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FMI intelligent traffic road weather services 5G test track

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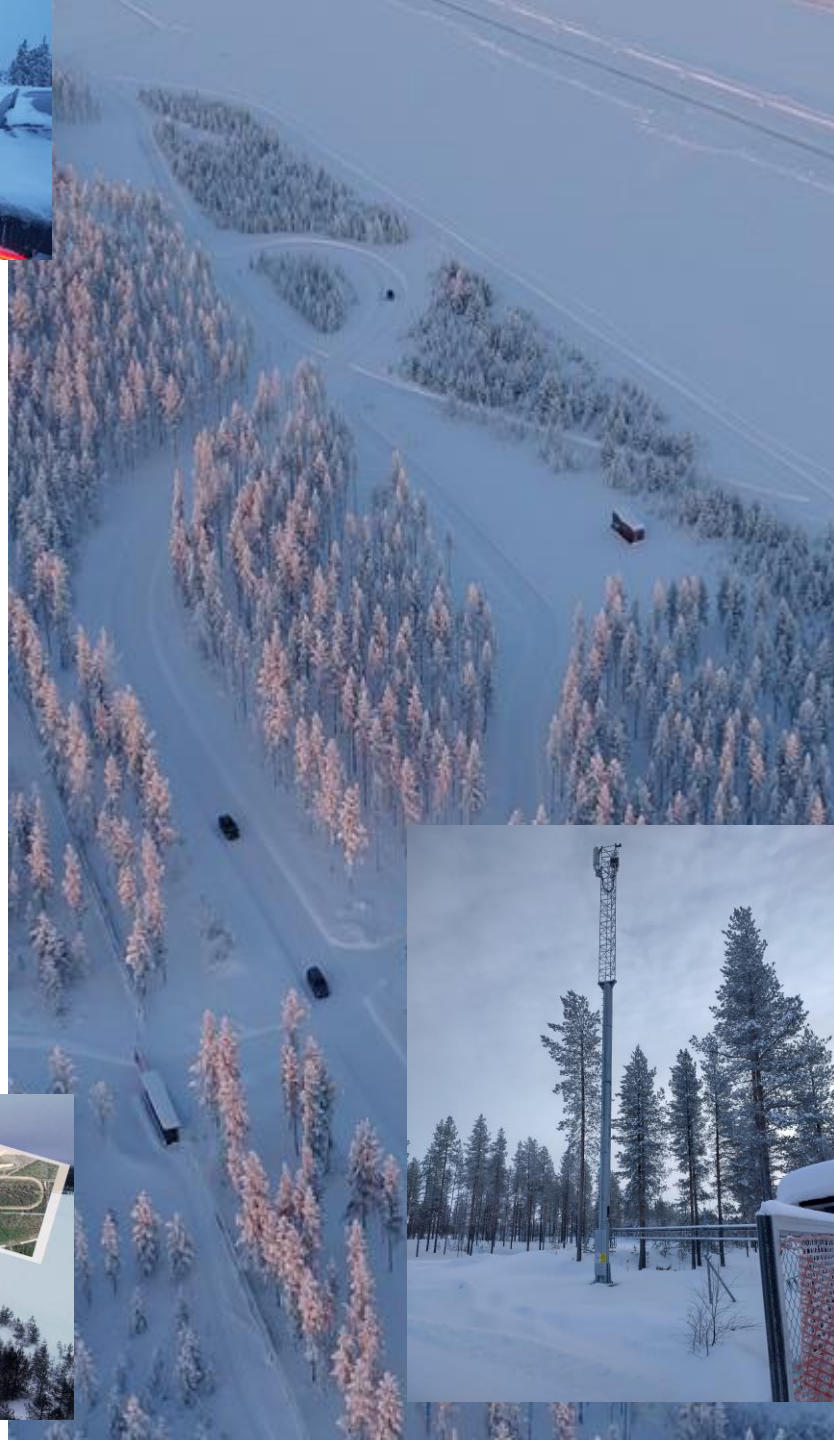
Intelligent traffic



- **Road weather services exploiting Intelligent Traffic Systems (ITS)**
  - 5G enabled road weather services
  - Road weather services tailored for autonomous vehicles
  - Digital Twin modelling of test track
  - Energy efficiency, green tech
  - Weather radar-assisted road weather
- **Sod5G – Vehicle winter testing track for combined intelligent traffic and road weather services development and testing**
  - Testing and demonstration platform for all intelligent traffic research projects
  - Permanent measurement infrastructure

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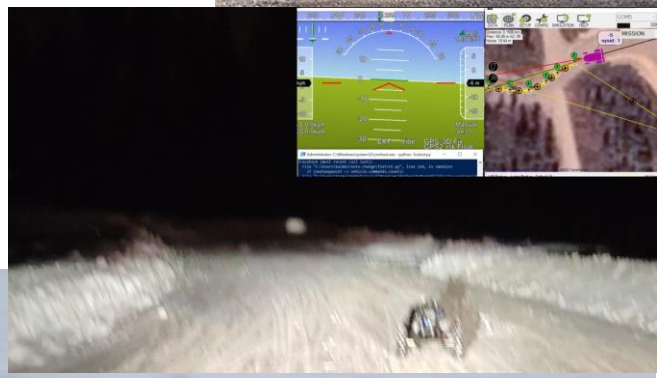
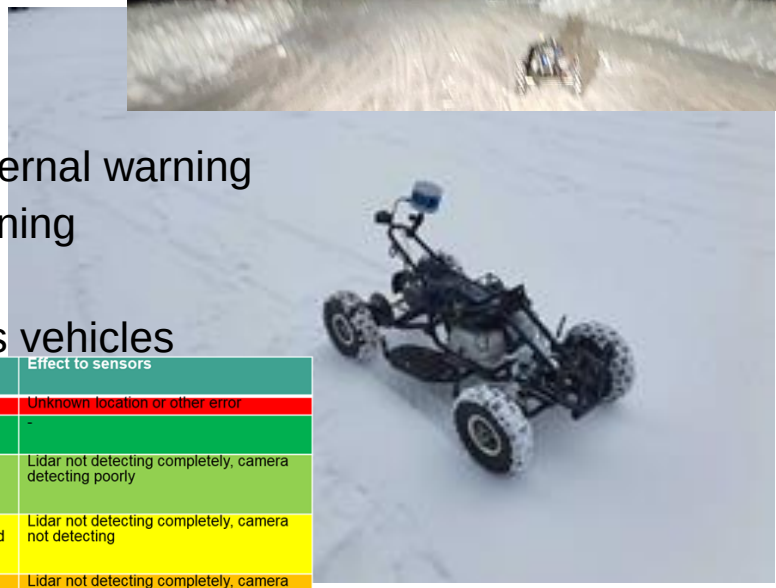
Test track permanent infrastructure

- Versatile vehicle winter testing track, 1.7 km main track (gravel/concrete)
- Monitoring hub for on-site control & configuration of measurements
- Non-standalone 5G in 3.5 GHz with narrowband IoT, part of 5GTN
- ITS-G5-test network (2 interactive RWS + mobile devices)
- Road weather obs infrastructure (2 RWS + Vaisala GroundCast surface-embedded sensor, mobile vehicular measurements with Vaisala MD30, Teconer RCM 411/511 and Luft MARWIS)
- LoraWAN IoT weather sensor network
- Autonomous miniature vehicle as local UAV
- Luosto weather radar, supplying Nowcasting data
- Instrument pipelines in concrete section, for under-surface sensors
- Digital Twin-replica of the track with Sitowise Unity engine
- http://sod5g.fmi.fi

Autonomous miniature vehicle

- Miniature vehicle
  - Carries all the monitoring instrumentation present in passenger UAVs
  - Provides all the sensor data composed by UAV and can react to services linearly with autonomous passenger UAVs
- Current equipment
  - Pixhawk 4 Flight Controller, with internal IMU and compass
  - 5G-capable Flight Controller companion computer
  - 2x uBlox ZED-F9P RTK Moving Base antennae
  - Velodyne VLP-16 "Puck" 360° LiDAR
  - Teconer RCM411 Road Condition Monitor/ Vaisala MD30
  - Options; vehicle radar, camera
- Current capabilities
  - Route-based driving with several routes in the test track
  - Alternative route manoeuvre as launched event or by external warning
  - Dodging maneuver as launched event or by external warning
  - Accepting different driving modes
  - Enhanced road weather services tailored for autonomous vehicles



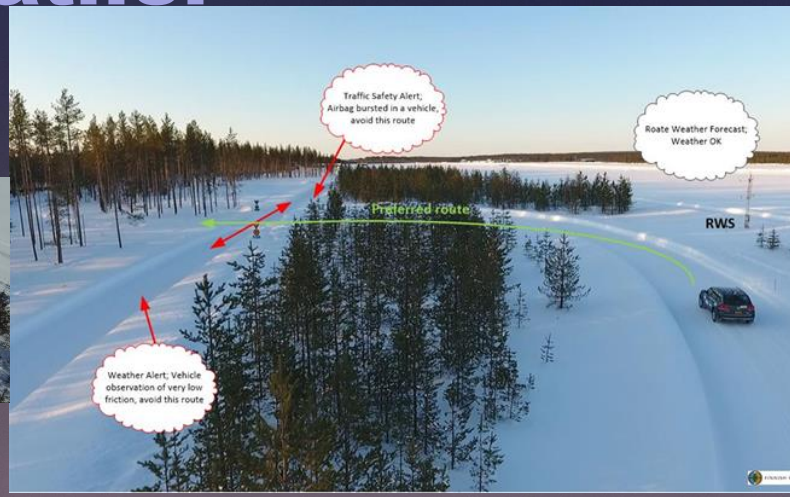


Driving mode	Driving specifics	Road weather and driving conditions	Effect to sensors
0	Must stop	Not defined	Unknown location or other error
1	No need to adjust speed nor driving	Fair weather. Good visibility and dry surface	-
2	Anticipate braking events by lowering speed, increase safety distance	Minor rain or snow / light snowdrift / light fog. Fairly good visibility and friction.	Lidar not detecting completely, camera detecting poorly
3	Halve the speed, increase safety distance	Moderate rain or snow / moderate snowdrift / light or dense fog. Reduced visibility or friction.	Lidar not detecting completely, camera not detecting
4	Minimum speed, prepare to stop	Heavy rain or snow / high snowdrift / freezing rain / dense fog. Reduced visibility or friction.	Lidar not detecting completely, camera not detecting, radar not detecting completely, ice and snow on the sensors
5	Must stop	Heavy rain or snow / moderate or long-lasting freezing rain / heavy fog. Very low visibility or friction.	Lidar and camera not detecting, radar detecting poorly, ice and snow on the sensors

Interactive vehicular weather and safety services

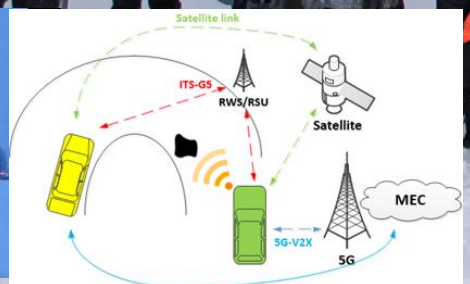
5G-SAFE (2016-2018);

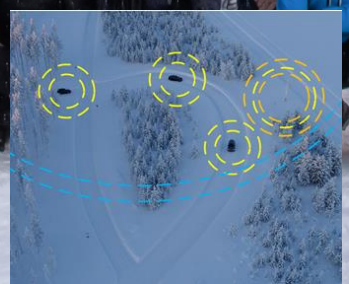
- Road Weather Forecast
- Traffic Safety Alert
- Weather alert
- Vehicle See-through



5G-SAFE-Plus (2020-2023);

- 5G-enabled weather, road safety and maintenance services (with Vaisala)
- Obstacle detection and warning with hybrid communication for CAV (with VTT & Unikie)
- Ultra-low delay services for CAV, including pedestrian warning (VTT)
- Cyber-security issues (Wedge Networks)
- Digital Twin model of the test track

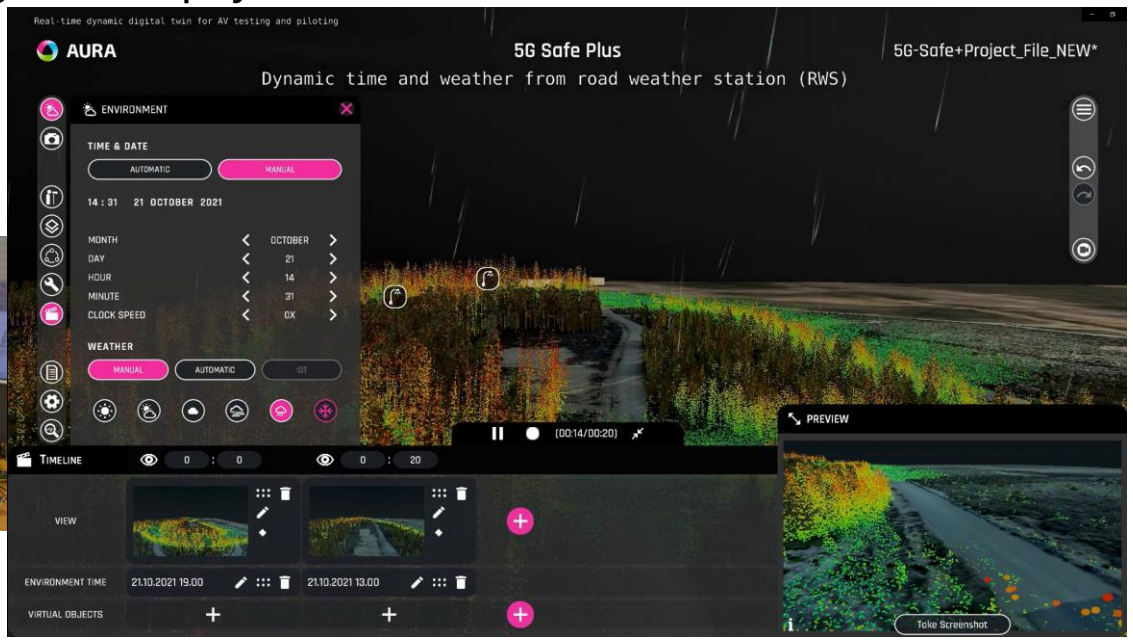




Digital Twin of the test track

- Environment
  - Unity real-time graphics, created by Sitowise
  - allows complex lighting, physics, interactive environments, and high-fidelity audiovisual quality across multiple platforms
  - The 3D environment combines multiple information sources and formats; initial data models, combination models, presentation models, standardized 3D-formats, XML bidirectional data, HTTP, MQTT, sockets, websockets, IoT devices and sensors
- Purpose
  - Visualization of test scenarios, in varying weather conditions
  - Monitoring vehicle tests via Digital Twin interface in the test track hub
  - Planning the instrument configuration, designing new instrumentation implementations
  - Future; creating virtual fleets alongside the physical ones

SITOWISE



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Road weather service development in public roads

SafeTrucks

Xecs

Arctic Trucks/SafeTrucks–up to 6 mine trucks collecting & consuming road weather service data

- Currently 3 friction devices and one camera monitoring system equipped
- SafeTrucks-project functionalities installed during 2024

Roadside infrastructure providing supplemental data for road weather services

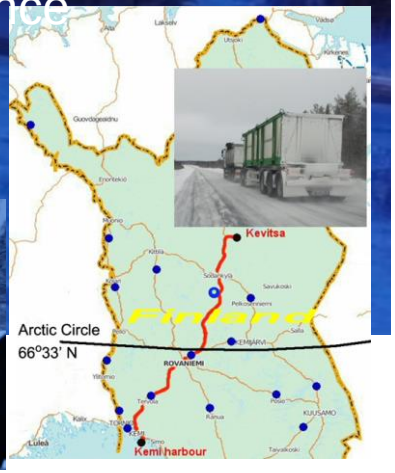
- Interactive road weather station in Petäjämaa with advanced measurements (Temperature, wind, surface temp & state, friction, visibility, road frost) and communication systems (4G, ITS-G5, WiFi)

Surface-embedded sensors in selected spots analysing road endurance

- Surface-embedded sensors, Perco-stations monitoring underground road layers (University of Oulu, Material- and machine technics)

On-board external sensors for ad-hoc measurements

- Friction instruments of Vaisala, Teconer and Luft
- Camera-based weather and road-condition analysis by Vaisala and Destia



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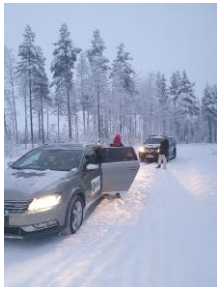
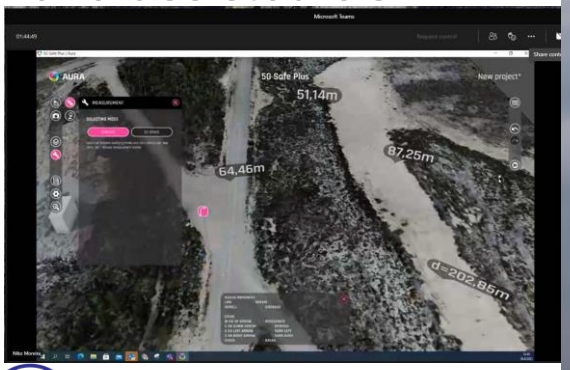
VR TRANSPOINT

Future work:

- Road weather services tailored for autonomous vehicles, including weather radar Nowcasting
- High-speed uploading of autonomous vehicle sensor data, hierarchical data analysis methods
- More dense and versatile road weather sensor IoT network
- Vehicle-specific tailored road weather and safety services for the heavy traffic
- More configurable Digital Twin of test track
- mmWave 5G network (28 GHz)
- WiFi6/7 network hotspot(s)
- Drone-assisted 5G





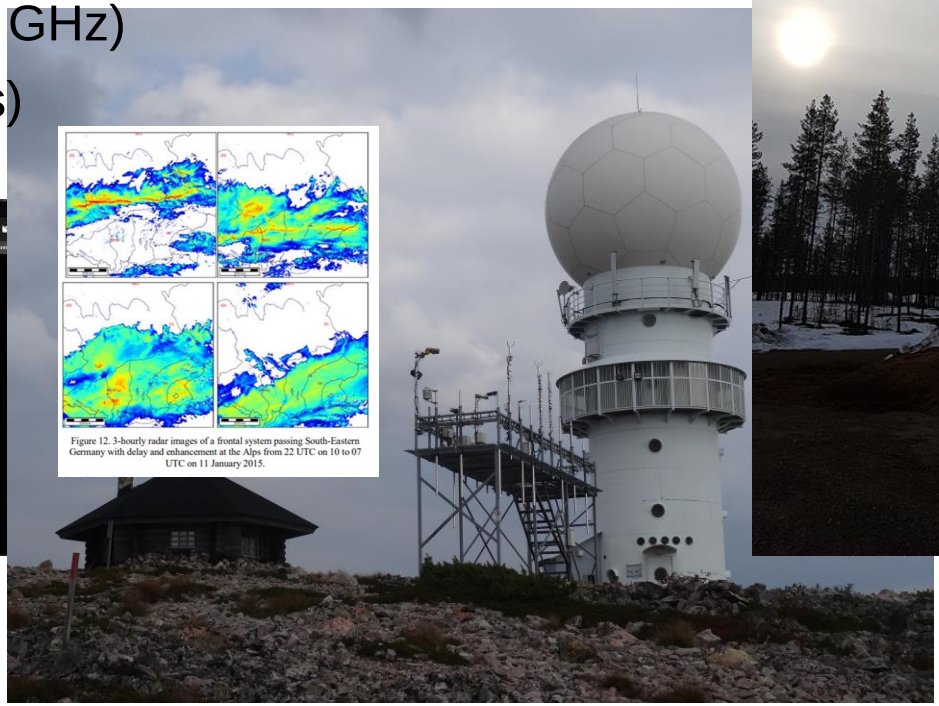


Figure 12. 3-hourly radar images of a frontal system passing South-Eastern Germany with delay and enhancement at the Alps from 22 UTC on 10 to 07 UTC on 11 January 2015.

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