ROADVIEW

Robust Automated Driving in Extreme Weather

ROADVIEW project

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Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them. Project grant no. 101069576.

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Swiss participants in this project are co-funded by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract no. 22.00123.

ROADVIEW

Partner's name	Acronym	Country
Halmstad University	HH	Sweden
Lapland University of Applied Sciences	LUA	Finland
Ingolstadt University of Applied Sciences	THI	Germany
Swedish National Road and Transport Research Institute	VTI	Sweden
Cerema (Centre for Studies on Risks, the Environment, Mobility and Urban Planning)	CE	France
RISE Research Institutes of Sweden AB	RISE	Sweden
Finnish Geospatial Research Institute	FGI	Finland
Repli5	Repli5	Sweden
Konrad GmbH	KO	Germany
Ford Otosan	FORD	Turkey
Canon Research Centre France	CRF	France
accelopment Switzerland AG	accelCH	Switzerland
The University of Warwick	WMG	UK
VTT Technical Research Centre of Finland Ltd	VTT	Finland
AVL Software and Functions GmbH	AVL	Germany

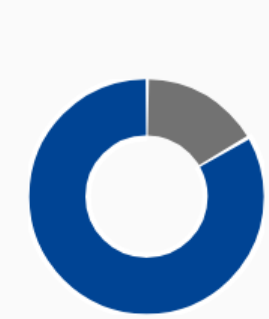
Start date
1 September 2022

End date
31 August 2026

Funded under
Climate, Energy and Mobility

Total cost
€ 8 014 105,55

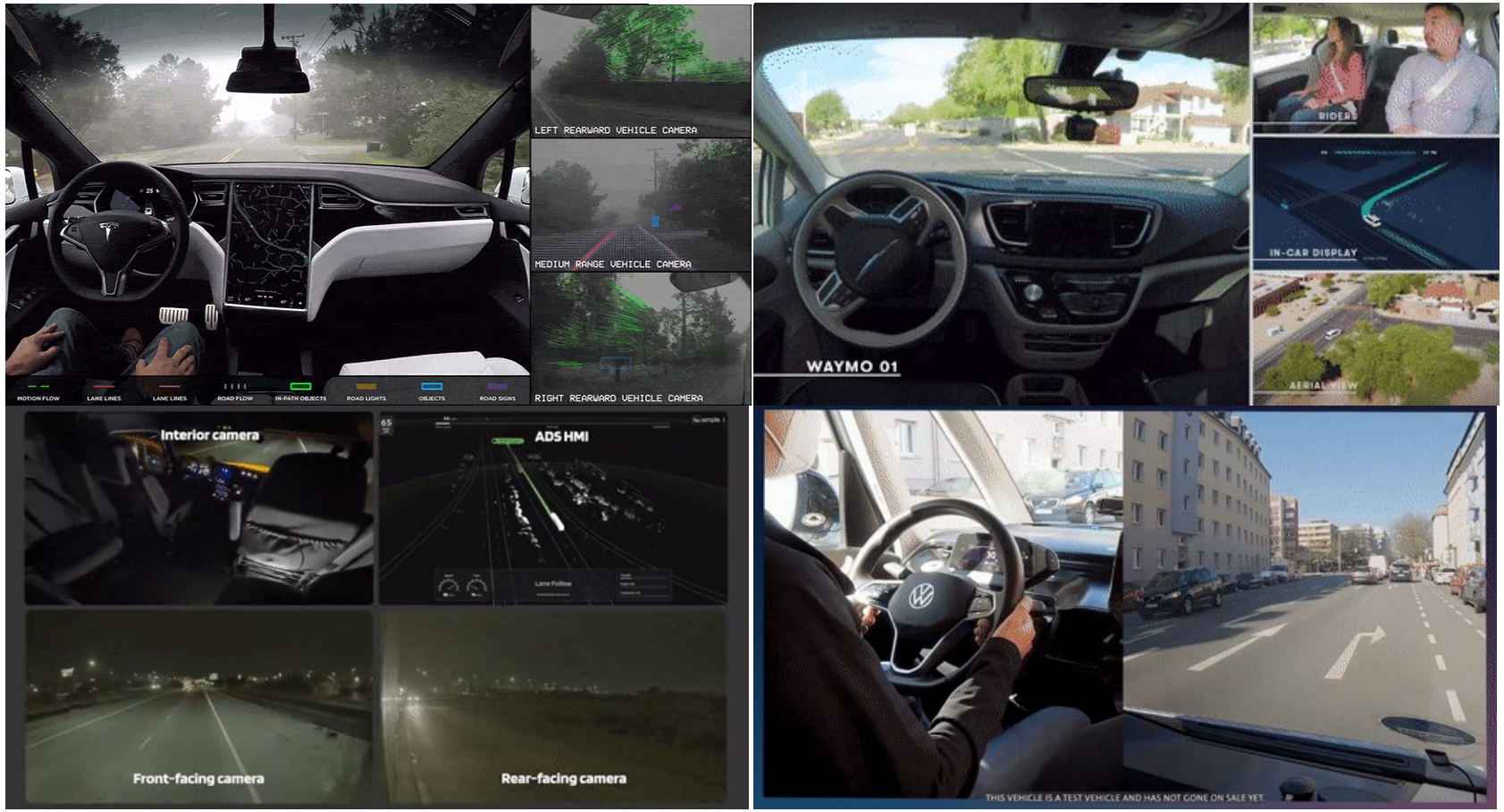
EU contribution
€ 6 652 915,80



The AV Challenge

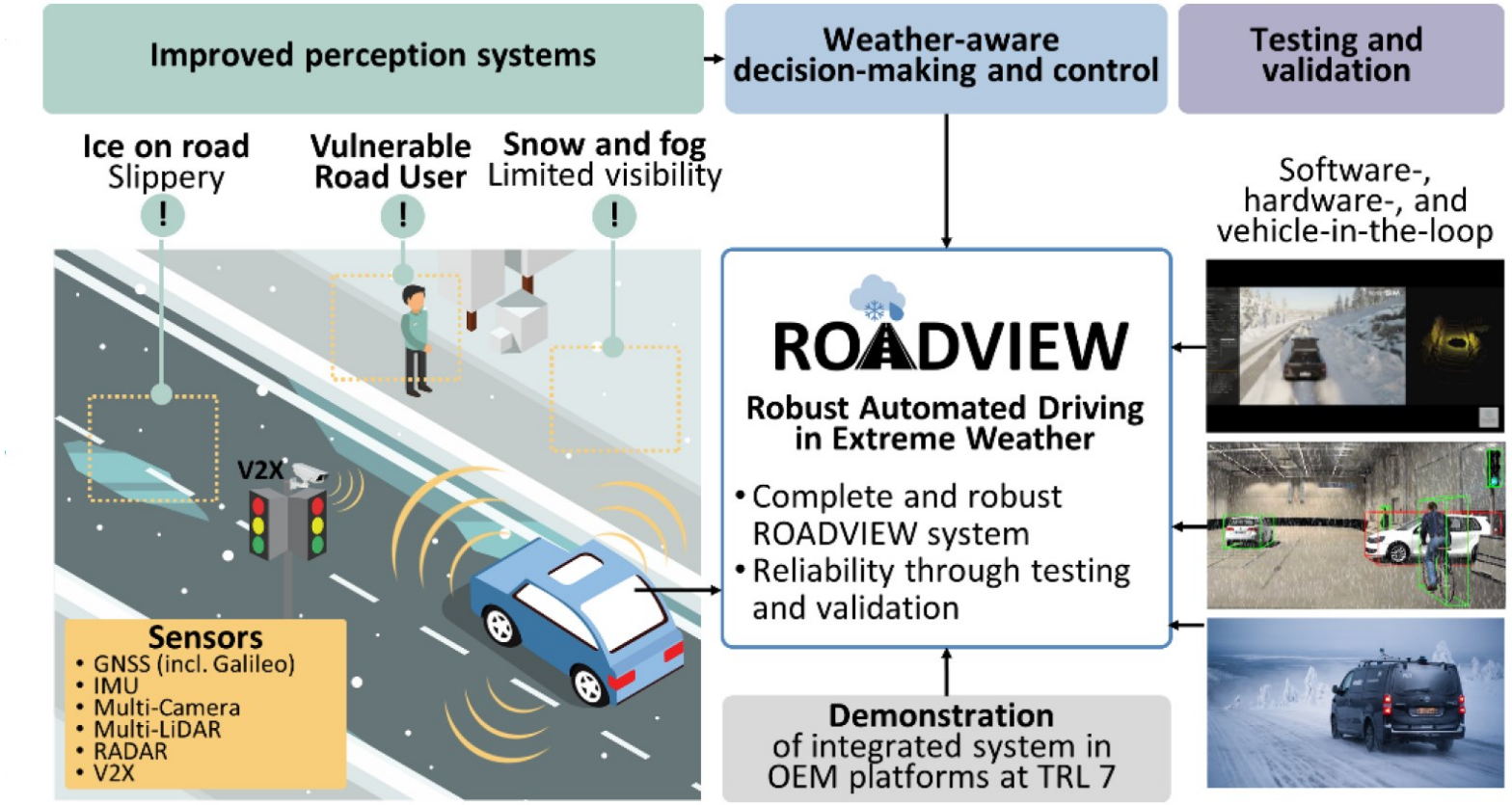
“Not every kilometre driven is equal”

Most autonomous vehicles have been primarily **trained and tested under optimal weather** and **road conditions** with clear visibility!

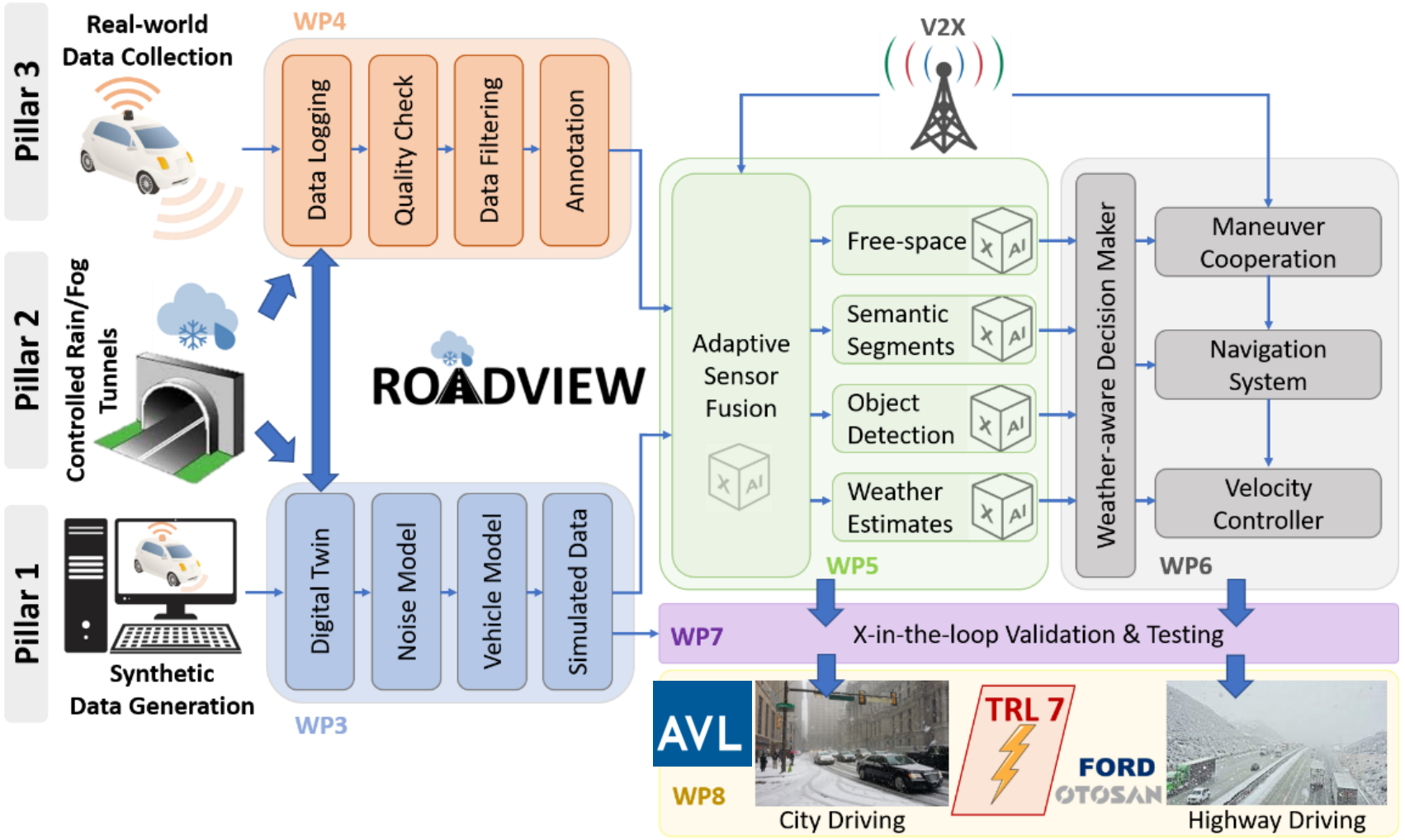


ROADVIEW: The solution

ROADVIEW addresses these **weather-related challenges** by **developing** robust and cost-efficient embedded **in-vehicle perception and** weather-aware **decision-making systems** for connected and automated vehicles with enhanced performance under harsh weather conditions.



ROADVIEW: Robust Automated Driving in Extreme Weather



ROADVIEW aims to move toward systems at ***Technology Readiness Level 7***

Example of results

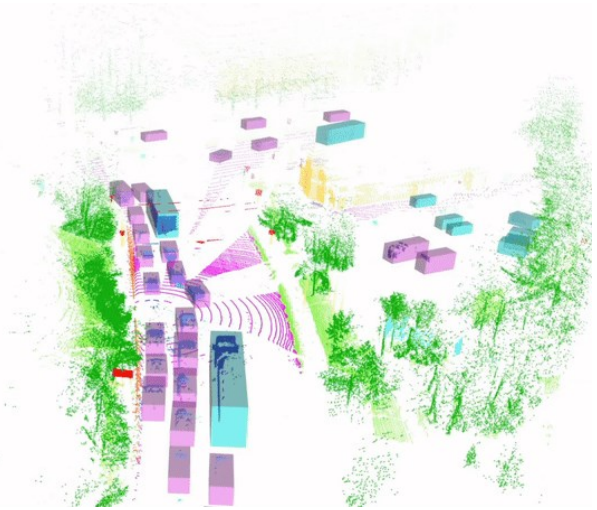
Logging and annotating multimodal harsh weather dataset:

- ROADVIEW has **logged large-scale datasets in four seasonal conditions (clean, rain, fog, and snow)** using its multiple vehicles.
- As a **unique contribution**, these **datasets were fully 3D annotated to address multiple perception tasks**: 3D object detection, semantic segmentation, and filtering.

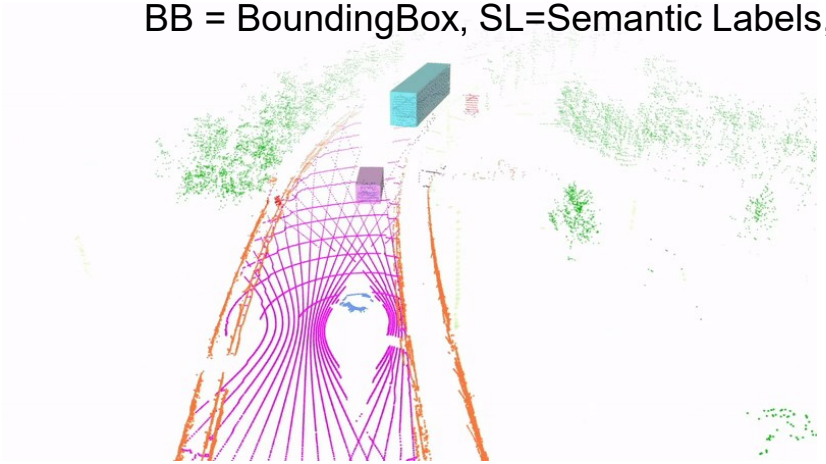
		Modality				3D Annotation					
Dataset	**Year**	**LiDAR**	**RGB**	**Thermal**	**GNSS/IMU**	**BB**	**SL**	**SF**	**#Frames**	**#Classes**	**Snow**
KITTI [15]	2012	64	90°	-	✓/✓	✓	-	-	15K	8	-
KAIST [10]	2018	32	26°	25°	✓/✓	✓	-	-	95K	3	-
nuScenes [7]	2019	32	360°	-	✓/✓	✓	✓	-	40K	23	-
Waymo [29]	2020	64*	360°	-	✓/✓	✓	✓	-	230K	4	-
A2D2 [16]	2020	16	360°	-	✓/✓	✓	-	-	12K	14	-
Argoverse 2 [34]	2021	32	360°	-	- / -	✓	-	-	150K	30	-
SemanticKITTI [4]	2021	64	-	-	✓/✓	-	✓	-	43K	28	-
CADC [22]	2021	32	360°	-	✓/✓	✓	-	-	7K	10	✓
WADS [20]	2021	64	-	-	-	-	✓	✓	2K	22	✓
Ithaca365 [13]	2022	128	60°	-	✓/✓	✓	-	-	7K	6	✓
Boreas [6]	2023	128	81°	-	✓/✓	✓	-	-	7K	3	✓
ZOD [1]	2023	128	120°	-	✓/✓	✓	-	-	100K	29	✓
SemanticSTF [36]	2023	64	-	-	-	-	✓	-	2K	21	✓
MSU-4S [19]	2024	64	150°	-	✓/✓	✓	-	-	100K	3	✓
MAN TruckScenes [14]	2024	64	360°	-	✓/✓	✓	-	-	30K	27	✓
Snowy Scenes	2025	128	70°	72°**	✓/✓	✓	✓	✓	5K***	27	✓

* For the top spinning LiDAR. ** Combined HFOV of 3 thermal cameras. *** Total amount of collected data is over 22K.

BB = BoundingBox, SL=Semantic Labels, SF=Scene Flow



3D Semantic Segments, 3D Bounding Boxes, Noise Labeling



Multi-vehicle & Multi-domain

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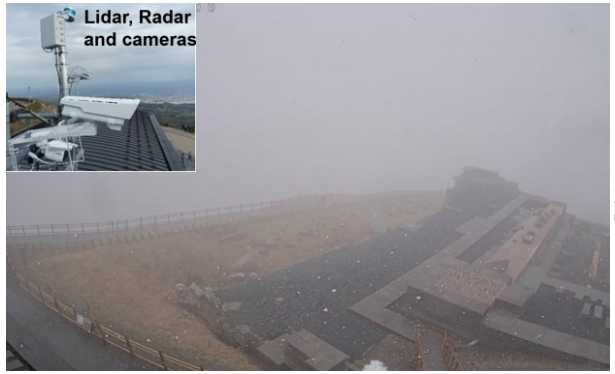
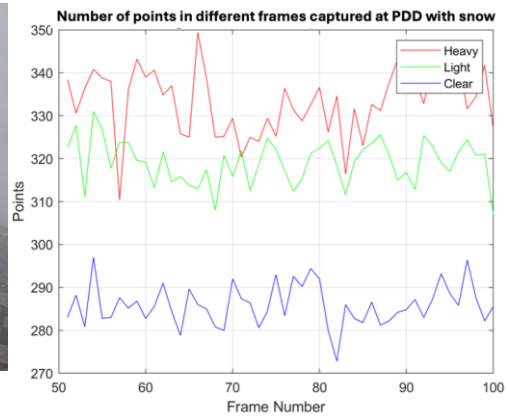
Example of results

Increasing the degree of challenges in the simulation tool:

- **LUA implemented high-fidelity digital twins of the Lapland Proving Ground (LPG),** enabling rigorous testing across Simulation-in-the-Loop (SiL), Hardware-in-the-Loop (HiL), and Software-in-the-Loop (XiL)
- WMG advanced computational **noise modeling** techniques to generate realistic, challenging sensor data—including **RGB images, 3D LiDAR, and 4D RADAR point clouds**.
- Complementing this, THI collaborated with LUA and implemented more challenging **simulated traffic scenarios**.



Data logging at Puy-de-Dome (PDD)



Compound Noise Modelling

Lapland Proving Ground (LPG)

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Collaborative Perception Solutions with Infrastructure-based Perception Systems

Data collection in Finland

- Infrastructure RSU installed in Muonio 01/2025

- Minimum recorded temperature - 34 °C

V2X Manoeuvre Coordination Module (MCM)

- MCM request: MRM or speed advice

V2X Road Weather Message

- RSU and vehicles exchange data about **friction and visibility** conditions

Roadside camera and Lidar

Power supplies
for roadside sensors

V2X Communication

Local area
network access

Roadside unit

Wide area
Network access

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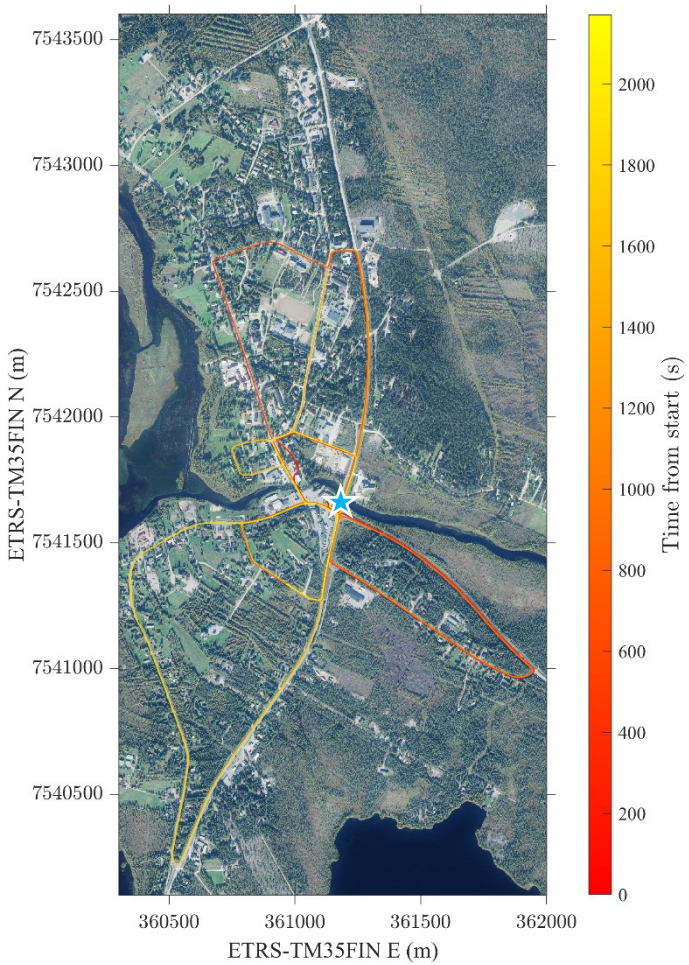
Collaborative Perception Solutions with Infrastructure-based Perception Systems

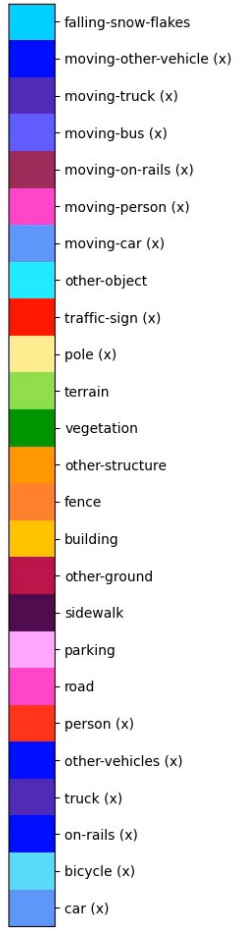
Recording with VTT vehicle – snow falling, road covered by snow

Recording with FGI vehicle – day & night, dry road & light snow fall

Collaborative Perception Solutions with Infrastructure-based Perception Systems

Global Fusion of roadside sensor detection, vehicle detections, and semantic segmentation





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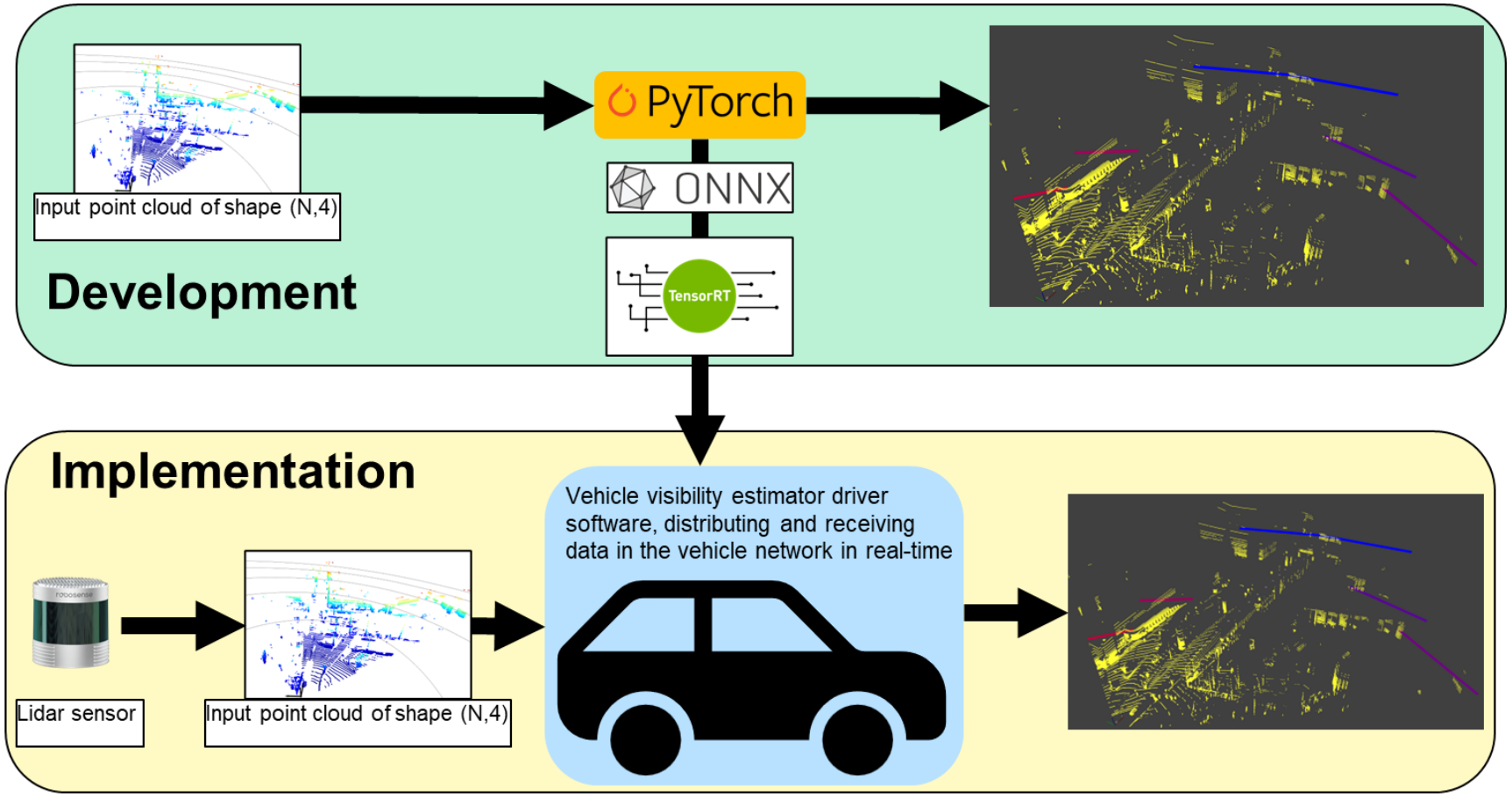
Visibility estimator (VTT)



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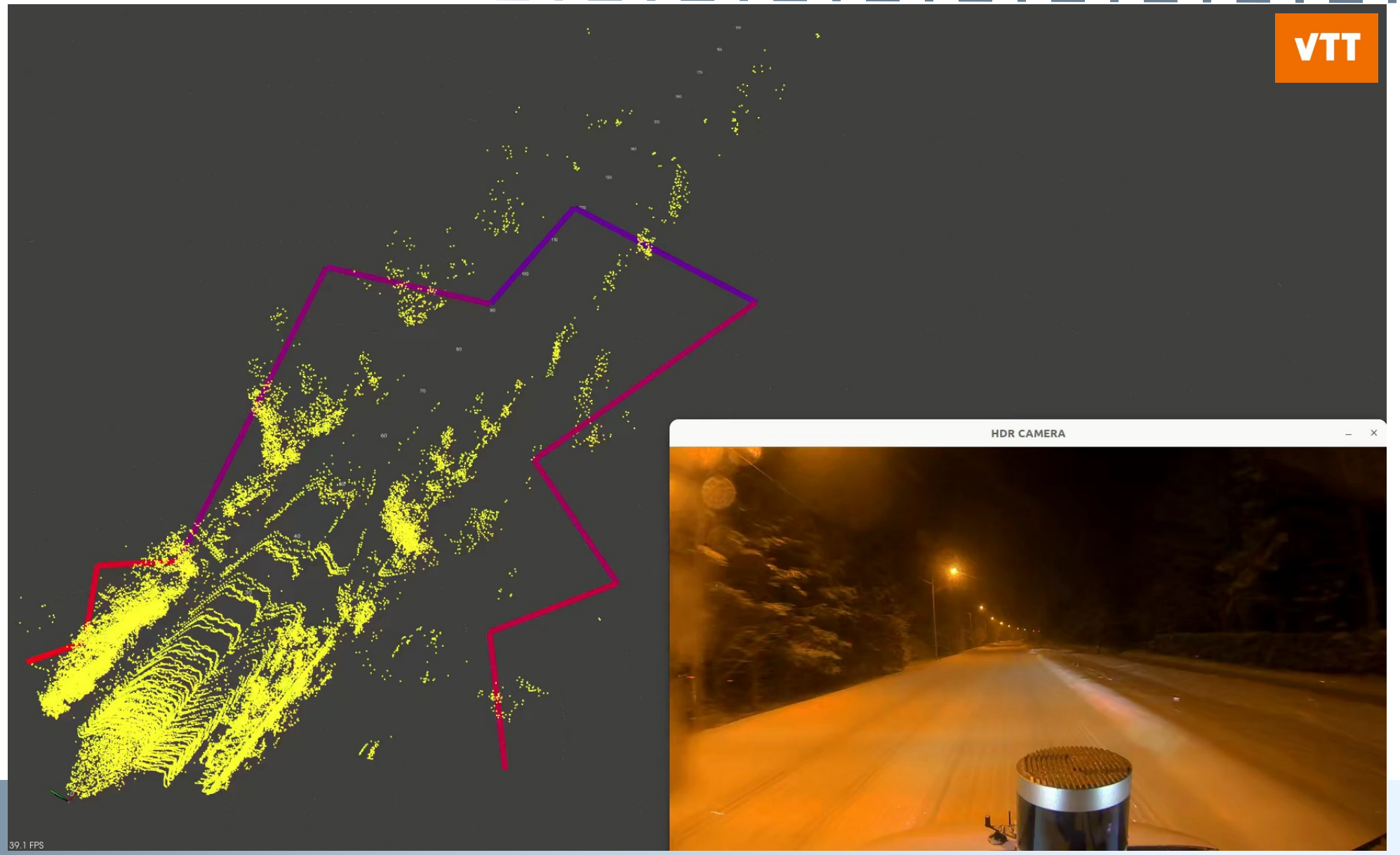
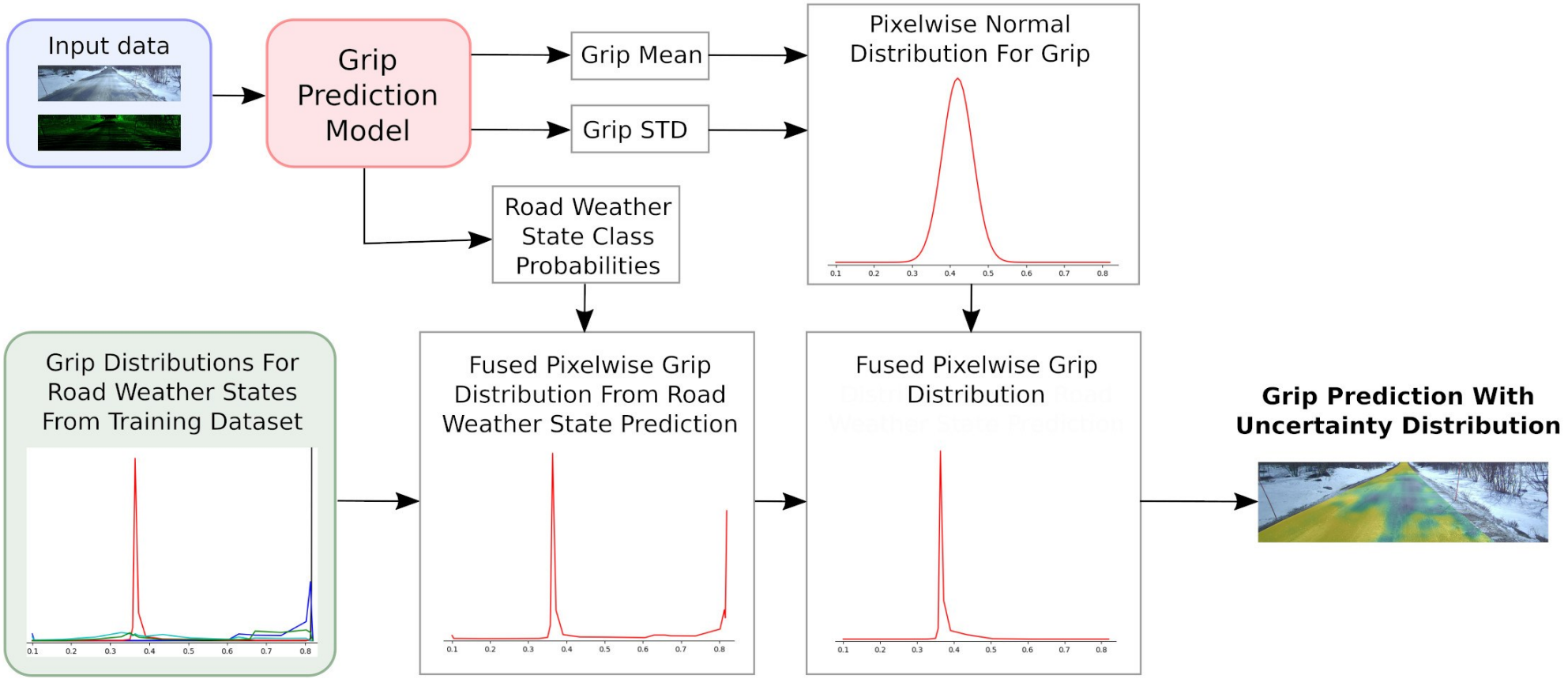


Slipperiness (grip) prediction (FGI)



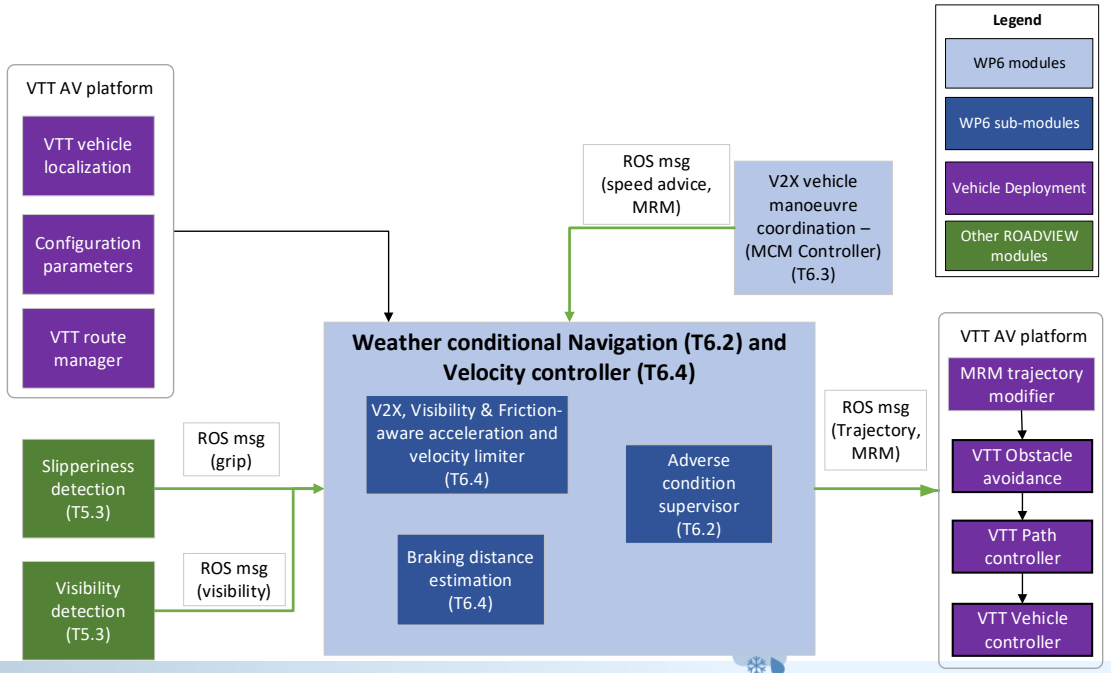
Slipperiness (grip) prediction (FGI)

Metric	Test set result
Mean squared error of predicted grip distribution **mean**	0.0620
Mean squared error of predicted distribution **median**	0.0642
Amount of measurements **within 95%** confidence intervals (%)	96.4
Road weather state prediction accuracy (%)	94.8

VTT AV, sensors and software architecture used in evaluations

Sensors on VTT Martti used during these tests:

- 4 x Basler RGB cameras, covering a full 360° surround view
- 1 x Robosense ruby plus128-beam LiDAR (on top of the vehicle 360° FoV)
- U-blox ZED F9P Global Navigation Satellite System (GNSS) & Xsens Mti-680g IMU
- Teconer sensor (as a reference) to measure friction in front of the right front tyre (https://www.teconer.com/surface-condition-friction-measurements/#RCM511)



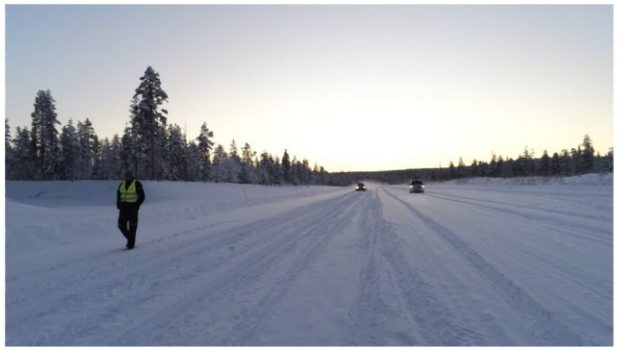
VTT artic tests in Lapland

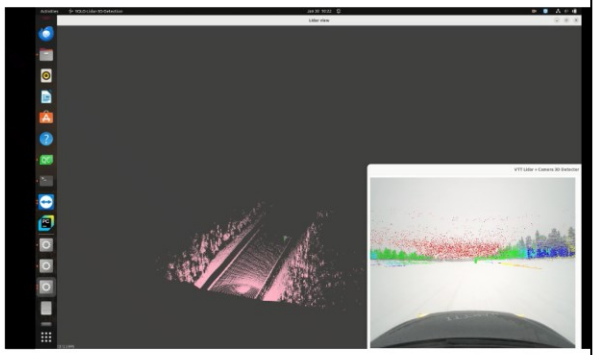
Weather conditional Navigation system and Velocity controller evaluation

The real-world evaluation tests took place in the **Tampere area on public roads** and at the **Lapland Proving Ground (LPG**, https://laplandpg.fi/) **closed test track**.

VTT measurements in LPG: C5

C 5	Friction needed to match the speed of another road user is taken into account by starting the deceleration early enough	Pedestrian walking along the lane to the same direction	UC3: interacting with VRU





The videos demonstrate the test scenario and conditions observed during the evaluation.
These videos were not captured from the same test drive.

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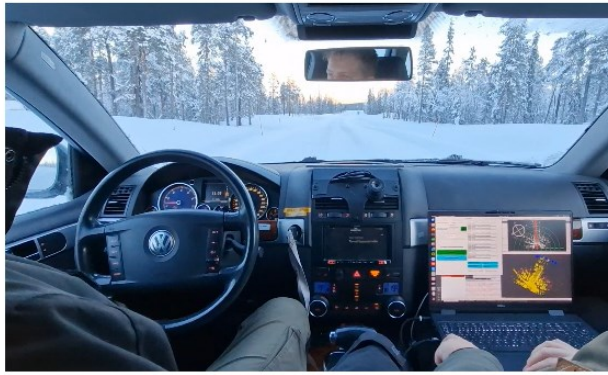
VTT measurements in LPG: C3

C3	Friction needed to change a lane and come to a full stop is taken into account by suitable speed and deceleration limitations during the manoeuvre	No other traffic participants	UC2: coming to full stop UC5: exiting a la



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Dissemination

ROADVIEW newsletter, https://roadview-project.eu/

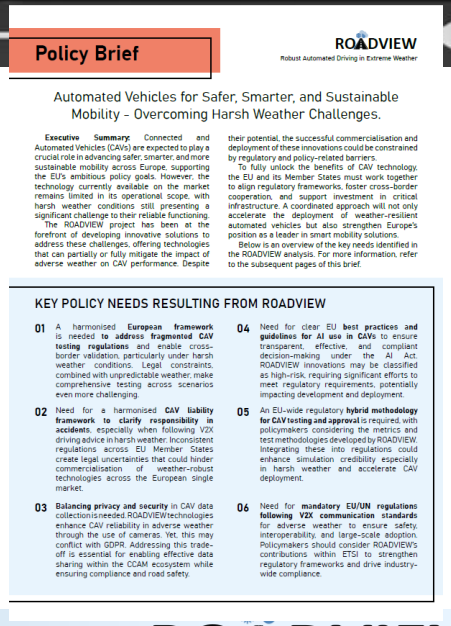
ROADVIEW webinars

- April 2024: **Standardisation & the Regulatory Framework**
- March 2025: **Robust Perception of AVs**
- More coming in 2026…

Policy brief - Published March 2025 - outlines key recommendations:

- Establishing a **harmonised European framework** for CAV testing and approval
- Defining **clear liability regulations** for CAV operations
- Ensuring **AI transparency and compliance** with the EU AI Act
- Balancing **data privacy and security** under GDPR
- Strengthening **V2X communication standards** for adverse weather conditions

https://roadview-project.eu/2025/03/10/policy-brief-automated-vehicles-for-safer-smarter-and-sustainable-mobility-overcoming-harsh-weather-challenges/


Policy Brief

ROADVIEW
Robust Automated Driving in Extreme Weather

Automated Vehicles for Safer, Smarter, and Sustainable Mobility - Overcoming Harsh Weather Challenges.

Executive Summary: Connected and Automated Vehicles (CAVs) are expected to play a crucial role in advancing safer, smarter, and more sustainable mobility across Europe, supporting the EU's ambitious policy goals. However, the technology currently available on the market remains limited in its operational scope, with harsh weather conditions still presenting a significant challenge to their reliable functioning.

The ROADVIEW project has been at the forefront of developing innovative solutions to address these challenges, offering technologies that can partially or fully mitigate the impact of adverse weather on CAV performance. Despite their potential, the successful commercialisation and deployment of these innovations could be constrained by regulatory and policy-related barriers.

To fully unlock the benefits of CAV technology, the EU and its Member States must work together to align regulatory frameworks, foster cross-border cooperation, and support investment in critical infrastructure. A coordinated approach will not only accelerate the deployment of weather-resilient automated vehicles but also strengthen Europe's position as a leader in smart mobility solutions.

Below is an overview of the key needs identified in the ROADVIEW analysis. For more information, refer to the subsequent pages of this brief.

KEY POLICY NEEDS RESULTING FROM ROADVIEW

01 A harmonised **European framework** is needed **to address fragmented CAV testing regulations** and enable cross-border validation, particularly under harsh weather conditions. Legal constraints, combined with unpredictable weather, make comprehensive testing across scenarios even more challenging.

02 Need for a harmonised **CAV liability framework to clarify responsibility in accidents**, especially when following V2X driving advice in harsh weather. Inconsistent regulations across EU Member States create legal uncertainties that could hinder commercialisation of weather-robust technologies across the European single market.

03 **Balancing privacy and security** in CAV data collection is needed. ROADVIEW technologies enhance CAV reliability in adverse weather through the use of cameras. Yet, this may conflict with GDPR. Addressing this trade-off is essential for enabling effective data sharing within the CCAM ecosystem while ensuring compliance and road safety.

04 Need for clear EU **best practices and guidelines for AI use in CAVs** to ensure transparent, effective, and compliant decision-making under the AI Act. ROADVIEW innovations may be classified as high-risk, requiring significant efforts to meet regulatory requirements, potentially impacting development and deployment.

05 An EU-wide regulatory **hybrid methodology for CAV testing and approval** is required, with policymakers considering the metrics and test methodologies developed by ROADVIEW. Integrating these into regulations could enhance simulation credibility especially in harsh weather and accelerate CAV deployment.

06 Need for **mandatory EU/UN regulations following V2X communication standards** for adverse weather to ensure safety, interoperability, and large-scale adoption. Policymakers should consider ROADVIEW's contributions within ETSI to strengthen regulatory frameworks and drive industry-wide compliance.

ROADVIEW TEST ENVIRONMENTS & DEMONSTRATIONS

Full-span of verification methodologies all around Europe has been established to address ***various use-cases and Operational Design Domains (ODDs)*** within ROADVIEW project.

ROADVIEW DEMONSTRATION DAY

3.3.2026 Motorspace track, Pirkkala
https://maps.app.goo.gl/Her89RVnWyqPqJAu5

Agenda:

11:00 – 13:30 Live demo onboard VTT AV

- In-vehicle road slipperiness estimation
- Roadside-vehicle (V2X) cooperation
- Weather-aware velocity control & MRM

12:00 – 13:00 Lunch

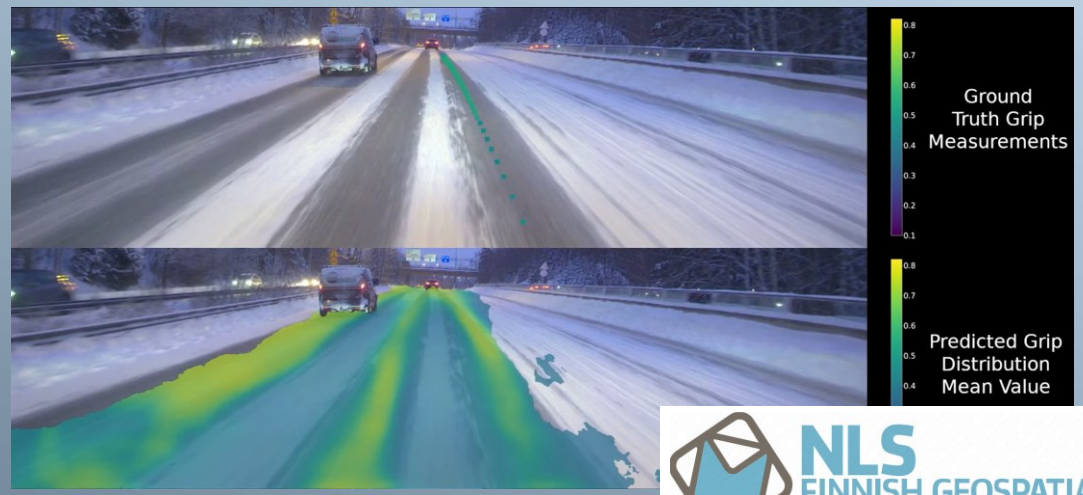
13:00 – 14:00 Q&A, networking

VTT

Register online

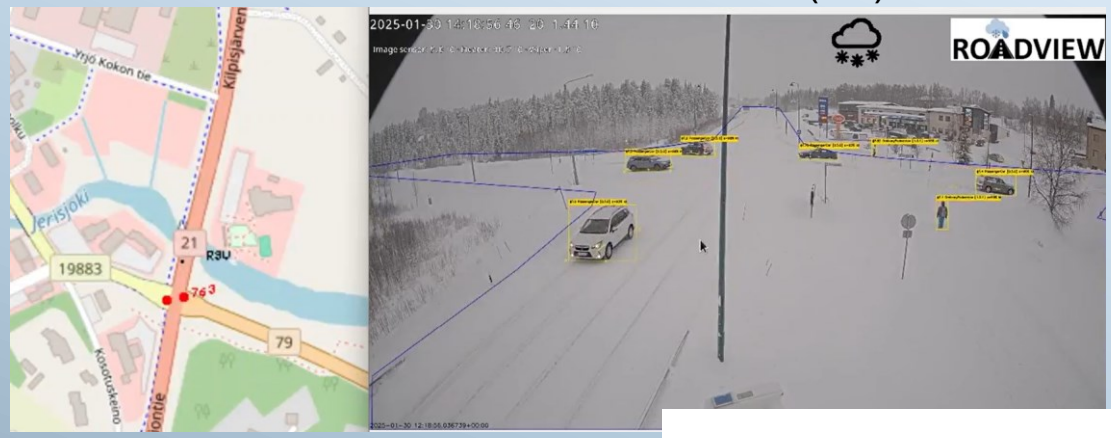
Weather-aware decision-maker

Automated Vehicles (AV)



Slipperiness estimation

NLS FINNISH GEOSPATIAL RESEARCH INSTITUTE FGI



Roadside V2X warning/ advice to AV

Canon

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Questions or comments?

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