ROADVIEW

Robust Automated Driving in Extreme Weather

Issue 5/September 2026

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Welcome to the ROADVIEW Newsletter, Final Issue

Dear Reader,

Welcome to the final edition of the ROADVIEW newsletter. After four years of research, development, integration and validation, the ROADVIEW project officially came to an end on 31 August 2026. In this concluding issue, we look back at some of the project's final and most important achievements and at how ROADVIEW has advanced automated driving towards safer and more reliable operation in adverse weather conditions.

We begin with Demonstration 2, carried out in the demanding winter conditions of Finnish Lapland. Led by VTT, the demonstration brought together ROADVIEW technologies for visibility and slipperiness estimation, HD-map-based localisation, cooperative perception, V2X communication and weather-aware decision-making on an automated vehicle. Testing on closed tracks and public roads showed how these technologies can work together to support safe automated driving in snow, ice and reduced visibility.

Next, we turn to Demonstration 5, ROADVIEW's final vehicle-level integration campaign at the AVL Mobility and Sensor Center in Roding, Germany. Using AVL's AutBus platform and the controlled conditions of the AVL weather hall, project partners evaluated technologies for LiDAR outlier detection, visibility and grip estimation, HD-map localisation, weather-conditional navigation and velocity control, as well as infrastructure-based perception and V2X communication under rain and fog. The demonstration showed that several ROADVIEW technologies developed by different partners could be integrated and operated simultaneously within a common automated driving platform.

Finally, we report on the ROADVIEW final event, held on 19 August 2026 at the AVL Mobility and Sensor Center. The event marked the culmination of four years of collaborative research by 15 partners from industry and academia across seven European countries. It showcased the project's advances in perception, localisation, connected intelligence, weather-aware decision-making and validation, as well as the datasets and research results that will remain available to support further development beyond the project.

As ROADVIEW comes to a close, we would like to thank all project partners, researchers, stakeholders and members of the wider automated mobility community who have contributed to and followed the project throughout its journey. The project may have officially ended, but its results provide a foundation for continued research and development towards automated vehicles that can operate more safely and reliably not only in fair weather, but also in rain, fog, snow and other challenging environmental conditions.

We hope you enjoy this final edition and the read!
accelopment on behalf of the project consortium

Demonstration 2: Automated Driving Takes on the Arctic Winter

In January 2026, ROADVIEW put its technologies to the test in one of Europe's most demanding environments: the winter conditions of Finnish Lapland. Demonstration 2, led by VTT Technical Research Centre of Finland Ltd (VTT), brought together several ROADVIEW innovations on a single automated vehicle to investigate how perception, localisation, connectivity and decision-making can support automated driving when roads are covered by snow and ice and visibility can change within seconds.

The demonstration took place across three environments. Tests were conducted at the Finnish Meteorological Institute winter test track in Sodankylä, on the runway at Sodankylä Airfield and on the public E8 road in Muonio. Temperatures during testing fell as low as approximately -21 °C, while snow-covered and partly icy surfaces provided authentic winter conditions. At the airfield, snow was deliberately blown into the air to create periods of reduced visibility for the automated vehicle.

At the centre of the demonstration was VTT's automated VW Touareg, known as Martti. The vehicle combines cameras, LiDAR, radars and high-precision positioning technologies with an automated driving system into which the ROADVIEW components were integrated. The demonstration connected innovations developed by VTT, the Finnish Geospatial Research Institute (FGI) and Canon Research Centre France (CRF), covering visibility and slipperiness estimation, HD-map-based localisation, cooperative perception, V2X communication and weather-aware vehicle control.

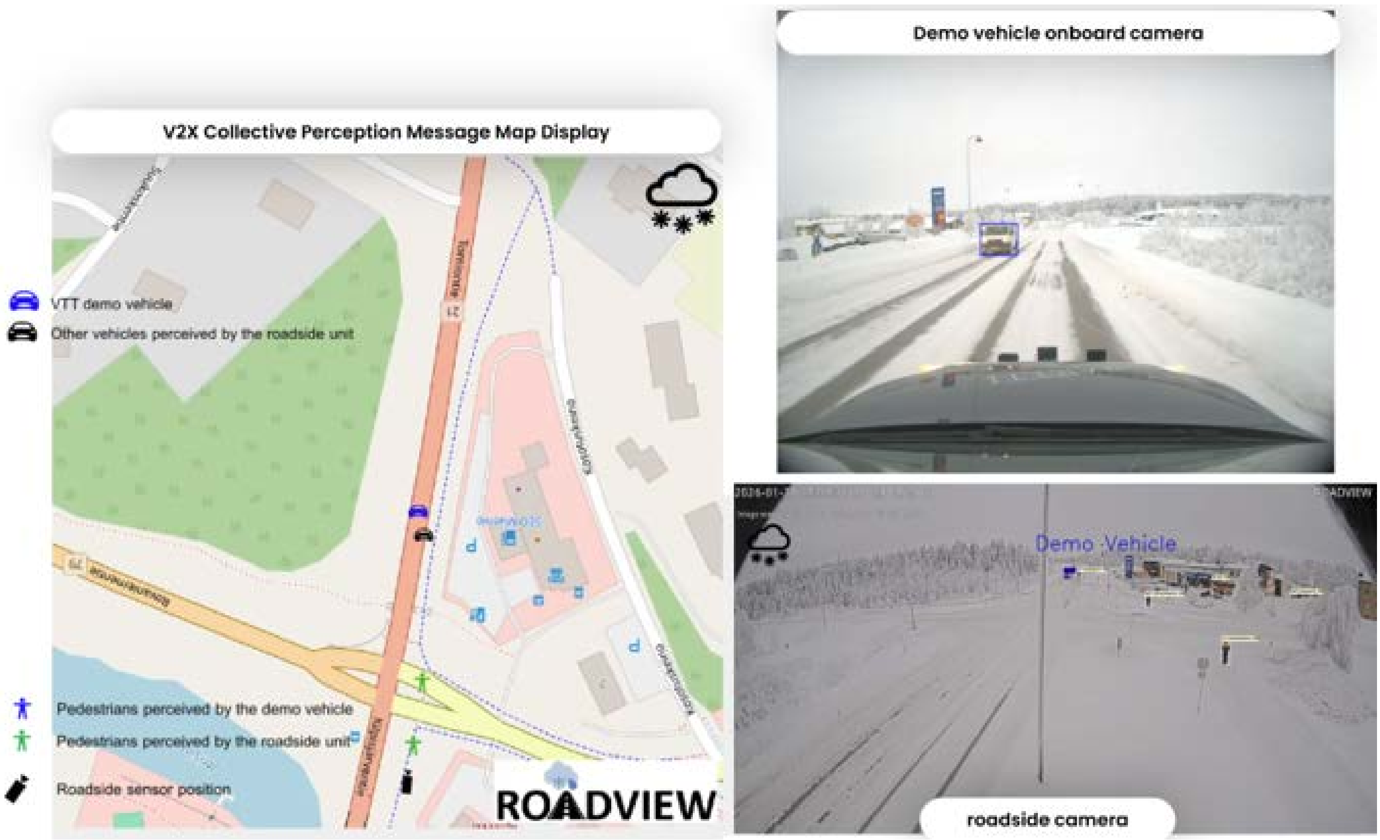

Figure 1. Cooperative perception in action: although the pedestrians are temporarily hidden from the automated vehicle by an oncoming vehicle, the roadside camera detects them and shares their positions with the vehicle via V2X communication.

Extending the vehicle's view through V2X: One focus was cooperative perception. On the E8 road in Muonio, roadside camera and LiDAR sensors monitored the road environment and communicated information to Martti through Vehicle-to-Everything, or V2X, communication.

In one scenario, two pedestrians were temporarily hidden from the automated vehicle by an oncoming vehicle. Although Martti's own sensors could not yet see them, the roadside system had already detected the pedestrians and transmitted their positions to the vehicle. Once the oncoming vehicle had passed, Martti's own sensors confirmed their presence.

The scenario illustrates an important advantage of cooperative perception. Automated vehicles do not necessarily have to rely solely on what their own sensors can currently see. Information from infrastructure can provide an additional perspective and help vehicles anticipate potentially critical situations, particularly when visibility is restricted estricted and the roads are very slippery.

Figure 2. Testing automated driving in reduced visibility at Sodankylä Airfield. Blowing snow reduces the vehicle's perception range, while the ROADVIEW visibility estimator detects the corresponding decrease in LiDAR sensing performance.

The infrastructure also transmitted weather-related information. Vehicle-based grip measurements and roadside weather observations were combined to create an enhanced picture of conditions on the road ahead.

ROADVIEW additionally demonstrated how this information can influence driving behaviour. In one test, Martti was travelling close to the local 50 km/h speed limit when the roadside unit issued a V2X speed recommendation of 35 km/h because of slippery road conditions in the intersection. The automated vehicle responded by reducing its speed. In another scenario, the roadside infrastructure issued a Minimum Risk Manoeuvre request, after which Martti decelerated and came to a controlled stop and a bus stop.

Seeing grip, visibility and position in winter: Demonstration 2 also examined how the vehicle itself can understand changing environmental conditions. FGI's slipperiness prediction technology uses RGB camera images to estimate road grip ahead of the vehicle. During the Lapland tests, the system successfully distinguished road areas ahead of the vehicle with different grip levels and also indicated areas where grip estimates were more uncertain.

Reliable localisation was addressed through FGI's Environment-Aware Normal Distributions Transform, or EA-NDT, HD mapping approach. An HD map of the Muonio area had been produced from data collected in April 2025. When Martti returned in January 2026, the appearance of the environment had changed considerably because of snow and winter conditions. Nevertheless, the vehicle was accurately localised without satellite (GNSS) positioning using the previously generated map in real time, demonstrating the robustness of the approach to substantial seasonal changes.

At Sodankylä Airfield, ROADVIEW tested what happens when the vehicle's perception range suddenly decreases. A vehicle travelling ahead of Martti generated a dense cloud of airborne snow. VTT's visibility estimator detected the resulting reduction in LiDAR

Figure 3. The same location in Muonio during HD-map data collection in April 2025 and the ROADVIEW demonstration in January 2026. Despite the substantial seasonal change, the HD-map-based localisation successfully supported real-time vehicle positioning.

sensing range. When the estimated visibility range remained below the required distance for safe automated operation, the weather-conditional navigation system initiated a Minimum Risk Manoeuvre and brought the vehicle to a controlled stop.

The weather-conditional velocity controller was also tested on surfaces with different friction levels. When approaching a stationary obstacle, Martti began braking earlier on ice than on snow. In another test, the system increased the safety distance to a preceding vehicle from approximately 40 metres on dry asphalt to 60 metres after detecting snow and reduced friction on the planned driving path.

Outcomes of Demonstration 2

Demonstration 2 marked the first full integration and real-world validation of several ROADVIEW perception and decision-making innovations under authentic winter conditions.

The results showed that:

- partner software modules could be successfully integrated into VTT's automated driving platform;
- visibility estimation, slipperiness prediction and HD-map localisation could operate in real winter conditions;
- roadside infrastructure and the automated vehicle could exchange perception, weather and manoeuvre information through V2X communication;
- weather-aware navigation and velocity control could adapt automated driving behaviour to reduced visibility and changing friction.

Together, the tests demonstrated a complete chain from observing environmental conditions to adapting automated driving behaviour. All objectives defined for Demonstration 2 were achieved, and nine demonstration videos were produced to document the different technologies and scenarios.

Scientific Relevance of Demonstration 2

For automated driving, knowing that environmental conditions have deteriorated is only part of the challenge. The vehicle must also understand how those conditions affect its sensors and the road surface and translate this information into appropriate driving decisions.

Demonstration 2 showed how ROADVIEW connects these different layers. Visibility and grip estimators describe current operating conditions, HD maps support reliable localisation despite seasonal changes, roadside infrastructure adds information beyond the vehicle's immediate field of view, and weather-aware decision-making converts these inputs into actions such as slowing down, increasing safety distances or performing a Minimum Risk Manoeuvre.

Testing this complete chain in Finnish Lapland provided important evidence that these technologies can work together outside the laboratory, under the snow, ice and reduced-visibility conditions for which ROADVIEW was designed.

Useful link:

- **Demonstration 2 playlist:** Click here to watch the ROADVIEW Demo 2 videos on the project YouTube channel.

Demonstration 5: Bringing ROADVIEW Technologies Together in Rain and Fog

How can technologies developed by different research teams be brought together on one automated vehicle and operated simultaneously under severe weather conditions?

ROADVIEW addressed this question in its fifth and final demonstration, led by AVL Software and Functions GmbH at the AVL Mobility and Sensor Center in Roding, Germany. Demonstration 5 represented the final vehicle-level integration campaign of the project, combining ROADVIEW technologies for perception, environmental-condition estimation, localisation, weather-aware decision-making and V2X communication on AVL's automated AutBus platform.

Testing took place over ten test days during the final six months of the project. Activities were conducted both outdoors and inside AVL's weather hall, where environmental conditions can be reproduced in a controlled and repeatable manner.

The weather hall is more than 80 metres long and 20 metres wide. It can generate artificial rainfall ranging from 15 to 120 mm per hour and fog that reduces visibility to approximately seven metres. Configurable lighting and dedicated environmental measurement equipment make it possible to investigate how vehicle sensors and automated driving technologies respond as conditions progressively deteriorate.

The demonstration vehicle, AVL's AutBus, is based on a VW T6.1 Multivan and equipped with cameras, multiple LiDAR and radar sensors, GNSS and an inertial measurement unit. ROADVIEW components from several project partners were adapted to this vehicle and its software environment.

Filtering the weather out of LiDAR data: One of the technologies tested was Halmstad University's 3D Outlier Detector, or 3D-OutDet.

LiDAR sensors use laser pulses to produce a three-dimensional representation of the vehicle's surroundings. In adverse weather, however, rain droplets and fog particles can themselves reflect the laser light. These unwanted returns can appear as points that do not correspond to real physical objects.

3D-OutDet identifies and removes these weather-induced artefacts before the LiDAR data is passed to other perception functions.

During Demonstration 5, the technology was evaluated in both rain and fog. Under dense fog, the raw LiDAR data could appear almost like a "wall" in front of the vehicle. After filtering, many of these fog-induced points were removed and relevant environmental structures became more distinguishable. In selected driving sequences, objects that were partly obscured by weather-induced returns were substantially clearer in the filtered point cloud.

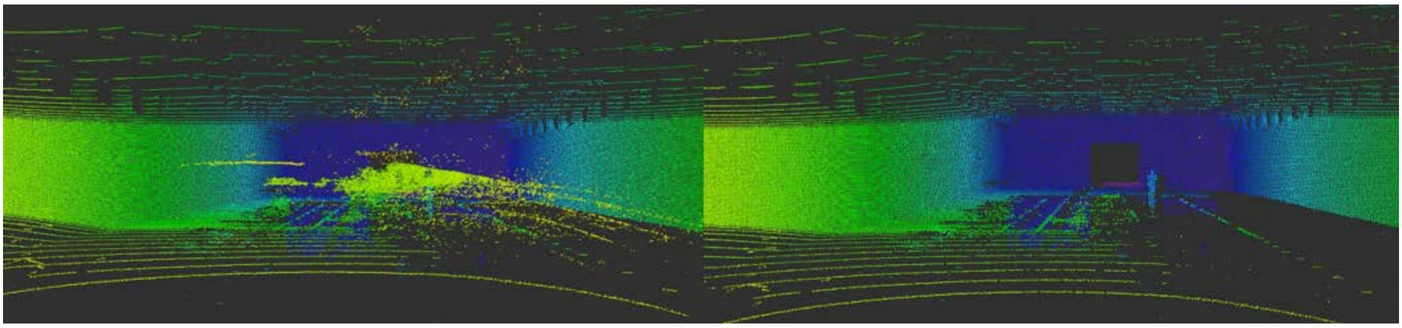

Figure 1. LiDAR perception in fog before and after ROADVIEW's 3D Outlier Detection. Weather-induced returns obscure the pedestrian dummy in the raw point cloud, while filtering makes the relevant environmental information more clearly distinguishable.

Understanding when perception becomes limited: VTT's visibility estimator addressed a related challenge: determining how far the LiDAR system can currently perceive the environment reliably.

As fog density increased in the weather hall, the estimator detected the corresponding reduction in effective LiDAR sensing range. Importantly, this information can be passed to weather-aware decision-making functions so that the vehicle can adapt its speed or request a Minimum Risk Manoeuvre when the available perception range is insufficient.

The tests also highlighted an important aspect of technology development. An estimator originally developed using real-world snow data had to be adapted to account for the geometry of the indoor weather hall. After fine-tuning, it provided stable real-time visibility estimates during both static and dynamic tests.

ROADVIEW also tested FGI's camera-based grip estimator. The technology successfully distinguished between dry and wet asphalt after artificial rain was introduced and continued to identify the wet surface under moderate fog. At very high fog densities or very low illumination, however, the road surface was no longer sufficiently visible to the camera, demonstrating the physical limits of vision-based grip estimation.

Staying localised when GNSS disappears: Another key ROADVIEW technology addressed localisation.

FGI's EA-NDT approach uses live LiDAR measurements together with a pre-generated, semantically enriched HD map. During testing, AutBus moved from the outdoor area into the weather hall, where satellite-based GNSS positioning becomes unavailable.

While the GNSS-based position estimate began to diverge after signal loss, LiDAR-based localisation continued to follow the vehicle trajectory using features in the HD map. The localisation remained stable during the tested rain scenarios and also under challenging fog conditions until the amount of usable LiDAR information became insufficient at very high fog densities. This demonstrates the potential of environment-aware localisation to provide an additional positioning source in situations such as tunnels, indoor environments or other areas where GNSS availability is limited.

A connected view of the environment: Demonstration 5 also incorporated infrastructure-based perception developed by Canon Research Centre France. A roadside camera installed inside the weather hall detected objects and weather conditions and exchanged information with AutBus through V2X communication.

This provided the automated vehicle with a second perspective on the scene. Rather than replacing the vehicle's own sensors, infrastructure perception complemented them within the area covered by the roadside system. The fog scenarios particularly highlighted the potential of this approach when onboard perception is degraded by adverse weather.

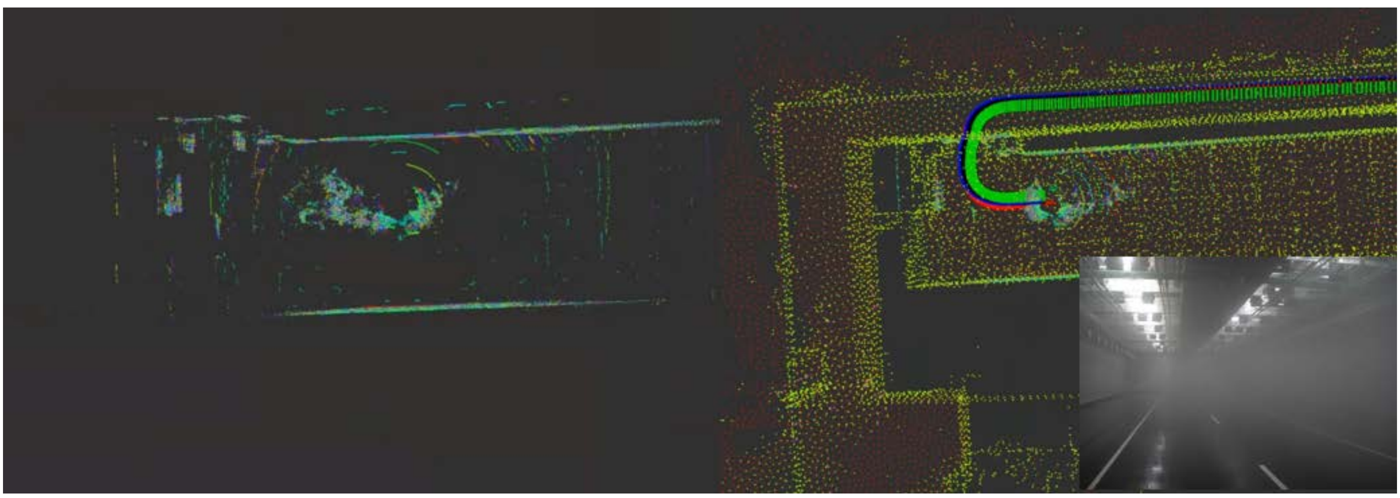

Figure 2. ROADVIEW's EA-NDT localisation operating under dense fog. Despite the substantial reduction in usable LiDAR information, the vehicle maintained stable localisation along the demonstrated trajectory.

Figure 3. Comparing onboard and infrastructure-based perception in fog. When reduced visibility limits the vehicle's own camera perception, roadside sensing and V2X communication provide an additional source of information about surrounding road users.

Outcomes of Demonstration 5

The final integration campaign successfully brought together the main ROADVIEW components selected for vehicle-level testing. These included:

- 3D LiDAR outlier detection;
- visibility estimation;
- camera-based road grip estimation;
- EA-NDT HD-map localisation;
- weather-conditional navigation and velocity control;
- infrastructure-based perception and V2X communication.

Following individual integration and testing, several components were operated simultaneously on the AutBus computing platform. The combined configuration achieved real-time operation with stable communication between the different functions.

The demonstration was also important because it revealed where further development is required. ROADVIEW components had originally been developed by different partners using different software environments and interfaces. Integrating ROS1-based ROADVIEW components into the ROS2-based AutBus architecture therefore required dedicated bridging and adaptation. Very dense fog also demonstrated the fundamental limitations that arise when cameras and LiDAR receive too little information from the surrounding environment.

Scientific Relevance of Demonstration 5

Demonstration 5 was not intended to present a production-ready automated driving system capable of operating autonomously in every weather condition. Instead, its value lies in showing that ROADVIEW technologies can be transferred to an automated vehicle platform, run simultaneously and evaluated under repeatable adverse-weather conditions.

The campaign demonstrated how the technologies complement one another. Outlier detection improves the quality of weather-affected LiDAR data. Visibility and grip estimation provide information about operating conditions. HD-map localisation supports positioning when GNSS is unavailable. Weather-aware decision-making can use environmental information to determine safe vehicle behaviour, while V2X provides an additional perspective beyond onboard sensing

These results provide a practical foundation for taking ROADVIEW innovations beyond research prototypes. Future development can focus on improving robustness, simplifying software integration and identifying technologies with the greatest potential for continuous operation and commercial vehicle applications.

Useful link:

- **Demonstration 5 - Playlist:** Click here to watch the Demo 5 videos on the project YouTube channel.

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ROADVIEW Final Event: Four Years of Research Towards Automated Driving in Rain, Fog and Snow

On 19 August 2026, the ROADVIEW consortium gathered at the AVL Mobility and Sensor Center in Roding, Germany, to present the results of four years of research and development dedicated to one of the most persistent challenges facing automated mobility: reliable operation in adverse weather.

Rain, fog and snow can reduce sensor performance, restrict perception range and make it more difficult for an automated driving system to determine whether the information on which it bases its decisions remains reliable. ROADVIEW, short for Robust Automated Driving in Extreme Weather, was established to tackle these challenges through new perception, localisation, decision-making, connectivity and validation technologies.

With a total budget of €9.7 million, ROADVIEW brought together 15 partners from industry and academia across seven European countries. From the beginning, the project focused not only on enabling vehicles to understand what is happening around them, but also on helping automated driving systems assess the reliability of their perception when environmental conditions change.

The final event provided an opportunity to bring these developments together and demonstrate how technologies developed across the consortium contribute to a more weather-resilient automated driving system.

From perception to decision-making: Over the course of the project, ROADVIEW developed technologies spanning the complete automated-driving information chain.

One example is 3D Outlier Detection. Rain, snow and fog can produce additional LiDAR returns that do not correspond to real objects. ROADVIEW developed methods to identify and filter these weather-induced artefacts, improving the quality of data available to downstream perception functions. Project investigations showed improvements of approximately 5% for semantic segmentation and up to 2% for object detection.

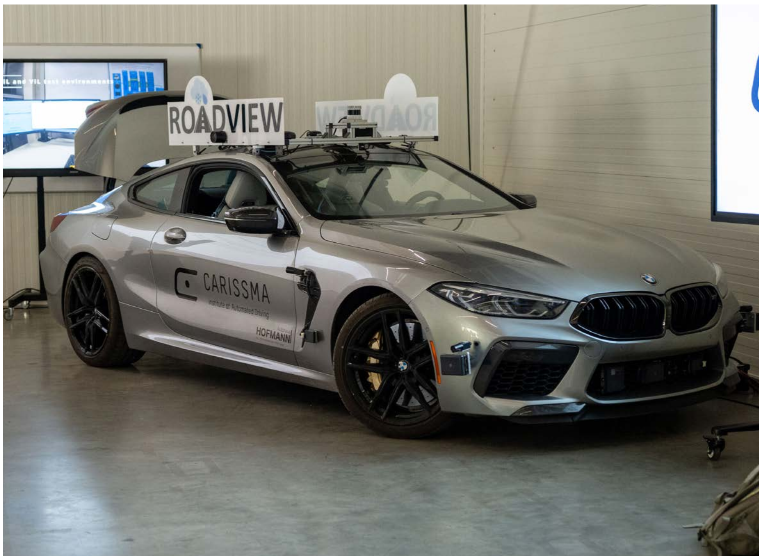
Another important area was localisation. Satellite-based positioning cannot always be relied upon, particularly in tunnels, indoor environments or locations affected by signal obstruction. ROADVIEW therefore developed a LiDAR-based approach that compares live sensor information against a high-definition, semantically enriched map, enabling the vehicle to maintain its position under challenging conditions.

ROADVIEW also investigated how connected infrastructure can extend the vehicle's situational awareness. Using V2X communication, information detected by roadside sensors, including objects and weather conditions, can be shared with vehicles. This complementary perspective can become particularly valuable when a vehicle's own sensors are affected by fog, precipitation or occlusion.

These technologies were complemented by visibility and road-grip estimation, adaptive sensor fusion, weather-conditional navigation and velocity control, and simulation-assisted validation approaches.

Putting extreme weather to the test: Validation was a central element of ROADVIEW. Throughout the project, partners collected sensor data under real-world conditions across all four seasons and investigated vehicle perception in rain, fog and snow.

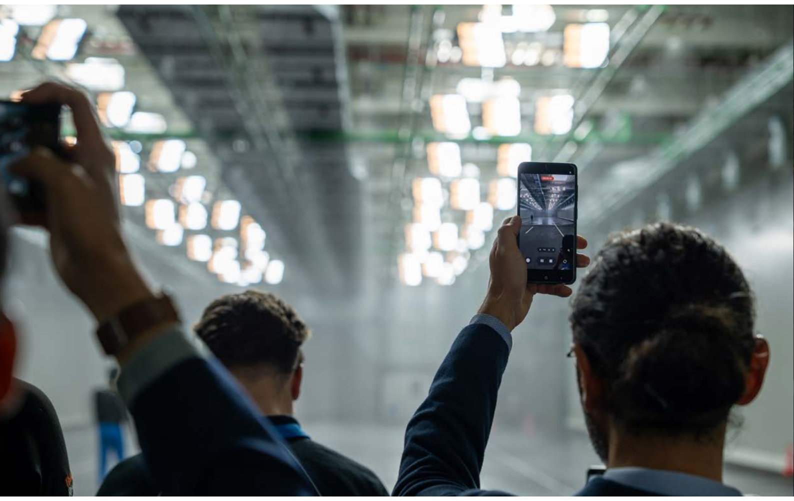
The AVL Mobility and Sensor Center provided a particularly important environment for the final phase of testing. Its weather hall can reproduce rainfall intensities of up to 120 mm per hour and dense fog with visibility reduced to approximately seven metres. Different lighting conditions can also be generated, allowing



technologies to be evaluated systematically under severe but controlled and repeatable conditions.

Alongside physical testing, ROADVIEW developed simulation and X-in-the-Loop approaches that enable weather effects to be reproduced virtually. Together, these methods provide researchers and industry with complementary routes for investigating automated driving systems before they are deployed in real traffic.

Data for the wider research community: ROADVIEW's legacy extends beyond the individual technologies developed by its partners.



The consortium has released several datasets collected under challenging environmental conditions. These include Snowy Scenes, a multimodal dataset recorded entirely in real-world snowy environments in Finland. It contains more than 22,000 synchronised multimodal samples and supports research tasks including 3D object detection, semantic segmentation and point-cloud denoising.

Making such data available helps the wider research community develop and compare new approaches for automated driving under conditions that remain difficult and expensive to capture at scale.

From "autonomous" to "snow-tonomous": Reflecting on the project's achievements, ROADVIEW Coordinator Eren Aksoy emphasised the ambition behind the project: moving automated driving beyond predominantly fair-weather operation towards more reliable performance in snow, rain and fog.

Through multimodal perception, weather-aware localisation, intelligent decision-making, V2X-supported operation and X-in-the-Loop validation, ROADVIEW has built and evaluated technologies designed to increase the safety, reliability and resilience of future connected and automated vehicles.

The final event therefore marked more than the conclusion of a four-year research project. It demonstrated how understanding the weather, understanding the limitations of sensors and adapting vehicle behaviour accordingly can become interconnected parts of a future automated driving system.

ROADVIEW's results provide a scientific and technological foundation for further development towards automated mobility that is better prepared for the conditions drivers encounter every day, not only clear skies and dry roads, but also rain, fog, snow and reduced visibility.

Useful link:

- **ROADVIEW demonstration videos:** Visit the official ROADVIEW YouTube channel to explore videos from the project's demos and validation activities.
- **Snowy Scenes dataset:** Explore the ROADVIEW multimodal winter-driving dataset.
- **ROADVIEW website:** Find project results, publications and further information at roadview-project.eu.

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