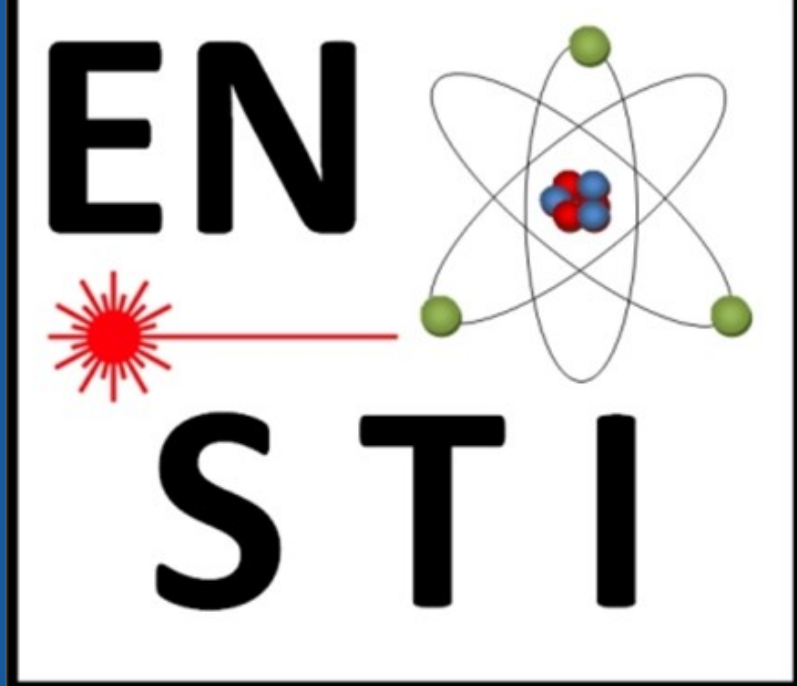




LHC Train Control System for Autonomous Inspections And Measurements

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FAIL-SAFE, ROBUST AND MODULAR

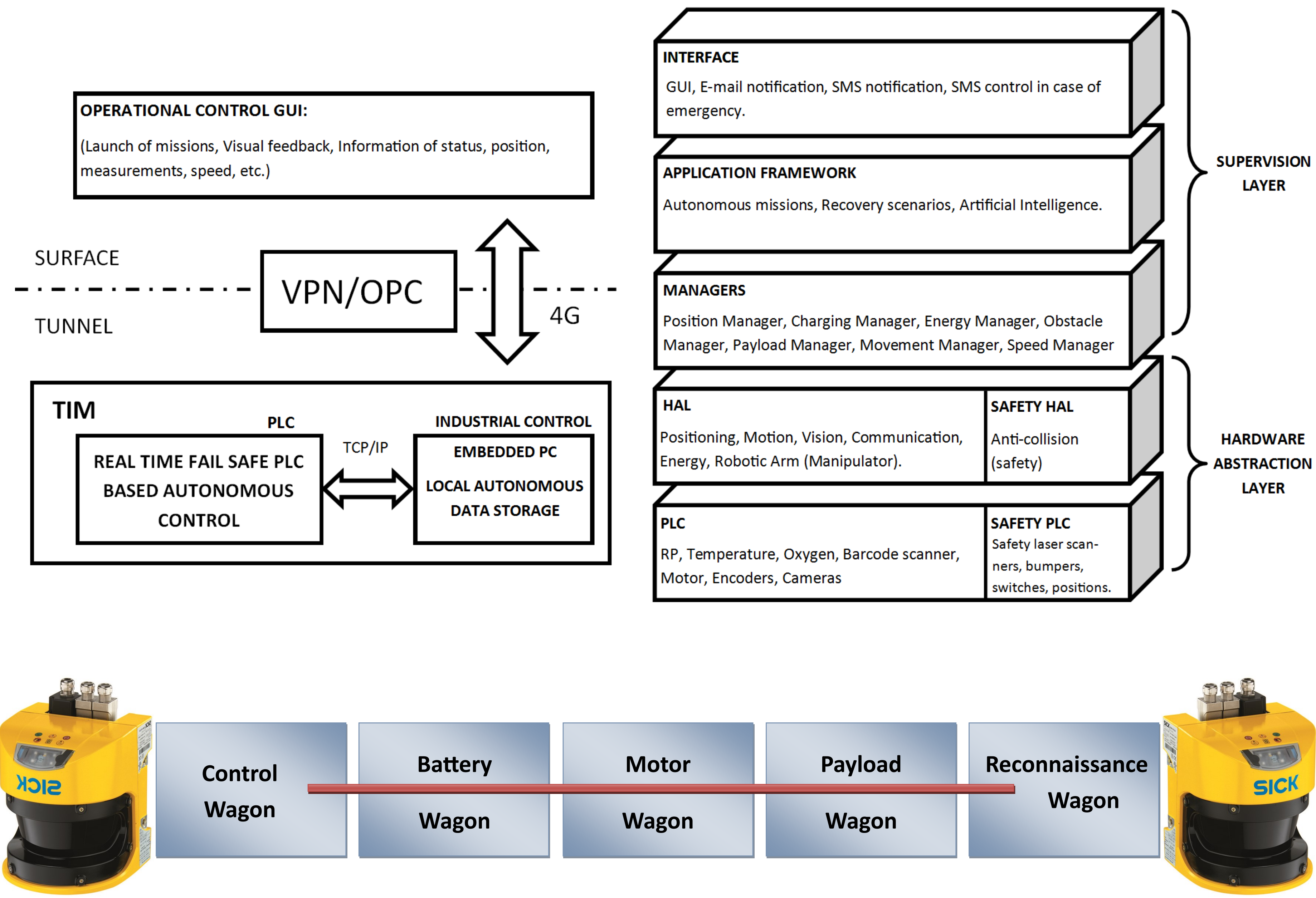
Control Architecture for CERN Inspectors

The Train Inspection Monorail (TIM) has been developed at CERN with the goal to provide unmanned actions in the LHC. Fitted on a monorail installed on the ceiling around the tunnel, TIM is operated from the surface via 3G/4G. Remote measurements of temperature, oxygen, photogrammetry and radiation dose at the beam height can be done autonomously by TIM, minimizing hazards exposures for the personnel and maximizing machines uptime. Visual inspection is possible from different PTZ cameras, as well as thermal cameras. Its control architecture allows the robot to perform autonomous missions while the data can be monitored in real-time, and then autonomously come back to its safe position when the mission has finished. The fail-safe system, composed of a fail-safe program, safety laser scanners, bumpers and switches, guarantees collision free operation and adaptable speed in case of obstacle presence. The modular design of TIM and its control architecture makes possible to have different configurations of the robotic system.

50+ successful missions performed | 1000+ km done with TIM in the LHC

ADAPTIVE AND MULTIMODAL

Control system design and communication



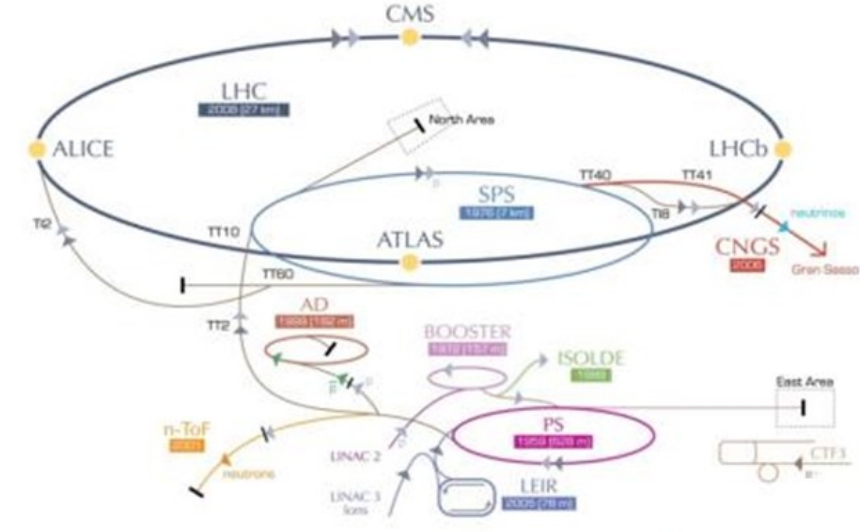
LHC OPERATION

Train Inspection Monorail



CERN NEEDS

Needs for remote inspections



Reduce exposure of personnel to hazards

Maximize machine running time

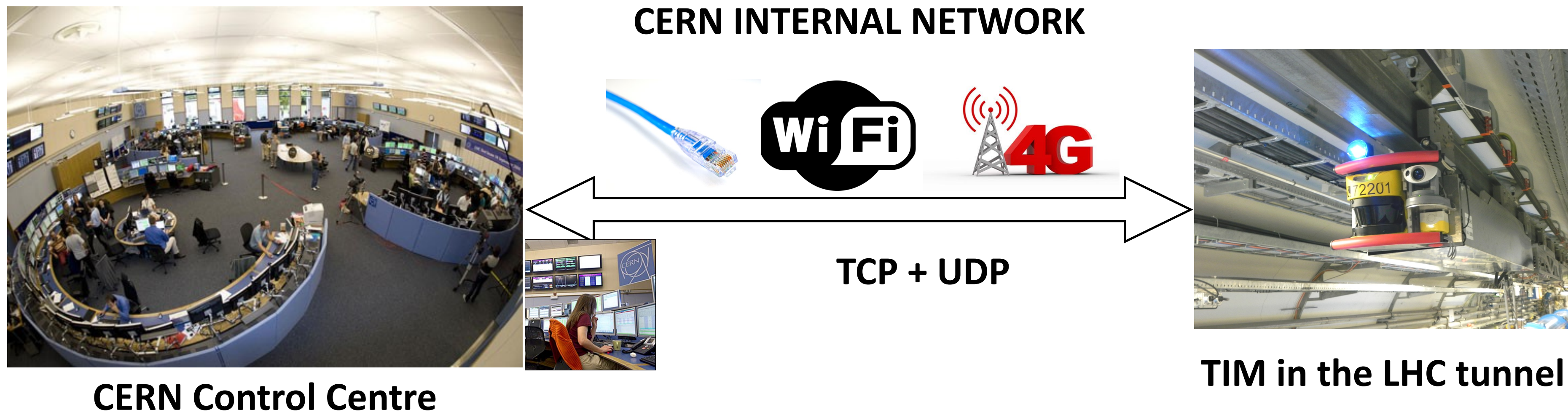
IMPORTANT PROPERTIES

Features

- Autonomous missions, safe recovery to garage afterwards, no human intervention needed
- On-board data collection with embedded industrial PC
- Web interface for live view of TIM operation, connected to TIM database, where all data collected is stored
- Modular design of control architecture allows TIM to be equipped with different sensors and mechatronic systems
- Fail-safe system** guaranteed by safety program, laser scanners, safety bumpers and safety switches

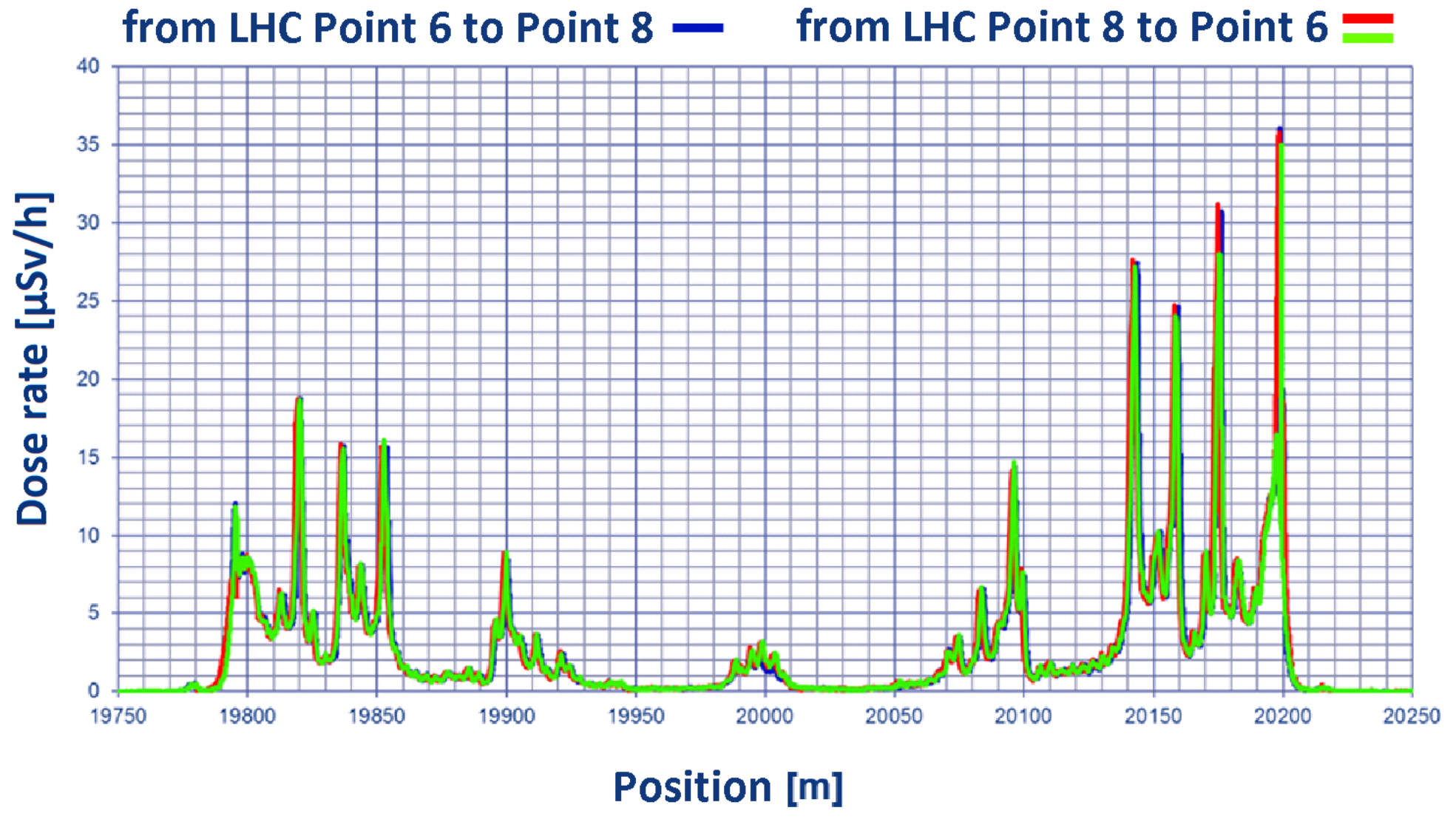
IMPORTANT PROPERTIES

Communication with the robot

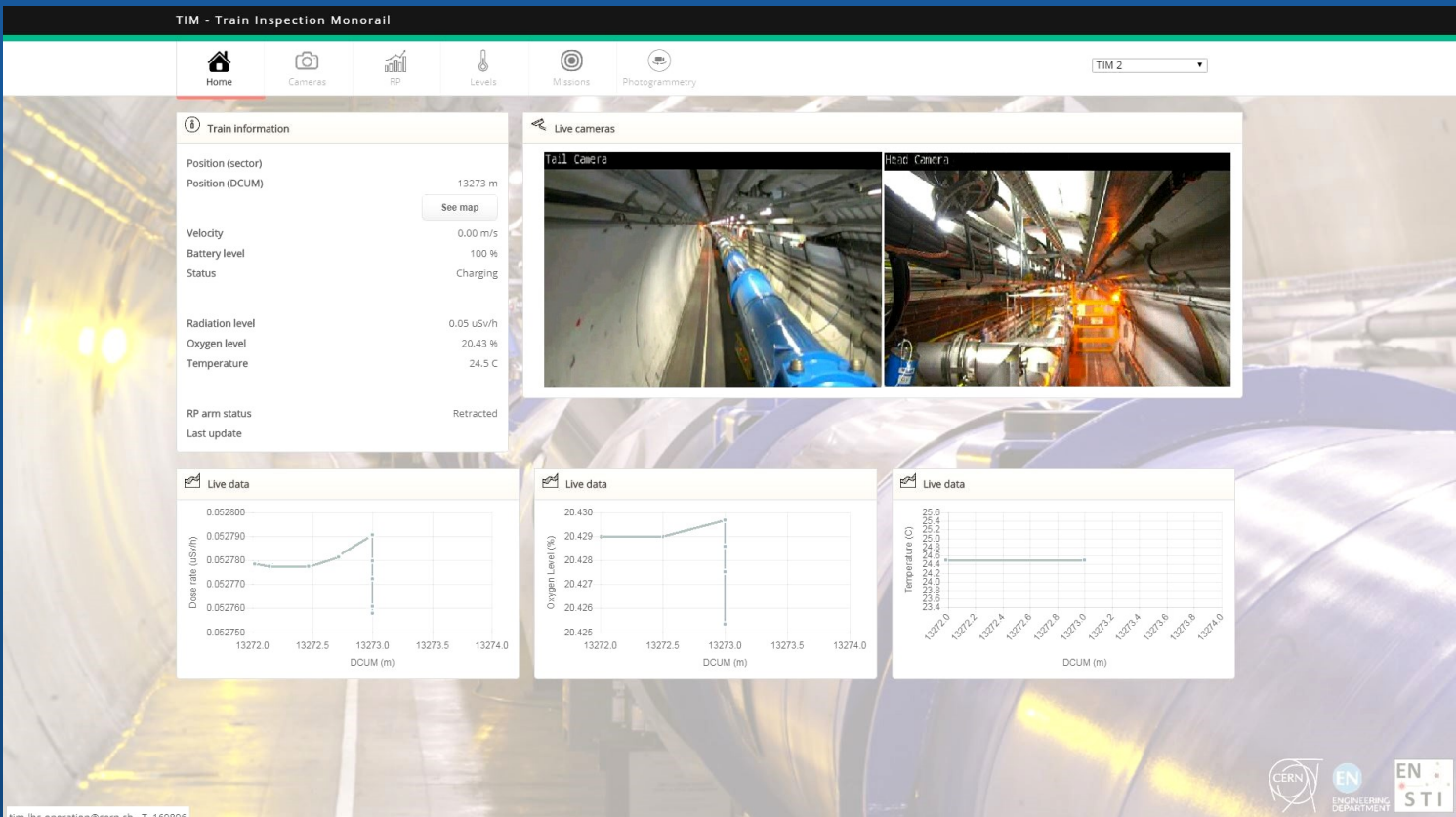


EXPERIMENTAL RESULTS

System validation



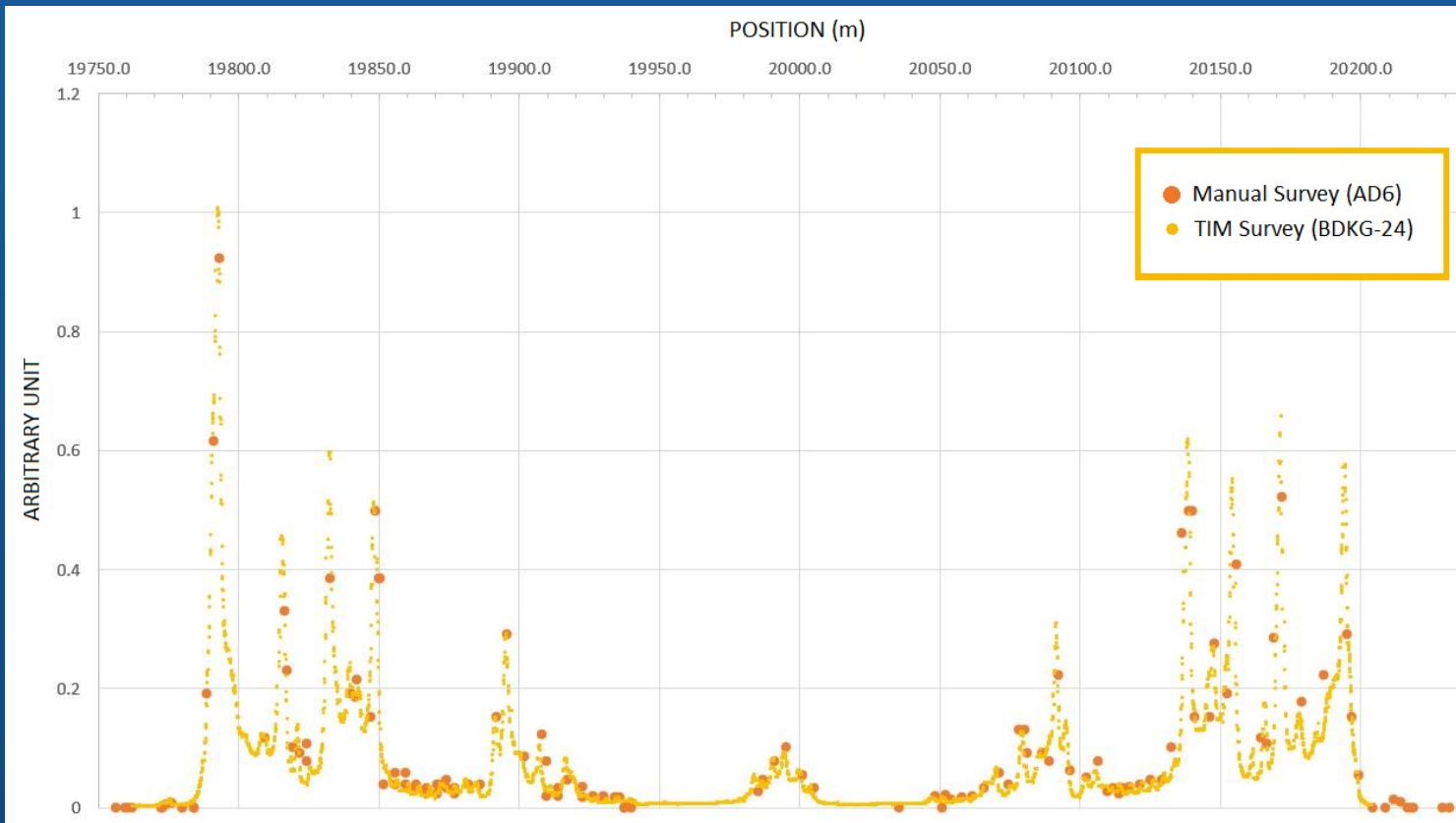
TIM Control System | Gallery



TIM website



TIM Human Robot Interface



TIM Data Comparison with human intervention (dose saved)