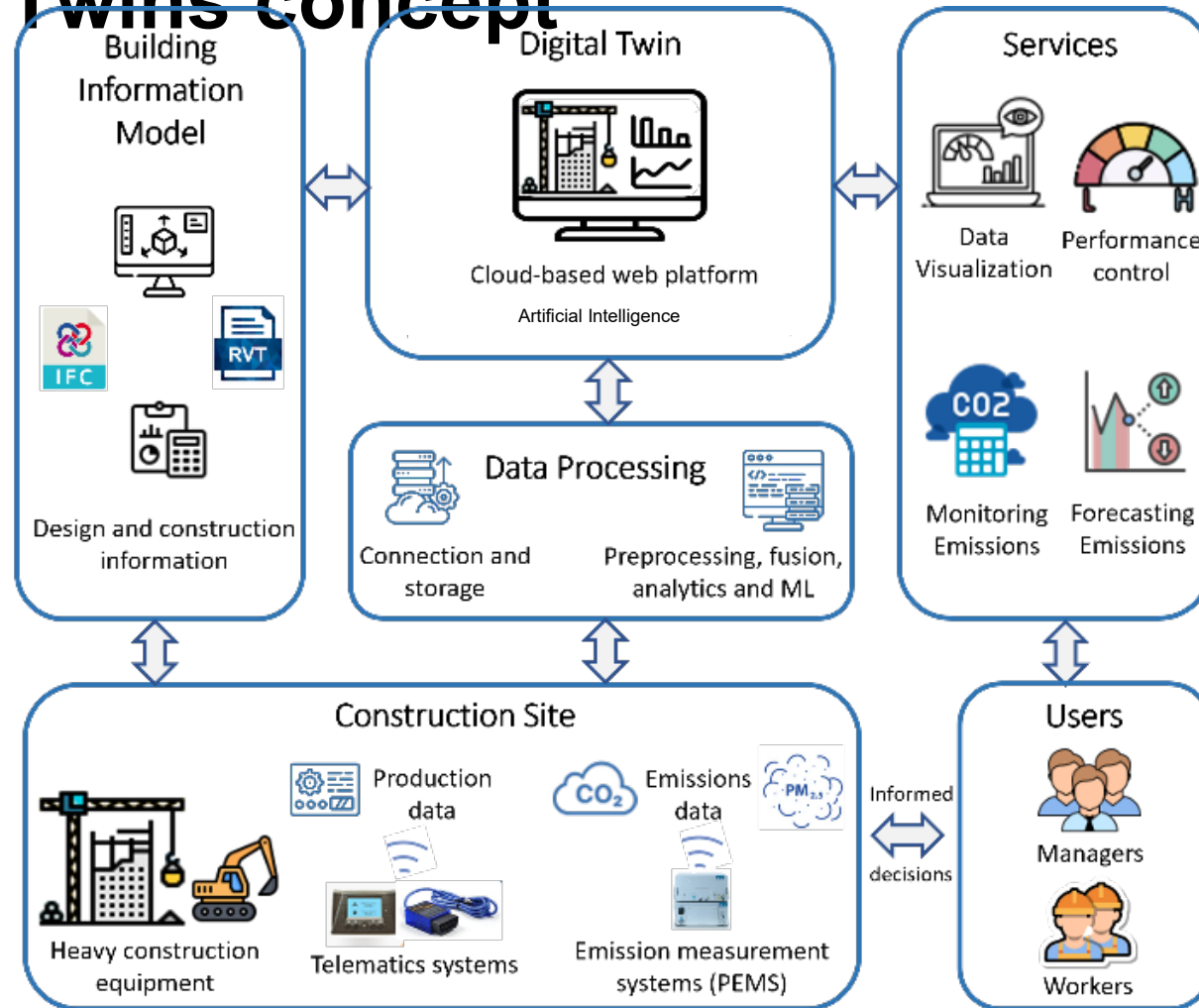
Example for emissions

AI for safety rule checking of BIM models

Before
– Unsafe construction model

After
– Safe construction model

BIM TWIN   G.A. 958398

Funded by the Horizon 2020
Framework Programme of the
European Union
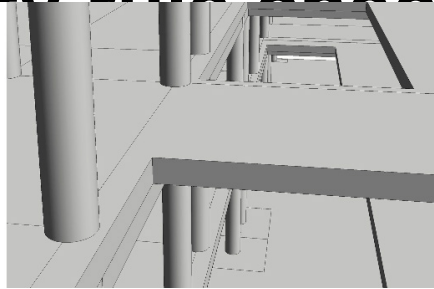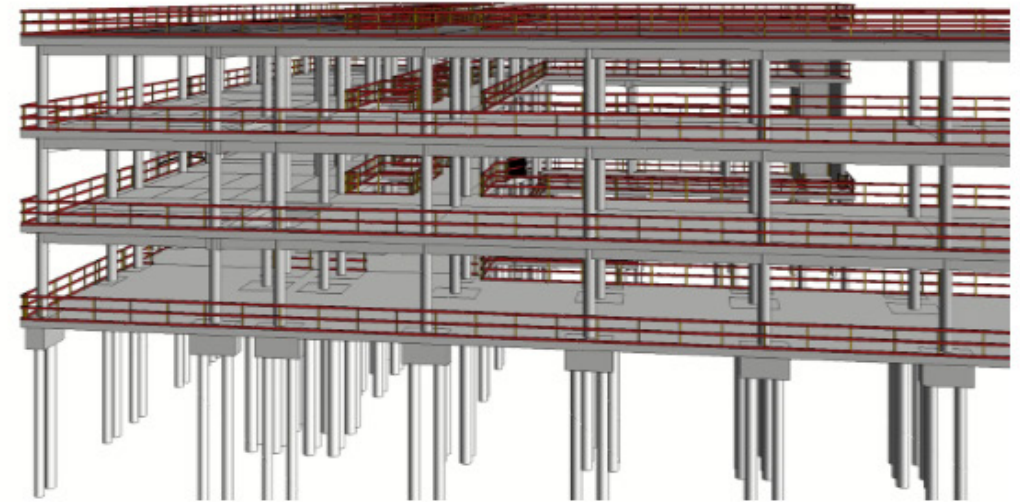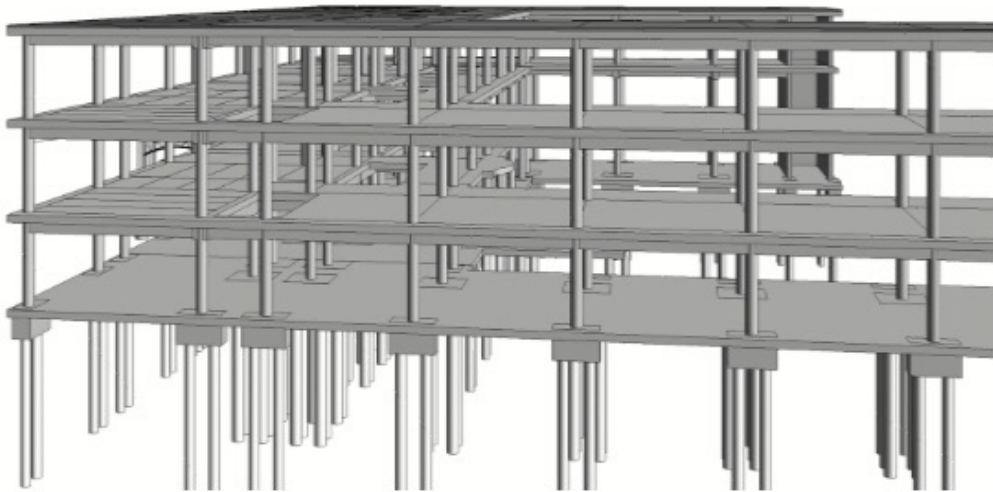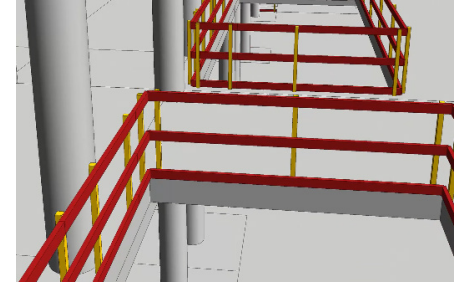
Autonomous conformance checking

Safety inspection of <u>static</u> PII of on construction site

- Apply UAV, ground level robotic or AR-handheld system
- Collect or generate point cloud data
- Translation and pose estimation of guardrails
- Classification and identification
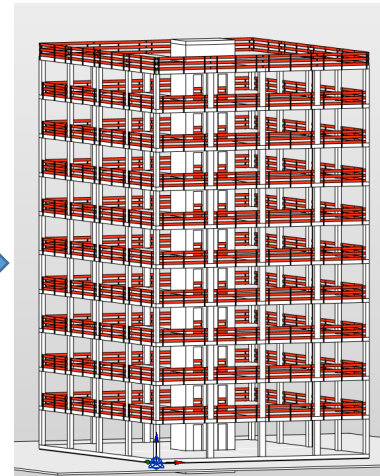- Assessment
- Reporting
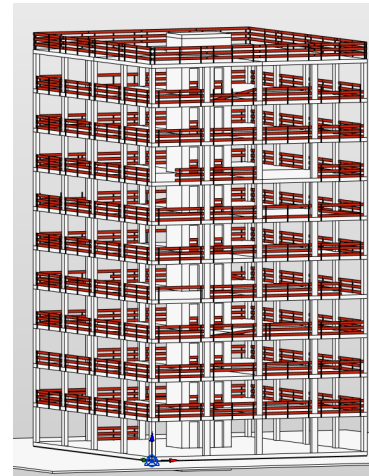- Mitigation

Safety rules
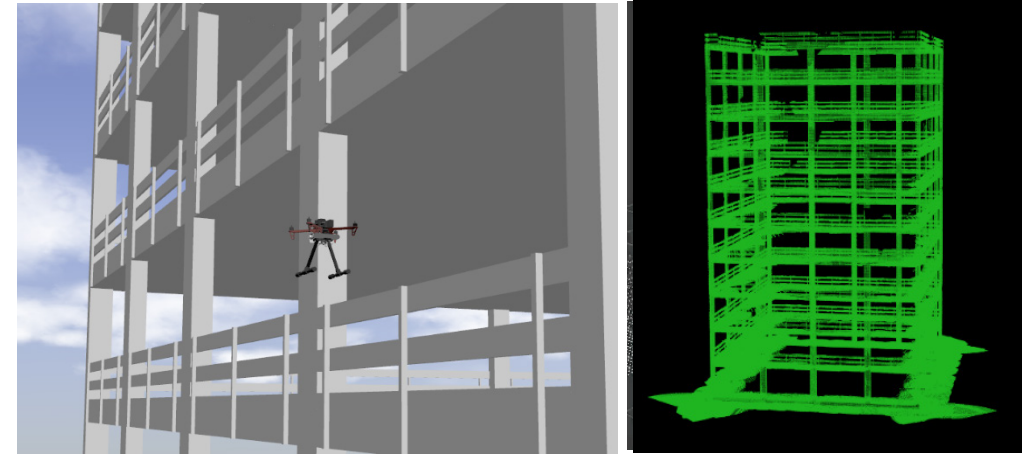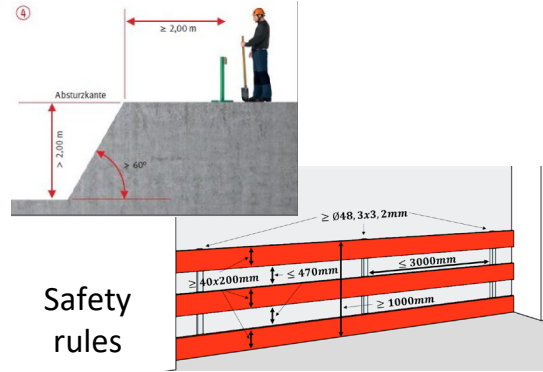
Simulated or real data from drone

Point cloud data
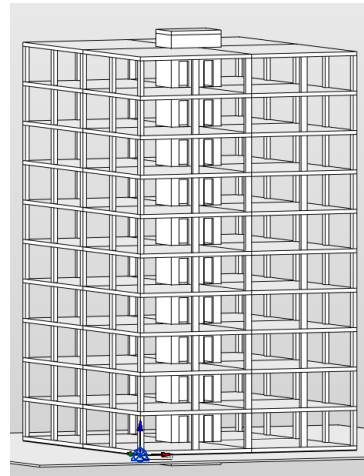
Utilize empty model (as-designed)
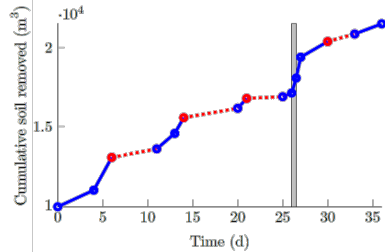

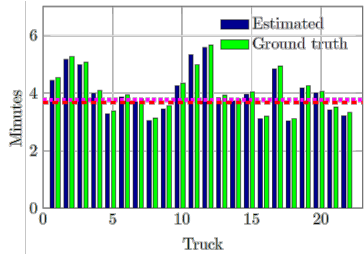Create safe model (planned)

Detect unsafe parts (reality)

Identify, alert, and, mitigate

Worksite progress monitoring

Excavated volume over time

Time to load trucks

Site without dump truck

Frame #15341

Pedestrian workers below load hazard
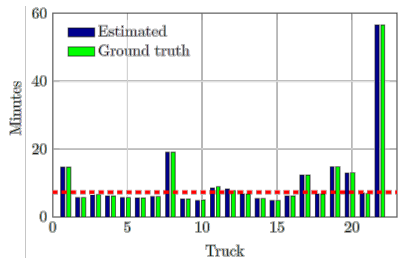
⭕ Truck at loading station

✖ Truck waiting

▽ Truck loading

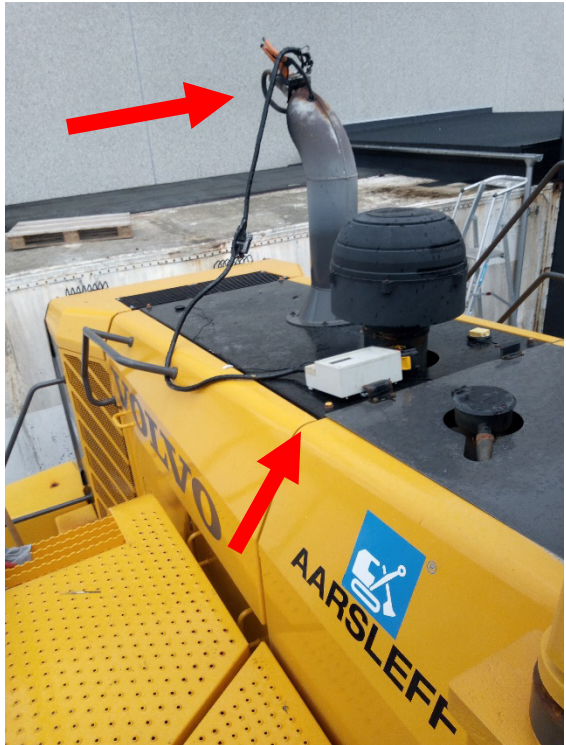# Real-time proactive proximity alerting of workforce that are too close to machines
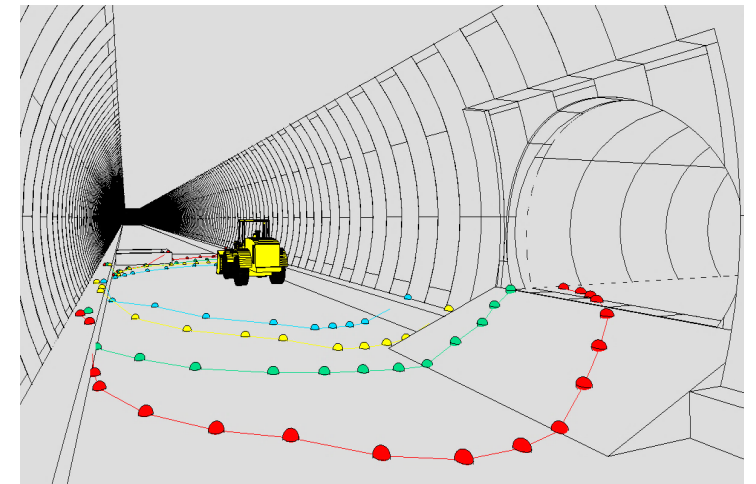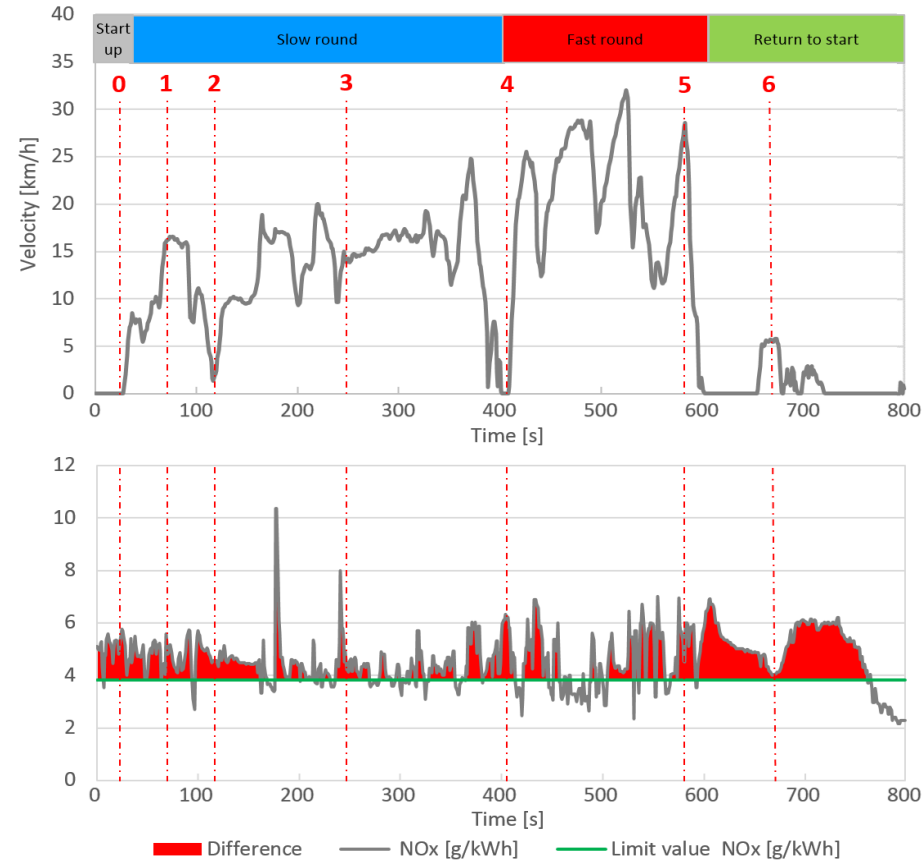

COGITO   G.A. 958310

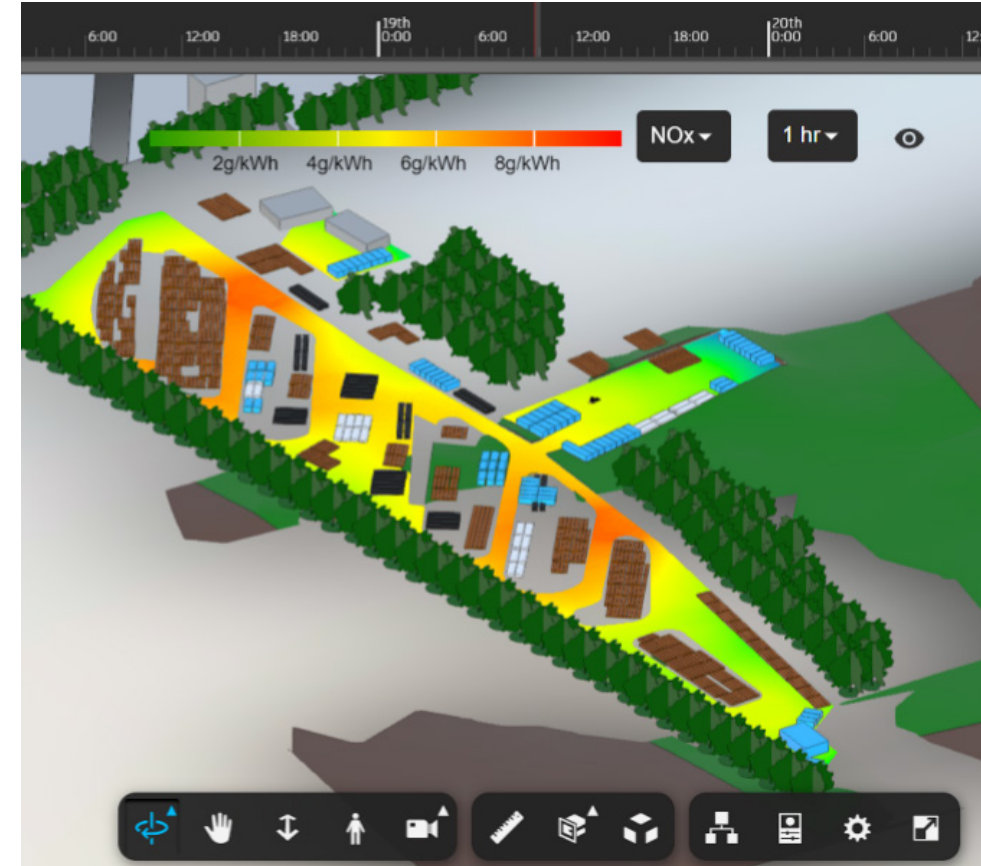Funded by the Horizon 2020
Framework Programme of the
European Union

Heavy equipment emissions monitoring
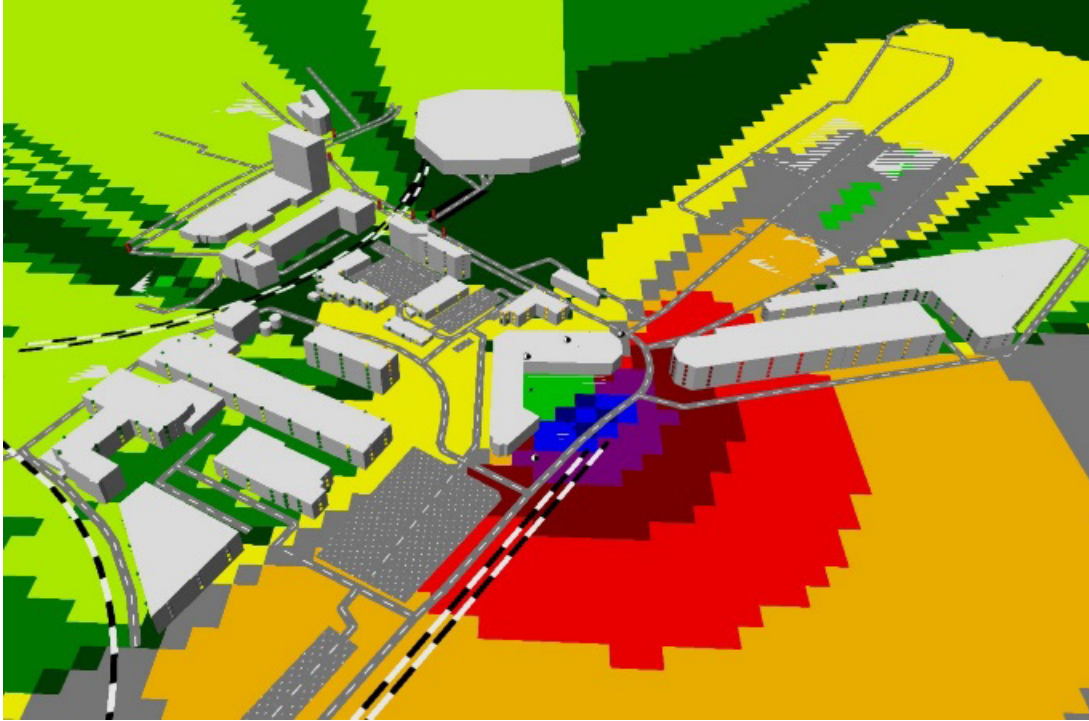

GHG and noise emissions

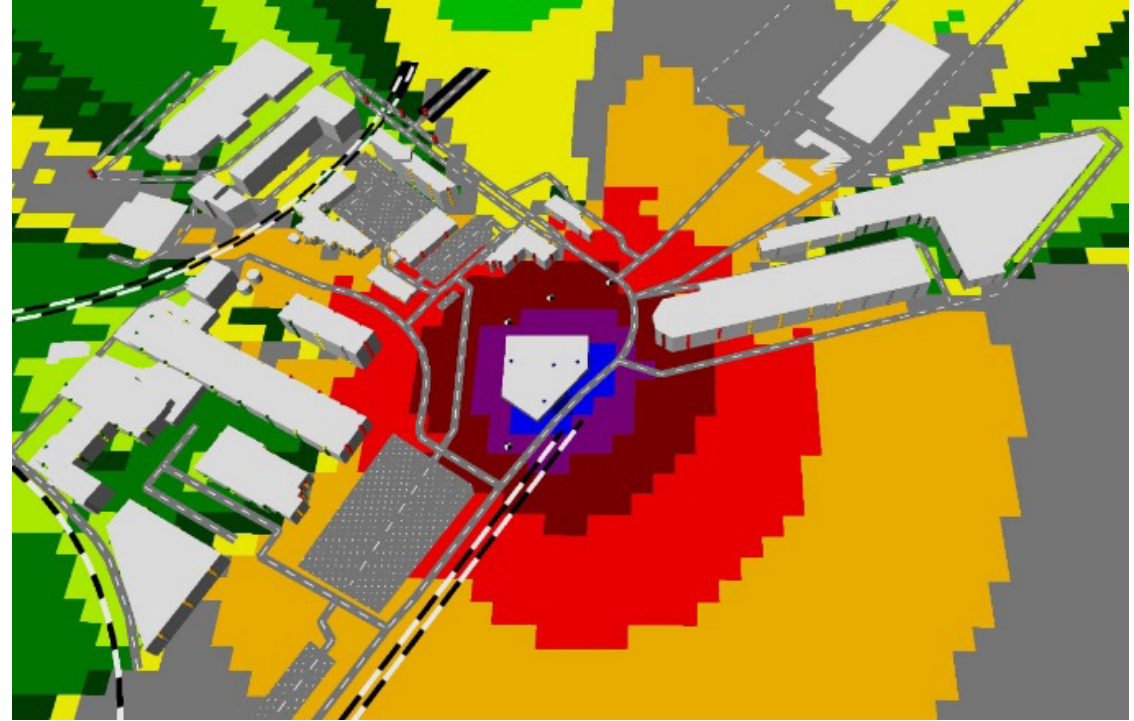Digital Twin, incl. data processing

Data visualization

IoT and AI for simulating construction noise emissions and elimination
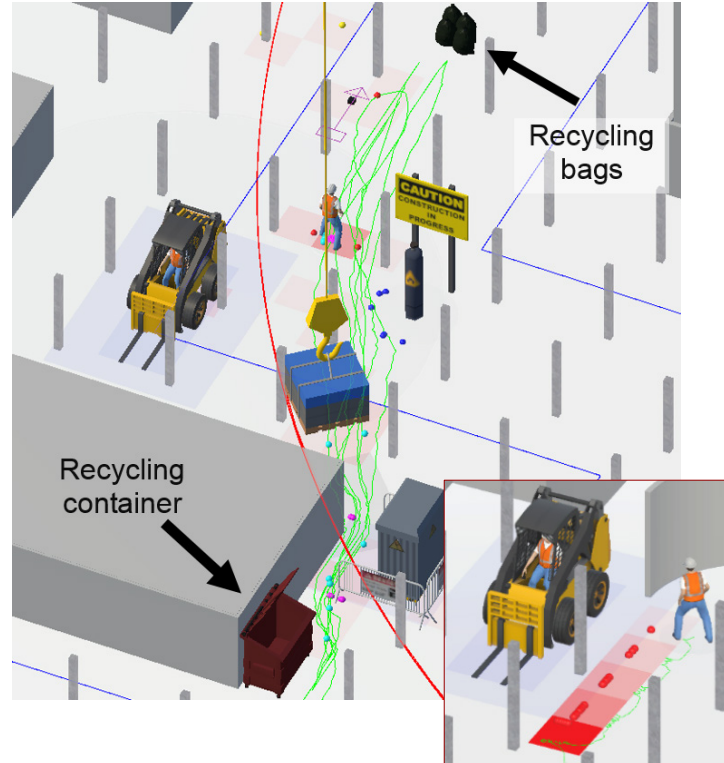

With the remaining structure

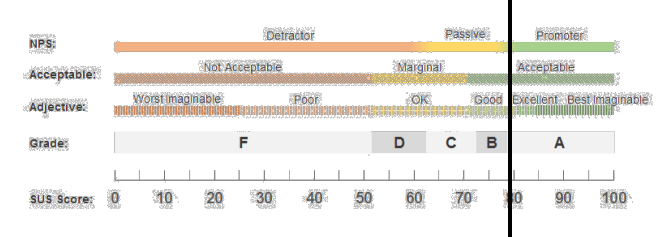Without the remaining structure

Active personalized safety training with XR

- Stimulating haptics

System Usability Score

User Experience (UX)
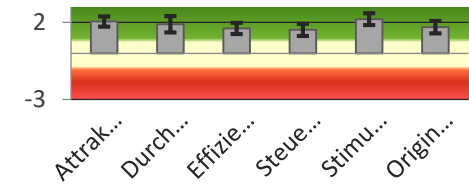
Net promoter Score

What is the likelihood that you will recommend this experience to someone else?

33,3

Recycling bags

Recycling container

BEEYONDERS G.A. 101058548

Funded by the Horizon 2020 Framework Programme of the European Union
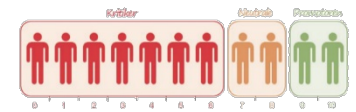
Alternative design and digital fabrication in a circular economy
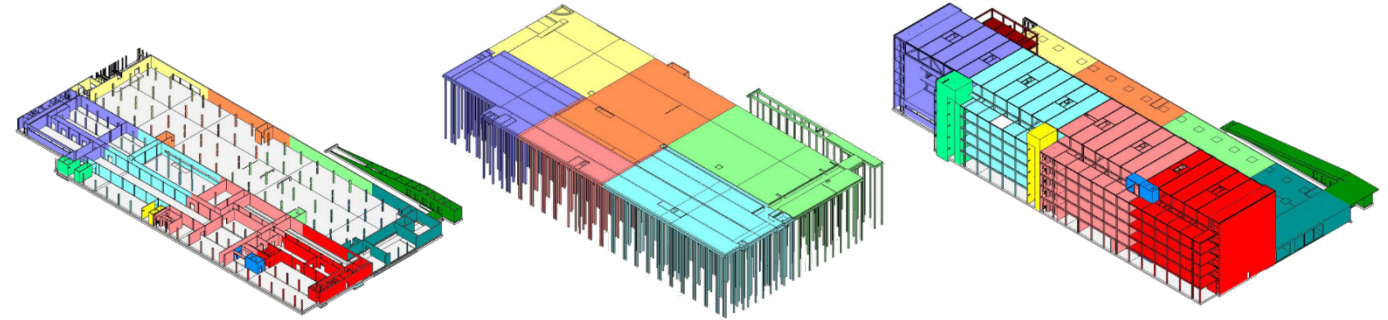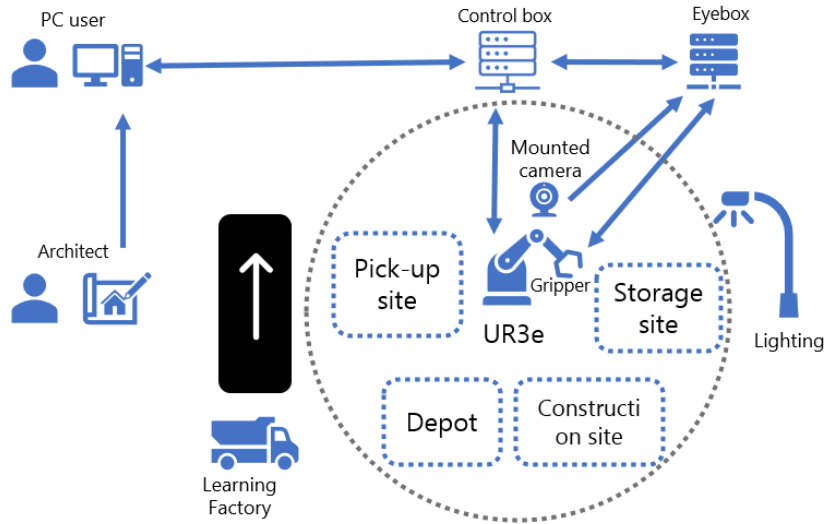
Future vision
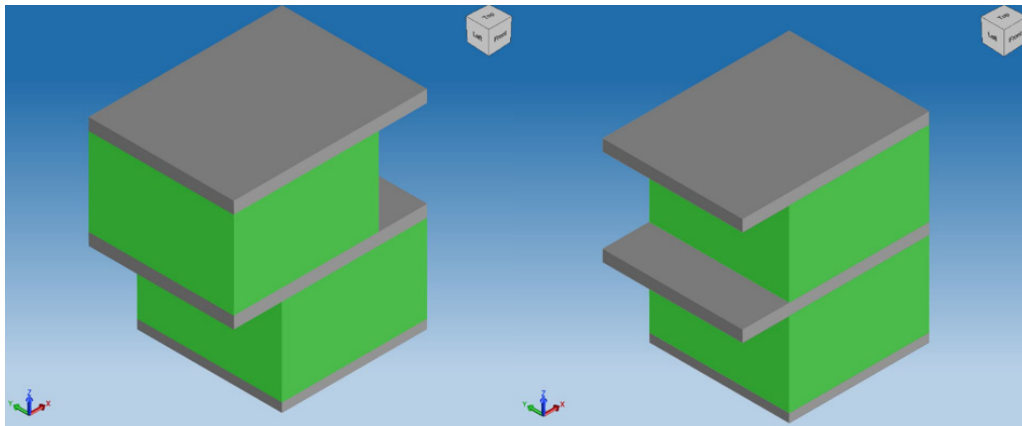
Simplified building
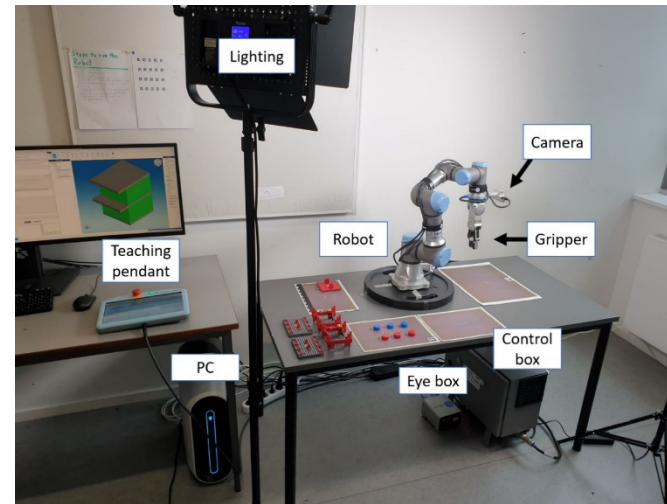
Automated production
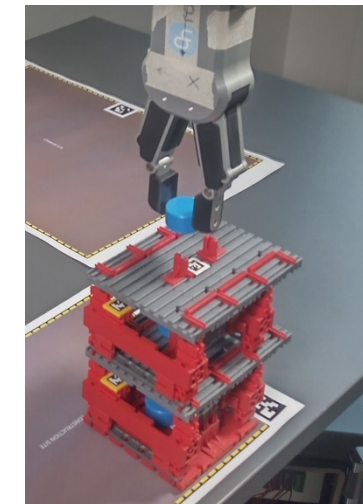
Associate Prof. Matteo Fumagalli, DTU Electro

Aerial robotics: physical interaction at height

AERO TRAIN

AErial RObotic TRAINing for the next generation of European infrastructure and asset maintenance technologies
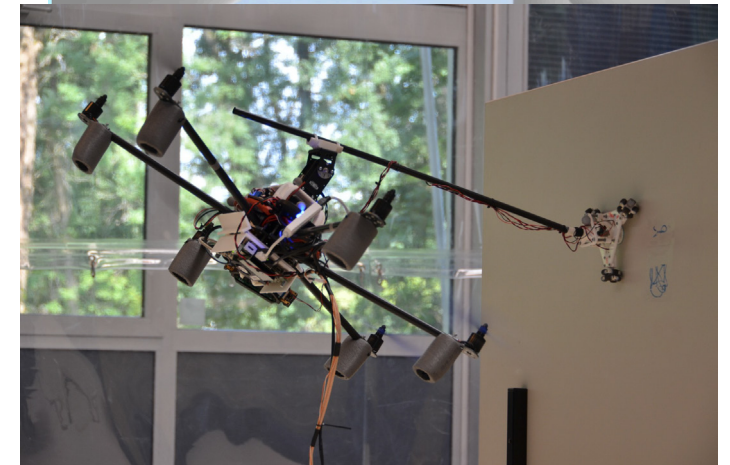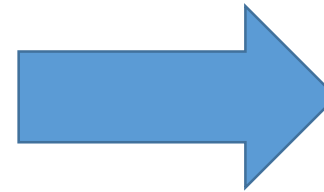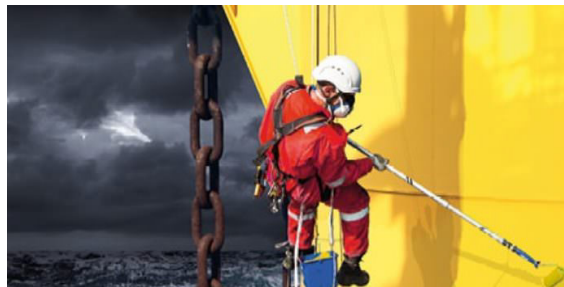
Why AERO-TRAIN?

AERO-TRAIN some intermediate results

Industrial collaborations

Active End-Effector Driven Omni-Sliding Employing an Over-Actuated Aerial Vehicle: Towards Versatile Ultrasonic NDT Technologies

Tong Hui, Marius Fehr, Nicolas Scheidt, and Matteo Fumagalli

The 18th International Symposium on Experimental Robotics (ISER 2023)

AERO-TRAIN some intermediate results

Integration week 2
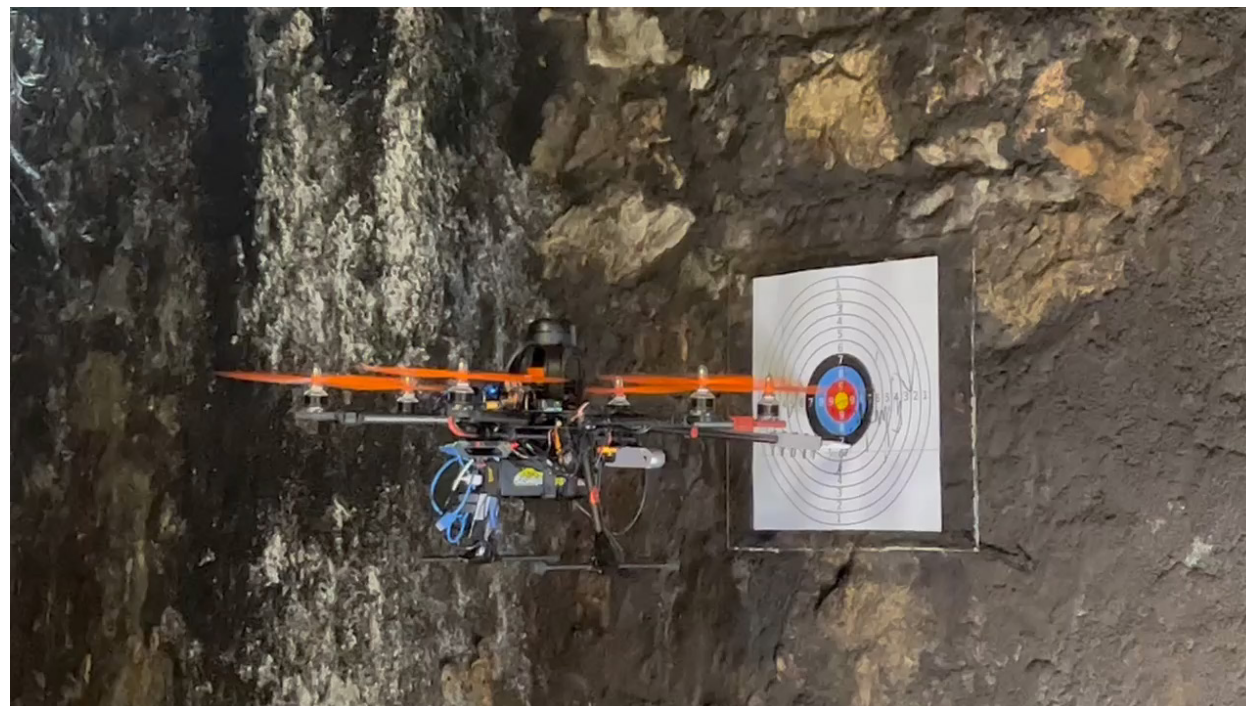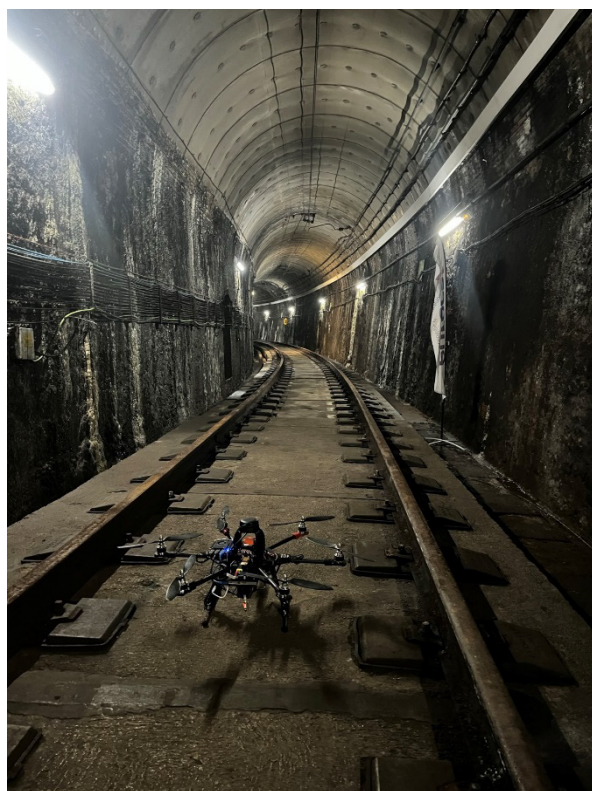
Technologies for lifetime extension of critical infrastructure
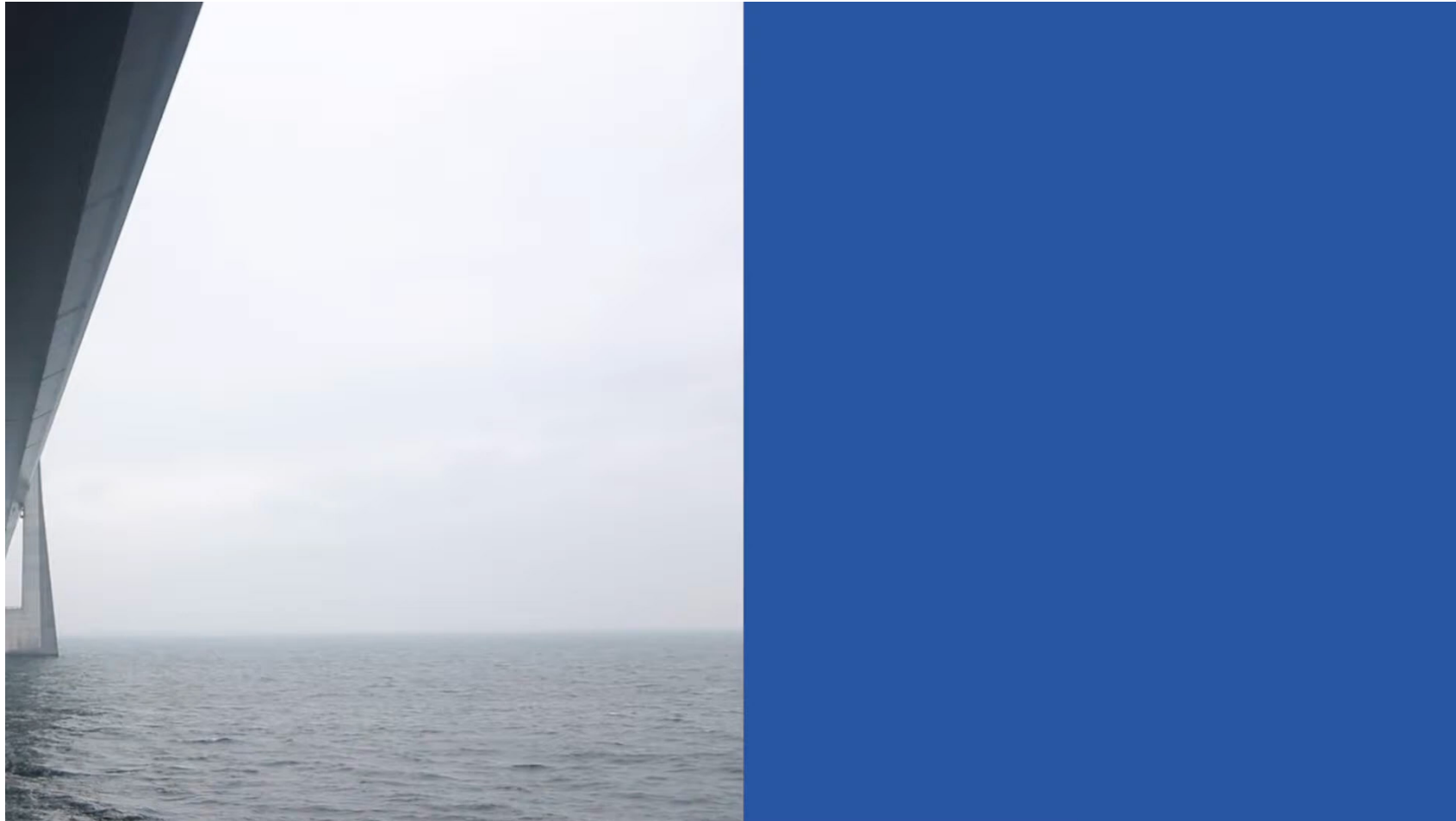
Prof. Lazaros Nalpantidis, DTU Electro
Associate Prof. Evangelos Boukas, DTU Electro
Associate Prof. Nils Axel Andersen, DTU Electro

Ground robotics: co-workers for smarter and safer operations

Wall building robotic platform (MBZIRC 2020)

- Robotic system knows the "building construction layout" (sequence of bricks to be aligned)

- It uses a hand-held camera in the end effector to spot the construction site and to distinguish the different bricks

- Current platform includes a small loading deck where to store multiple bricks

CoCoBot - Collaborative Construction site roBot for assistive logistic tasks (funded by Odense Robotics)

Human-robot collaborative construction system for ***shotcrete digitization*** and automation through advanced perception, cognition, mobility and additive manufacturing skills
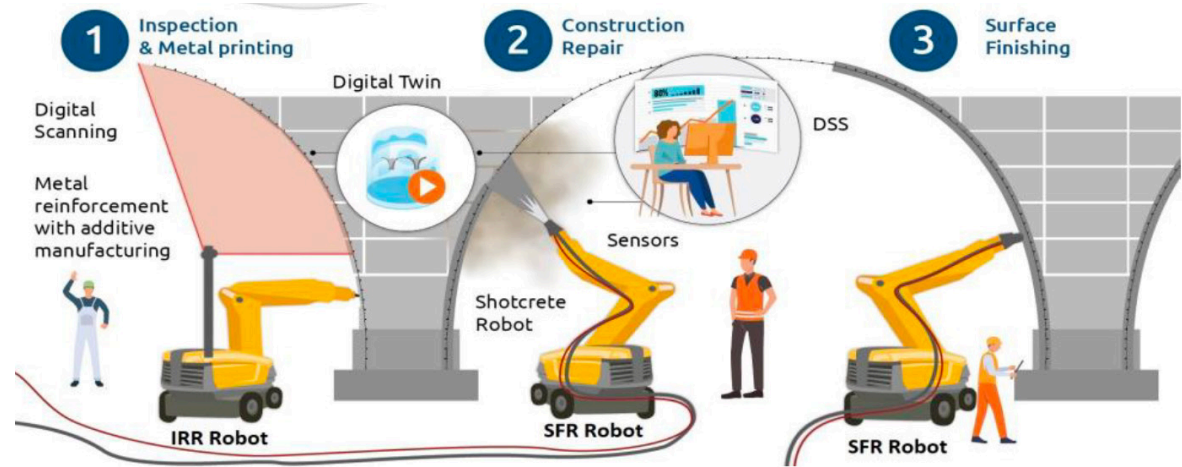
HORIZON-CL4-2021-TWIN-TRANSITION-01-12:
Breakthrough technologies supporting technological sovereignty in construction (RIA)

Human-robot collaborative construction system for *shotcrete digitization* and automation through advanced perception, cognition, mobility and additive manufacturing skills

Prof. Patrizio Mariani, DTU Aqua

Associate Prof. Roberto Galeazzi, DTU Electro

Marine robotics: "eyes" and arms below the water surface

Technology portfolio @ DTU

Sensor & Communication Technologies

Underwater Robots

Surface Vehicles
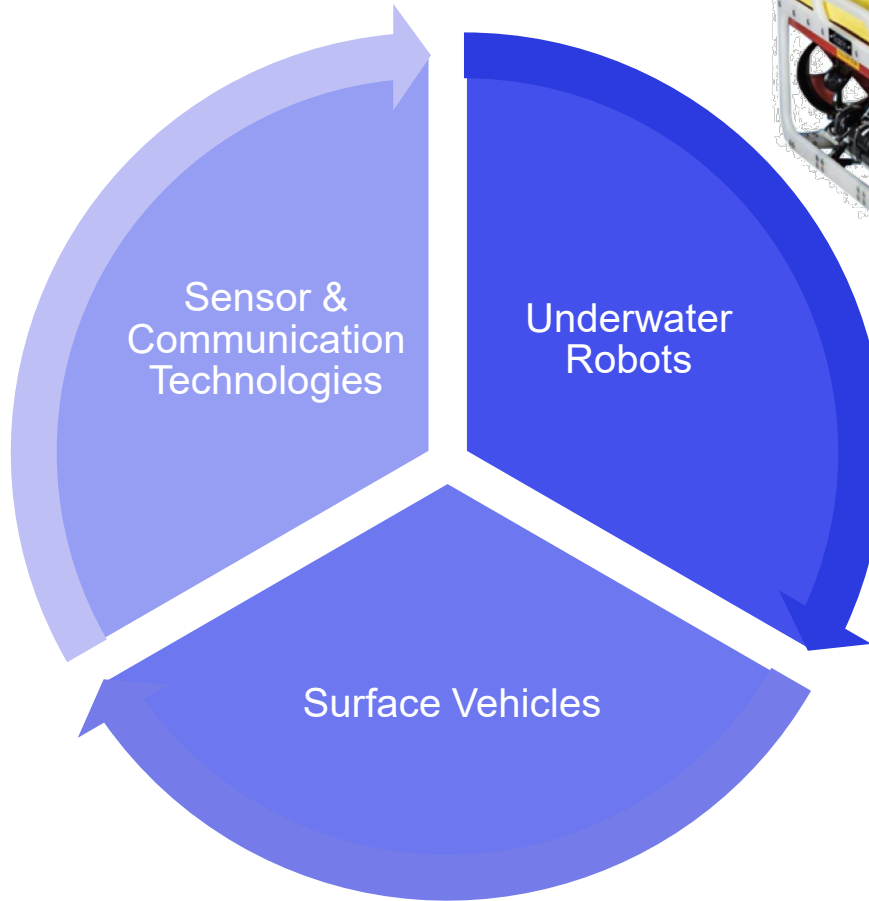
"Monitoring Sediment Plumes Generated by Construction Activities in Sensitive Marine Areas"

DTU Aqua

Patrizio Mariani
Adam Hambly
Owen Robertson
Rune Garmand

DTU Elektro

Roberto Galeazzi
Andreas Hansen

M&E Engineering

Jan Møller Hansen
Kasper Krarup-Christensen

ARUP

Katharine O'Sullivan
Francesco Petrella

DTU Aqua
National Institute of Aquatic Resources

DTU Elektro
Institut for Elektroteknologi

mee

ARUP

Vand **I**nnovation **S**MVer

DEN EUROPÆISKE UNION
Den Europæiske Fond for Regionaludvikling

Europas grønne region
Innovative løsninger på vandområdet

Vi investerer i din fremtid

SEDISENSE scope of delivery

- SEDISENSE focuses on conceiving, designing and operating an autonomous system for mapping water turbidity in marine environment.

- Autonomous mapping of large areas around a construction site in the Roskilde Fjord - which is situated in an EU classified Natura 2000 zone.

- Need for cost efficient solutions for the reliable and continuous monitoring of construction site → New underwater robotic technologies

Photo: NERI/Peter Bondo Christensen

Photo: Biofoto/S.F. Sørensen
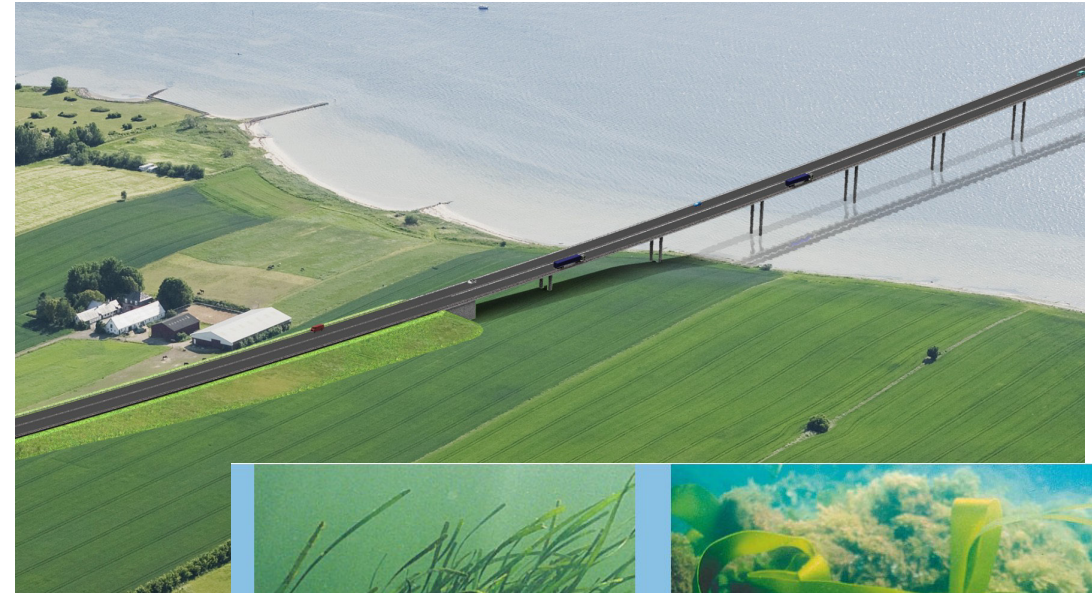
Integrated underwater robotic system

BlueROV V2

Onboard "intelligence"

Topside computer
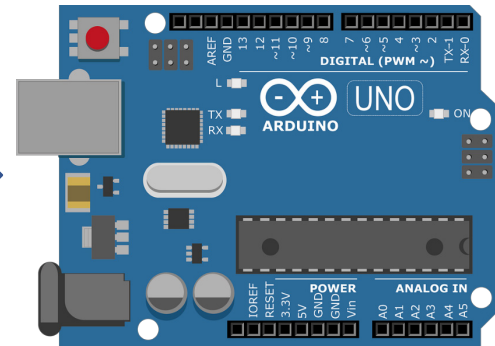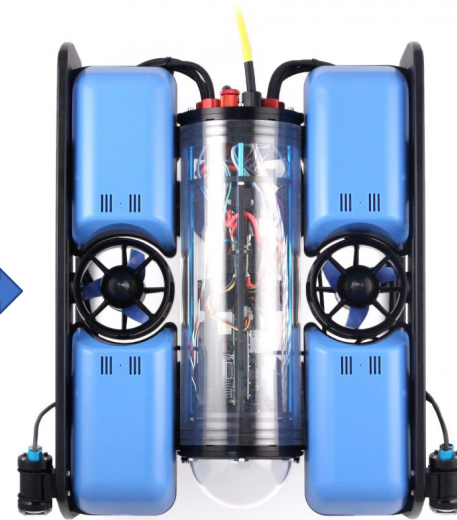
Water quality (turbidity) sensor

Acoustic positioning system

Fieldwork to test the integrated robotic system
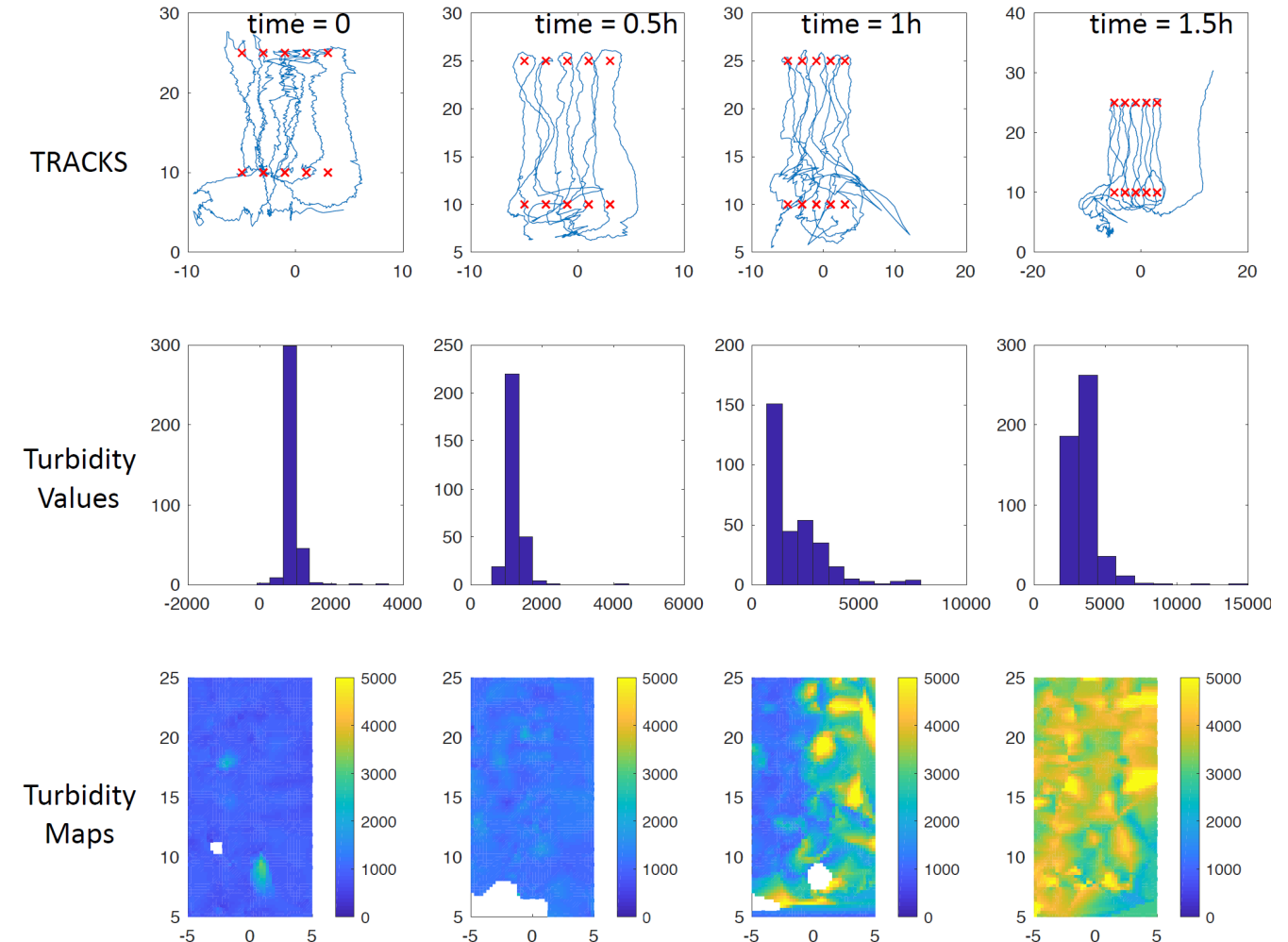
Fieldwork to test the integrated robotic system: Results
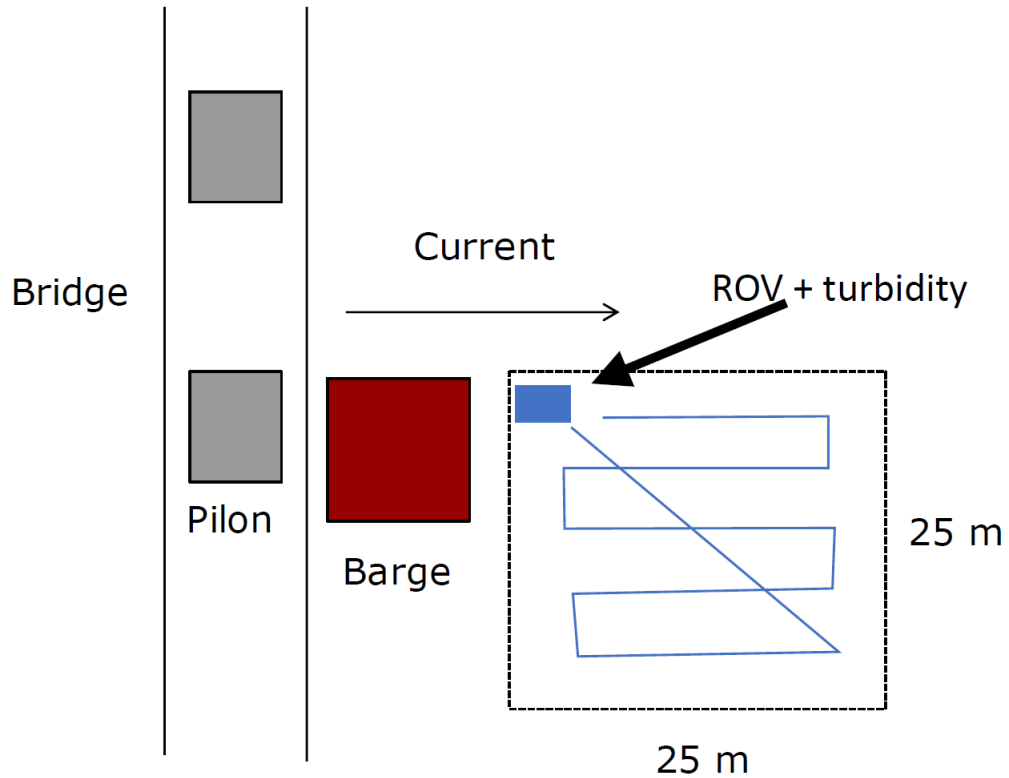
Key takeaways

Robotics, AI and Digital Technologies can significantly disrupt the construction industry helping the sector to win the challenges is being confronted with

Robotic, AI, and Digital Technologies will not replace human workers but help them to perform their job in a safer and healthier manner

Denmark has shown the ability of being a frontrunner in the integration of robotics and digital solutions in many other industries, hence it can do it also in the construction industry

DTU Centre for Collaborative Autonomous System has the competences and expertise to be your trustworthy innovation partner and we are here to help you bringing the next transformational innovation to your worksite

Research and Innovation powered by

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MBZIRC

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RobétArmé

CoCoBot

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SEDISENSE

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CoCoBot

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AI and Robotics for the Construction Industry