NLS
NATIONAL
LAND SURVEY
OF FINLAND

Resilient PNT and Maritime Navigation

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CGSIC

Research on Navigation and Positioning at the FGI

- Satellite and radio navigation
- Algorithms and sensor technology
- Positioning in challenging conditions
- Availability and security of spatial and temporal data
- Maritime situational awareness
- Intelligent transport and positioning

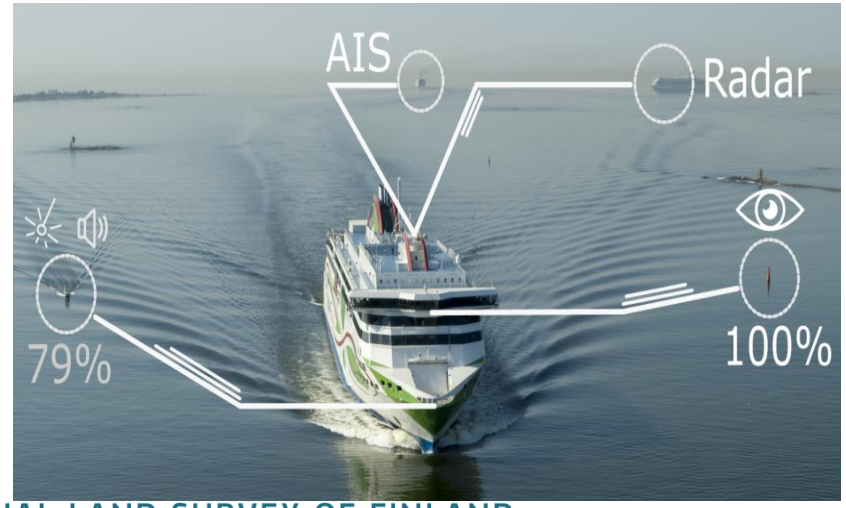
Maritime navigation Research at the FGI

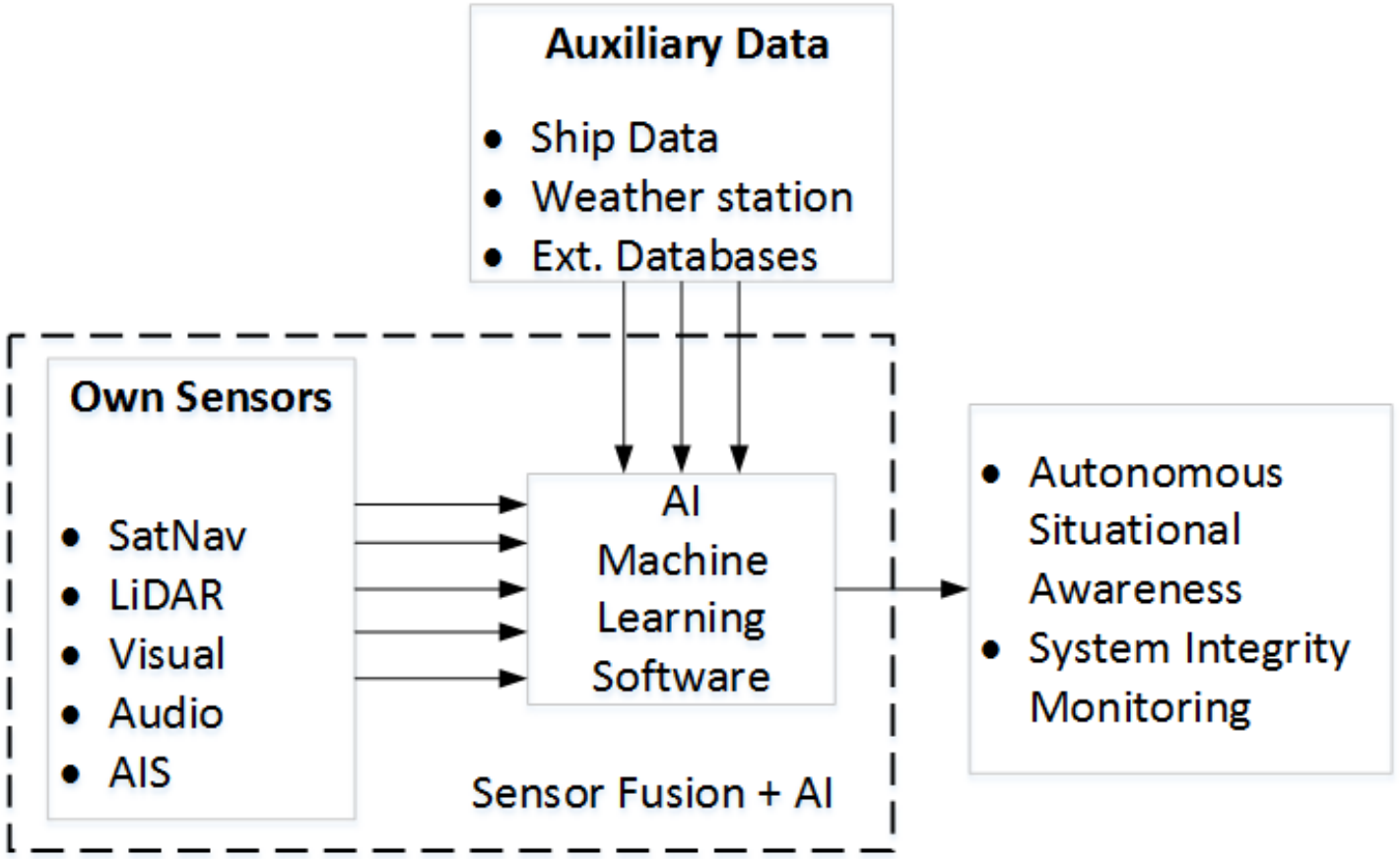
Project Abbreviation	Project Name	Funding Agency	Duration
ENHANCE	**Enabling Harbor to Harbor Autonomous Situational Awareness in Sea Ice Conditions**	ESA	2021-2023
MARITIME AI-NAV	**Artificial Intelligence/Machine Learning Sensor Fusion for Autonomous Vessel Navigation**	ESA	2019-2021
PETAL	Position, navigation and timE TrAffic Light	ESA	2020-2021
LNAV	LiDAR and Aids to Navigation	Finnish Transport Infra Agency	2020
PRESTIGEFIN	Preliminary Study on Utilizing GNSS-based Techniques for Enhanced Height Tracking for Vessels in Finnish Waterways	Finnish Transport Infra Agency	2019
FAMOS	Finalizing Surveys for the Baltic Motorways of the SEA	EU Connecting Europe Facility	2017-2018
BONUS STORMWINDS	Strategic and Operational Risk Management for Wintertime Maritime Transportation System	EU	2015-2018
BONUS ESABALT	Enhanced Situational Awareness to Improve Maritime Safety in the Baltic	EU	2014-2016
VORIC	Vessel Operations and Routing in Ice Conditions	Business Finland	2015-2016
ARCSAT	Arctic Real-Time Satellite Services for the Public and Commercial End-Use	Business Finland	2013-2014

Maritime situational awareness

Maritime AI-NAV (ESA), ENHANCE (ESA), LNAV (Finnish Transport Infr Agency)

- Sensor integration and AI machi learning for autonomous situatio awareness
- Twitter: @ai_maritime, www.maritimeai.org/





Sensor Fusion for Autonomous Vessel Navigation

INSTALLED SENSORS

EGNSS-enabled Receiver

CAMERAS

MICROPHONES

LiDAR

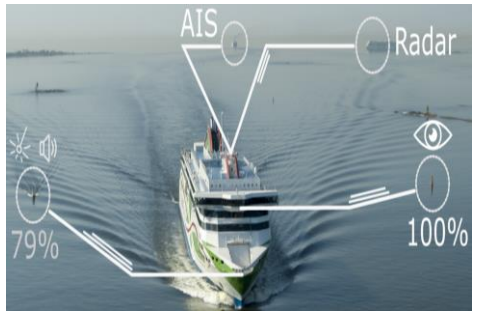
(Proof-of-concept)

SHIP SENSORS

RADAR

AIS

SHIP DATA INTERFACES



AUTONOMOUS SITUATIONAL AWARENESS

EXTERNAL MARITIME DATASETS

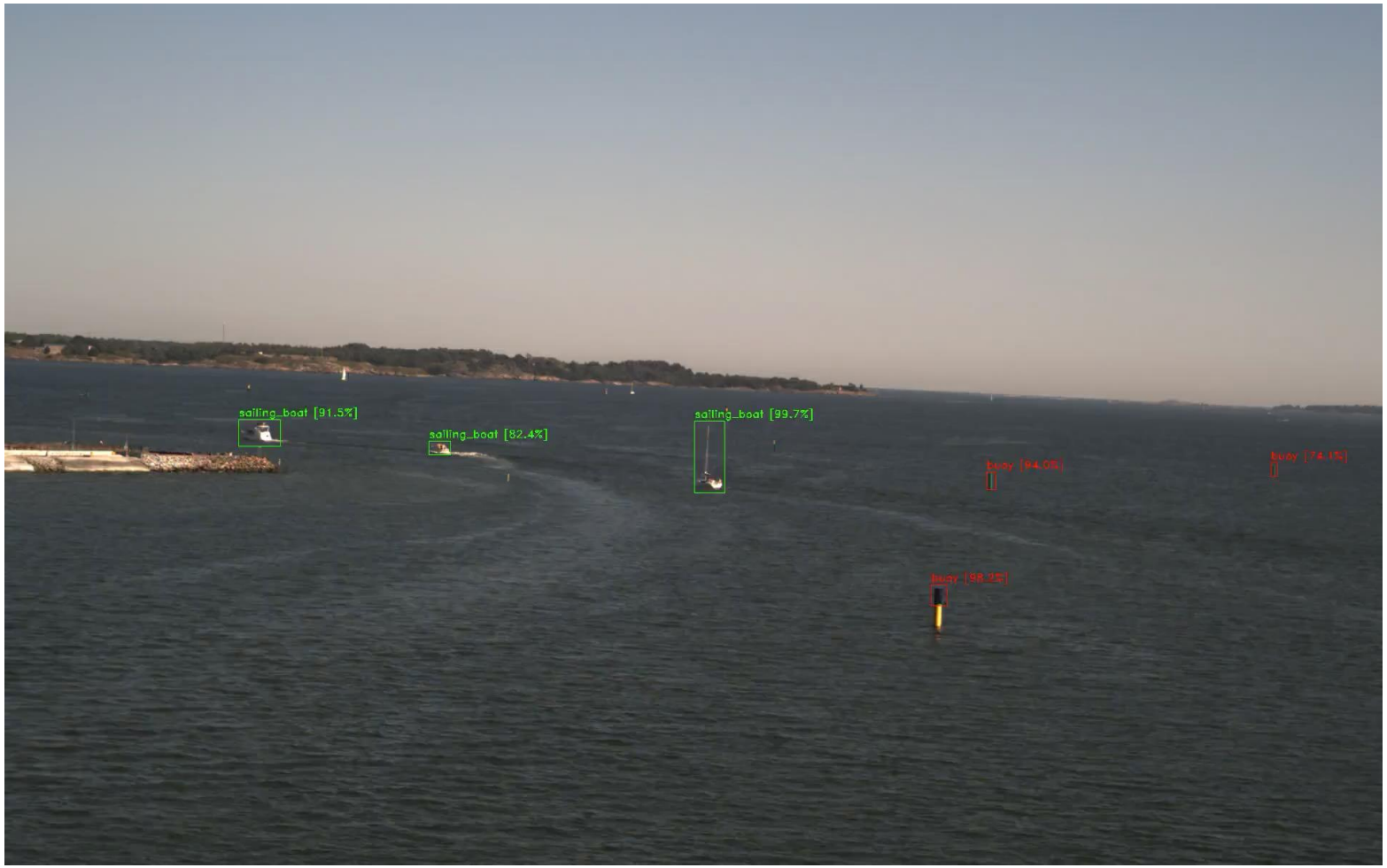
(Training Data)

*All *MS MEGASTAR* images courtesy of Tallink

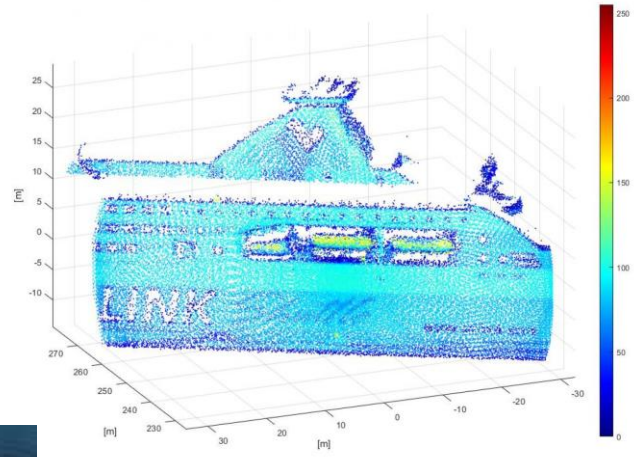
TALLINK SHUTTLE *MS MEGASTAR* (HELINKI – TALLINN)

Maritime AI Nav @Tallink megastar

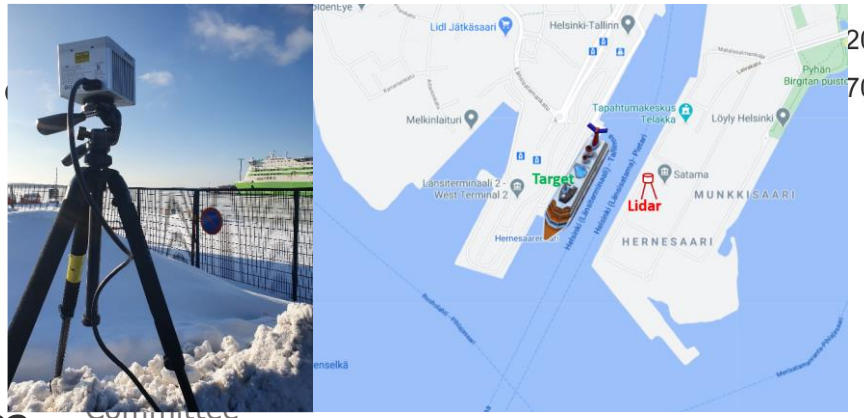
Automatic identification of buoys and other objects based on camera imagery. Video by Toni Hammarberg

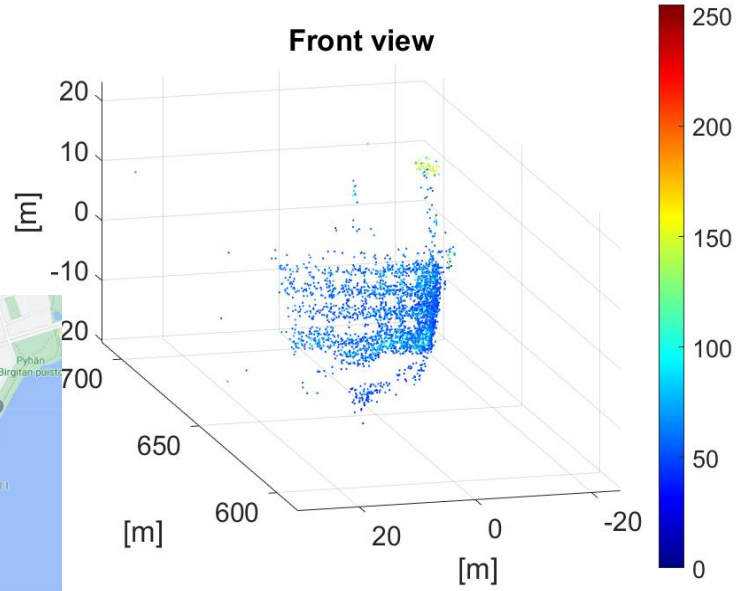


Feasibility of LiDAR detec



- Investigate the fundamental and theoretical applicability of the LiDAR towards maritime target detection
- Livox Tele-15 long-range LiDAR
- The visibility of three different sizes of vessels estimated detection with respect to the detection distance up to 1000 m
- Camera + AI up to 5 km





Findings from operational point of view

- Absolute localization of the vessel is possible with high-precision. Integrity, reliability, and continuous availability is the challenge in maritime (especially autonomous operations).
- Visual camera data seems to work well for reading the surroundings of the ship, even if the range is more limited than what a human can perceive (using binoculars). Directional zoom cameras could be an option.
- Eye-safe LIDAR is – due to limited range – only marginally useful on sea going ships and main use case would be as a parking sensor while berthing.
- Sound localisation presents an interesting aspect to ship systems. Existing elephant ear technology is rather low-tech and as such not very useful. Microphone placement is challenging, though.
- Access to a real ship, with real sensors is crucial to successful test campaigns and enables real-life realistic testing data

GNSS related issues in maritime navigation

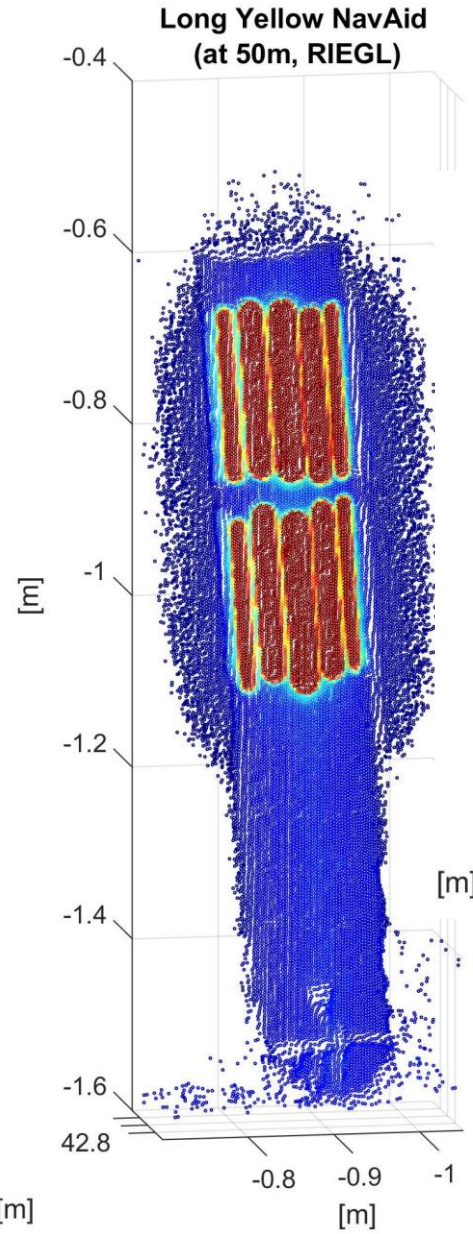
- The crew of Tallink Megastar reported about losing GNSS positioning for several minutes when being moored in a harbour (Helsinki and Tallinn)
- GNSS signals can be masked or reflected by harbour infrastructure which leads to degraded accuracy
- Apparently, some truck drivers use jammers to avoid being tracked

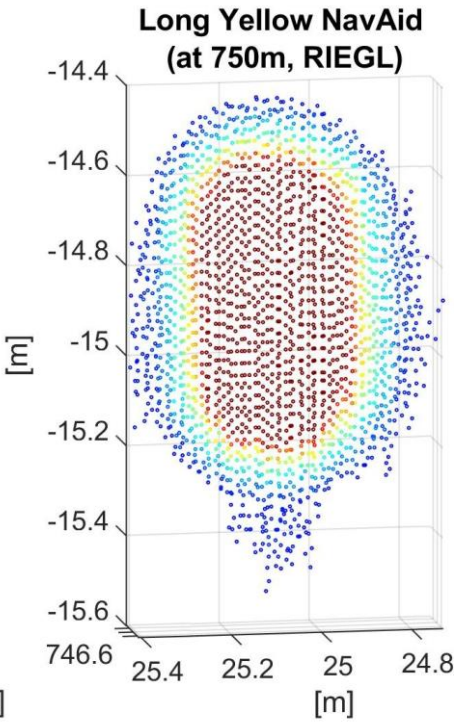
https://www.maanmittauslaitos.fi/en/topical_issues/how-make-ship-see-and-hear

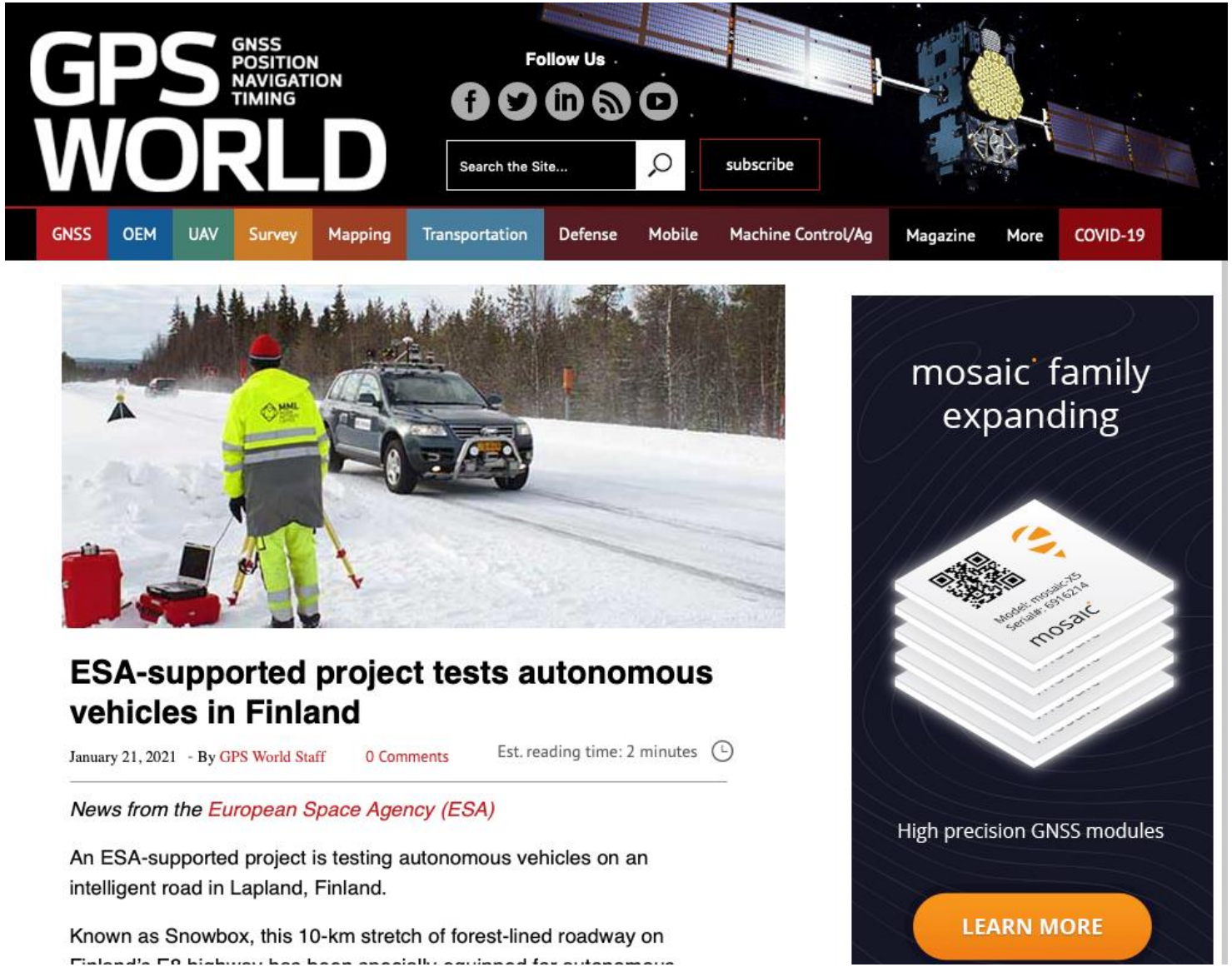
LiDAR + Navigation

- Characterization of reflector equipped maritime navigation aids for commercial lidar visibility
  - Lab tests
    - Incidence angle and ’backscattered reflectance’ analysis for various retroreflective materials (3M & Oralite)
  - Field tests
    - 5 nav. Aid segments measured at various distances with 2 commercial lidars (up to 800m)
- Visibility and detection analysis

=> Nav aids with reflectors are highly visible (in theory, well beyond 800m, eye-safely)







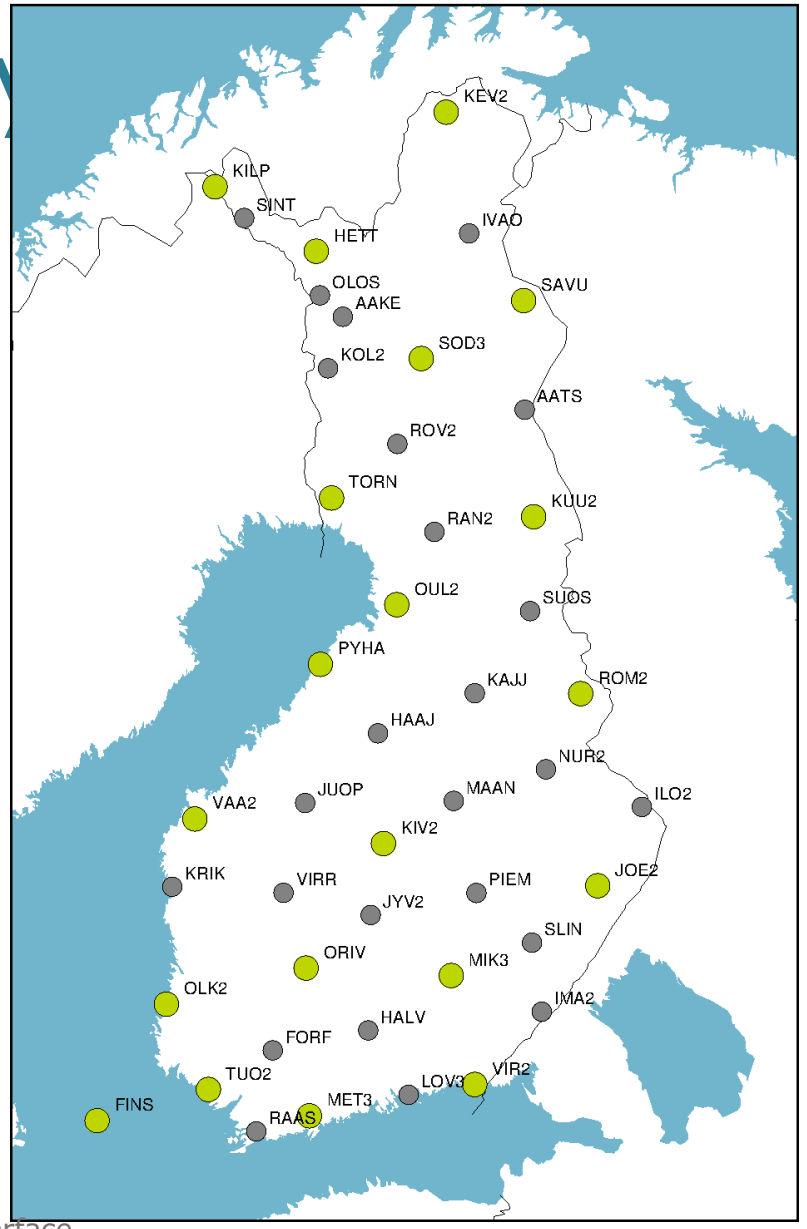
GNSS + sensors in smart roads

https://www.gpsworld.com/esa-supported-project-tests-autonomous-vehicles-in-finland/?TrucksFoT

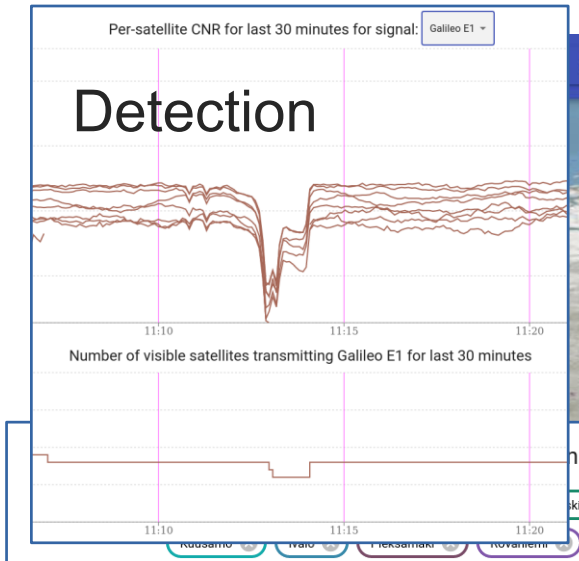
GNSS-Finland: Signal Quality Monitoring

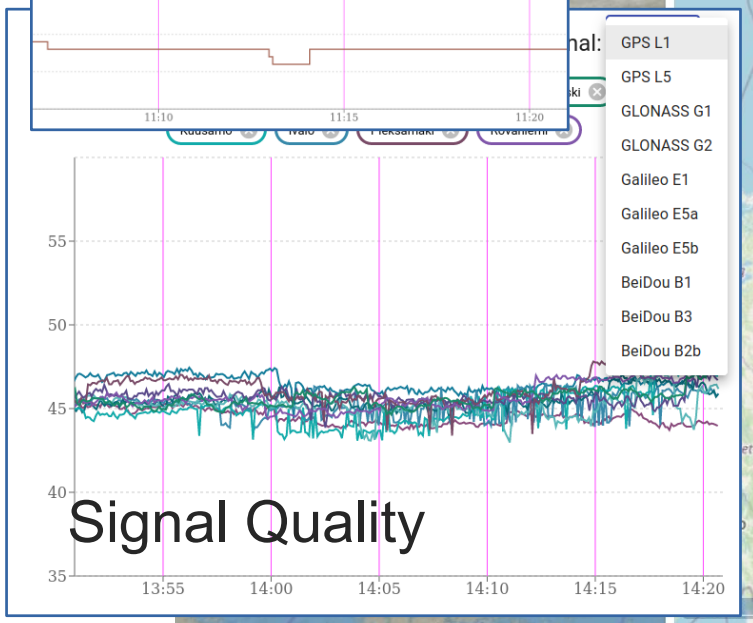
Real-time GNSS signal quality from FinnRef (Finnish Transport and Communications Agency)

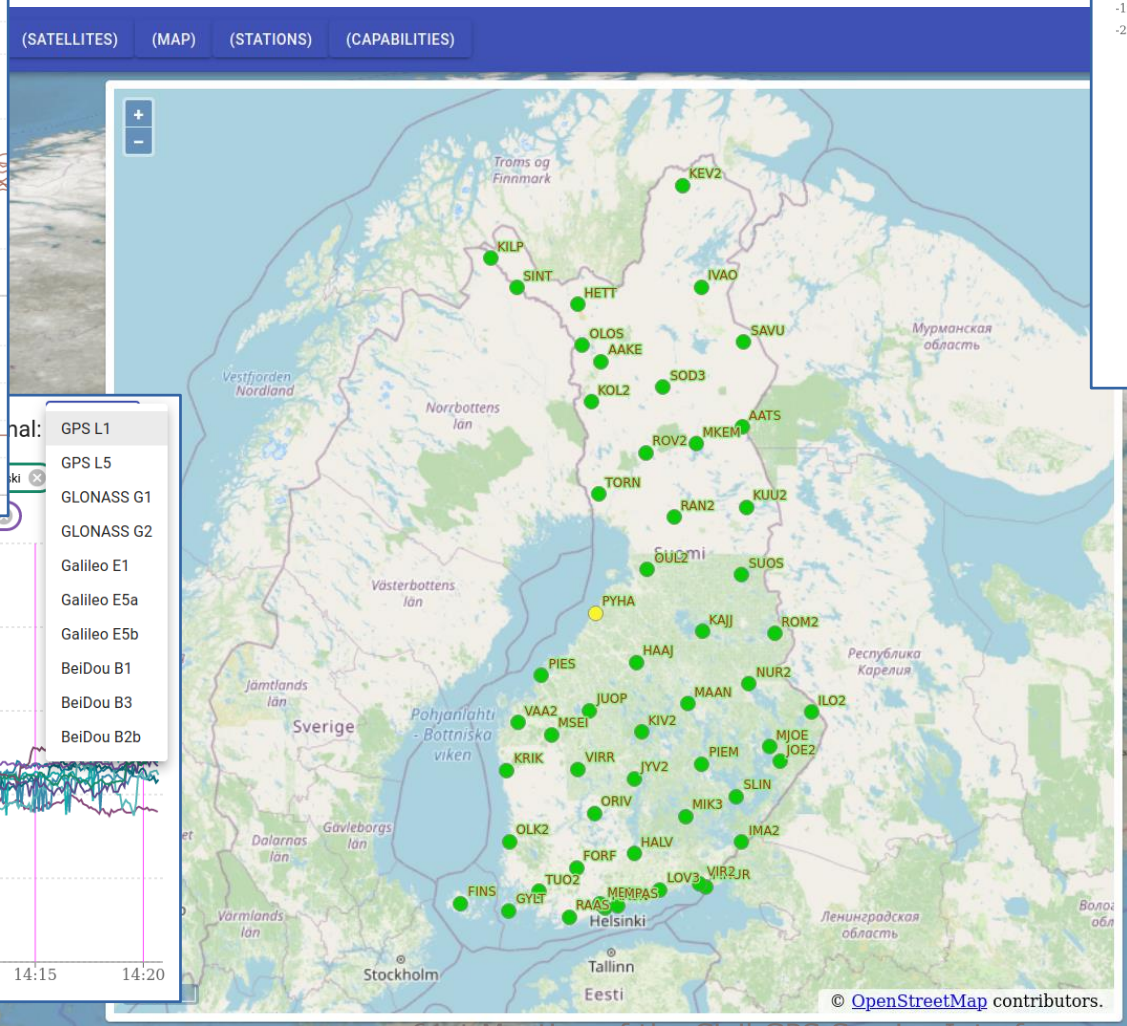
- 2019 prototype, 2020 operational + includes all GNSS systems, 2021 open to the public: https://gnss-finland.nls.fi
- Server and UI for user alerts
- Based on the national FinnRef network (50 stations)
- Development: FGI, maintenance: NLS production
- Parallel project from ESA: PETAL (Position, Navigation And Time Traffic Light)

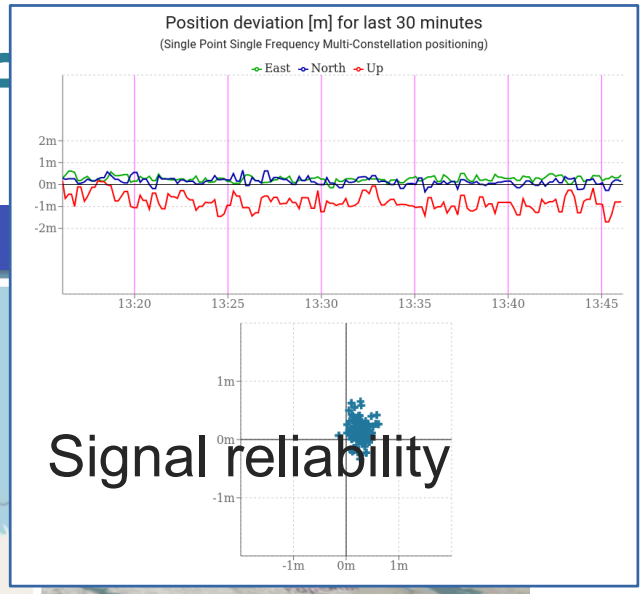


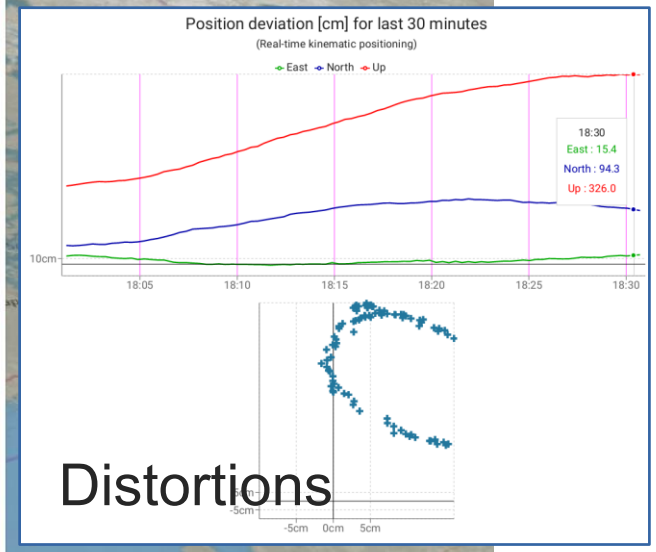
GNSS-Finland User interf



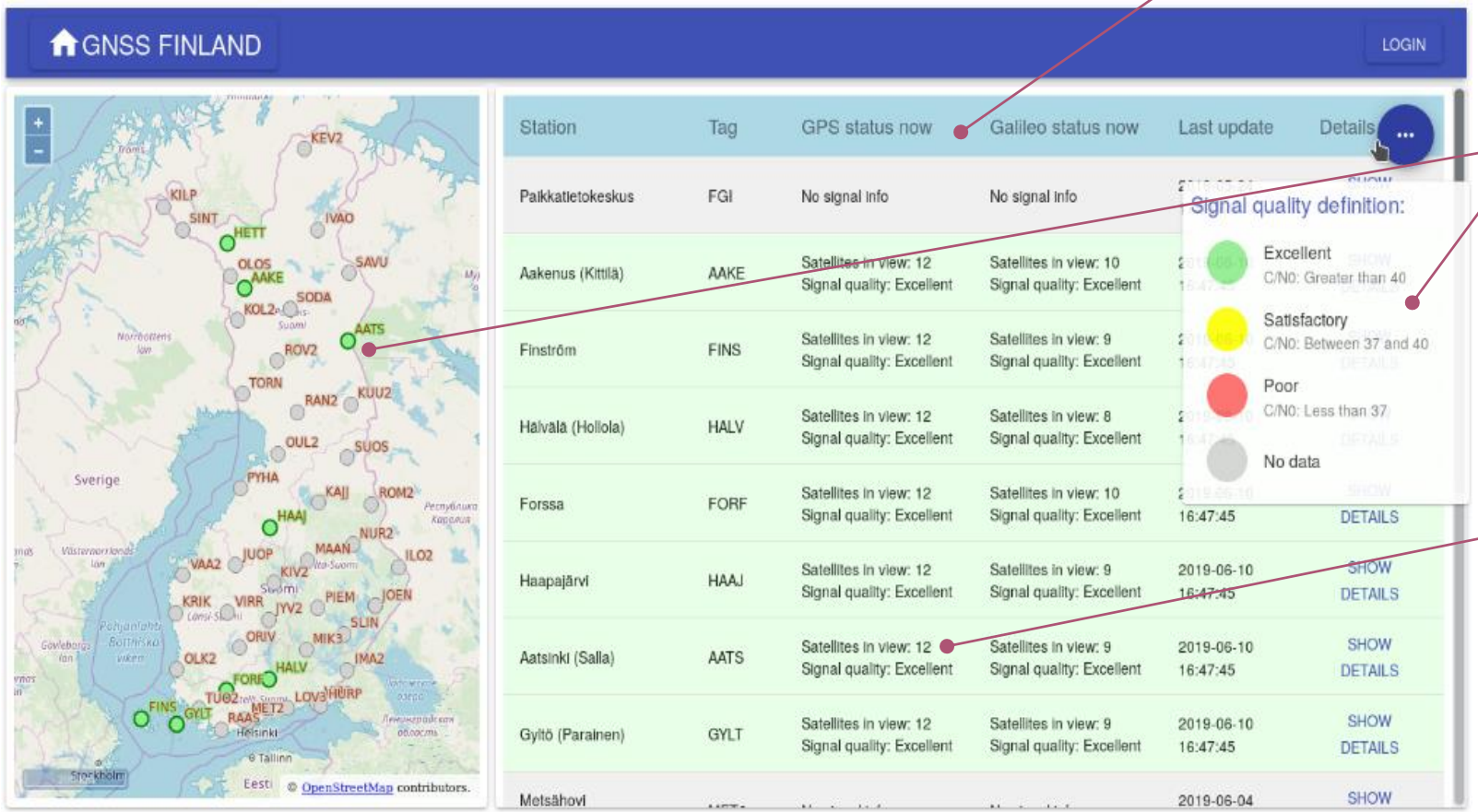








‘Traffic Lights’

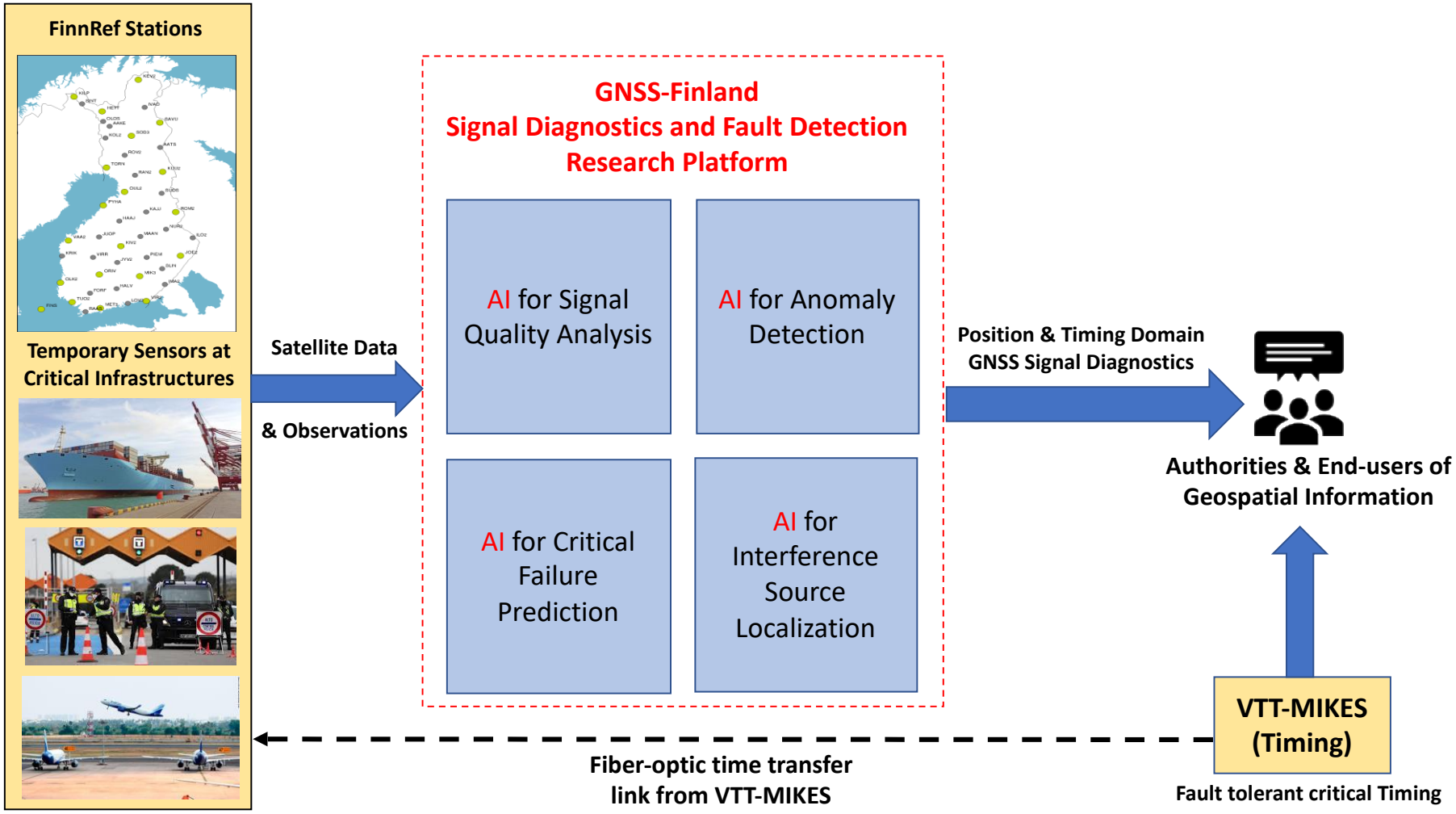


GPS, Galileo, GLONASS, BeiDou

Color codes to help general public

More detailed/advanced information

Extending GNSS-Finland to include time



Situational Awareness from Collaborative Positioning

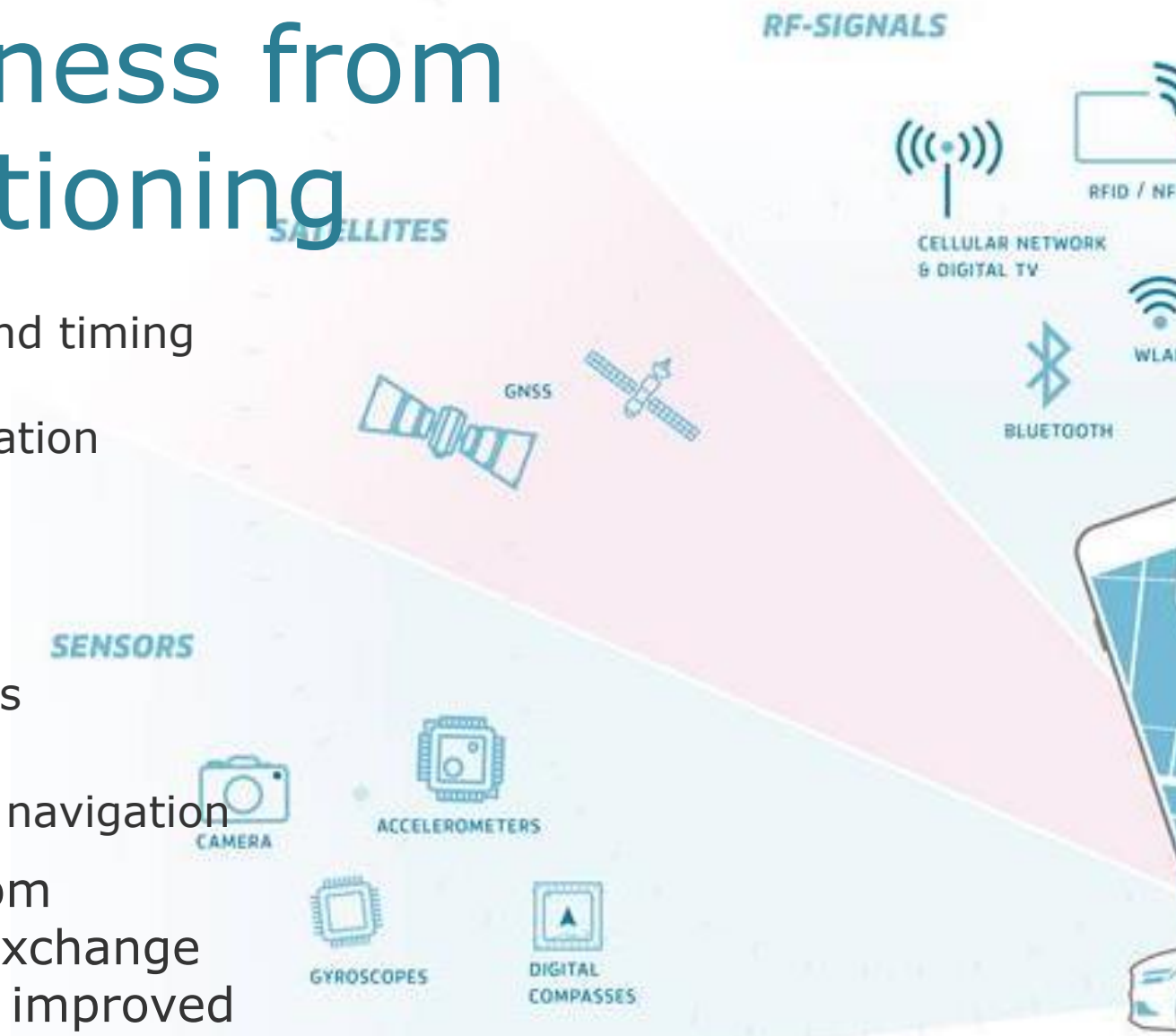
Satellite positioning:

- Robust multi-GNSS for positioning and timing (GPS, Galileo, Glonass, BeiDou)
- GNSS interference detection & mitigation
- Precise point positioning (PPP)

Non-GNSS and cooperative positioning

- Camera (light/Thermal/IR)
- Ultra-Wide-Band and other RF signals
- Lidar
- Inertial sensors (e.g., for pedestrian navigation

Collaborative augmented navigation from terrestrial ranging (with sensors) and exchange of information (situational awareness): improved accuracy in challenging conditions



Advancing together

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