

Airborne Demonstrator for Near-Real-Time Infrastructure Monitoring With On-Board Processing From Satellites

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<https://www.iimeo.eu>

Motivation

Near real-time automated monitoring of geographically dispersed critical infrastructure. Pilot use case: Railway track monitoring.

End-to-End Monitoring System

- Ground Platform for additional processing, storage, interface to present results.
- LEO Constellation (/ Airborne Demonstrator)
- 35GHz-SAR & RGB Cameras with shared field of view.
- On-Board Processing of SAR+RGB data up to anomaly detection, results are to be fused in the On-Ground Platform.

Conditions

- Spatial Resolution: < 50 cm
- Time from Request to Response: < 60 minutes
- Robustness against weather (rain, clouds) / night.

Airborne Demonstrator

Airplane (Stemme S10; "Condor") with two wing pods. Left wing: SAR and obliquely looking camera. Right wing: Nadir camera.

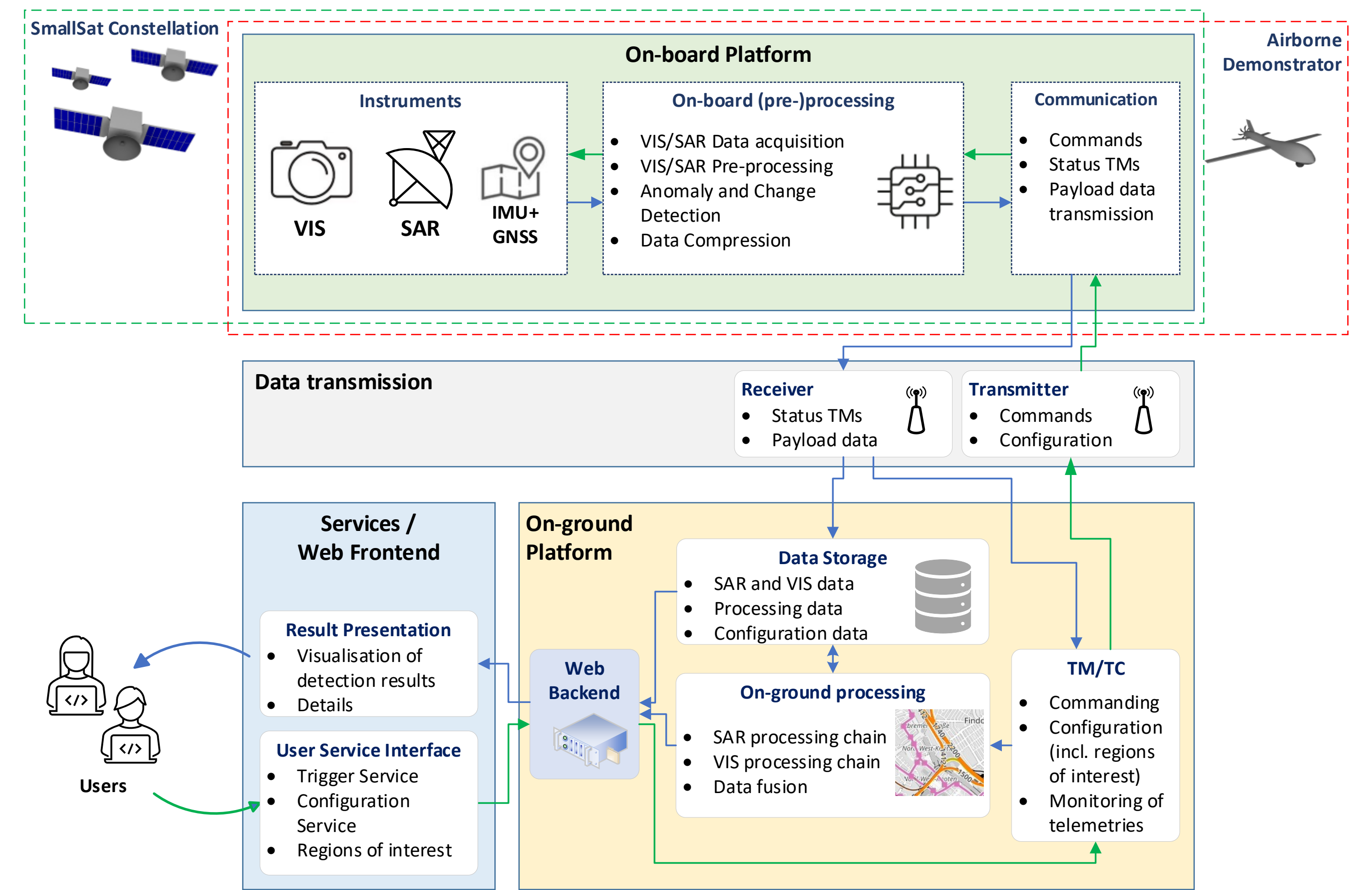


Image Processing

Successively acquired pictures are geo-referenced (without an elevation model), by recognizing images of ground-points in the overlap of both pictures. The ground points are used to compute the ground plane w.r.t. the airplane. Using the airplane's localization, we compute the map between image and geo-coordinates (a). From a track map (OpenStreetMap) we extract image regions potentially showing track, in which we identify railway track using a CNN (HRNet). Detected track samples are used to improve the geo-reference by optimizing for geo-reference parameters minimizing the mean squared distances between the geo-locations of the detections and the mapped track. This allows to flag image regions where railway track should be detected in the image but does not as in (b). Finally, obstacle detection results from images and SAR tiles covering the same region (c) are to be fused by computing the probability of pairs of detections stemming from the same physical obstacle. This will be used to compute the obstacle position estimates. (Currently work in progress.)

Rail/Obstacle Dataset

We acquired thousands of images of railway track, some with obstacles at known locations. (To be published.)

On-Board Data Processing

To achieve the response time, SAR and VIS data are not sent to ground immediately after acquisition but processed on-board. On-board processing is managed using ROS2, the individual processing steps being wrapped into ROS nodes, forming a processing graph.

The on-board processing nodes are run on four on-board computers, one per VIS camera for image acquisition and geo-referencing, one for SAR acquisition and image formation and one for the obstacle detection on VIS and SAR images. SAR image formation focuses only on pre-computed tiles corresponding to regions potentially including railway track, to limit the volume of data to be processed.

While the acquisition sensors and attached computers are not directly transferable to space, the main on-board processing computer (Unibap ix10-100) which runs the neural network inference for railway/anomaly detection is directly designed to be used in space. On the demonstrator, we use an engineering model (at our partner AWS). Obstacle positions are communicated to ground, where they are made available, where they are made available via a web UI (d) and a REST API.

