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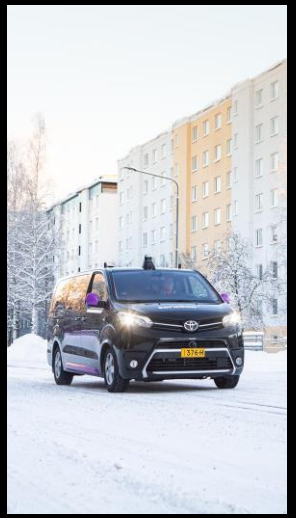
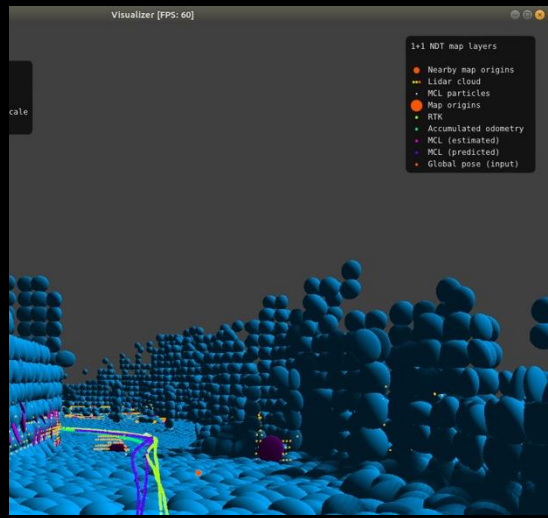
Automated Driving in Winter Weather and Issues With Snow

Jussi Suomela

CBO, Sensible 4





Sensible 4 Develops a Full-stack Autonomous Driving Software for the Last Mile

1. Our customers are OEM's and Tier-1's.
2. Together with them, we are developing a commercial software platform DAWN™ for Level 4 automated driving.
3. The use-cases for DAWN ™ are last mile passenger transportation and delivery vehicles and the vehicles for industrial areas.

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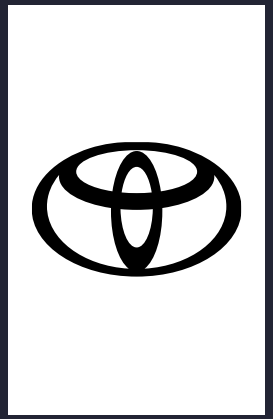
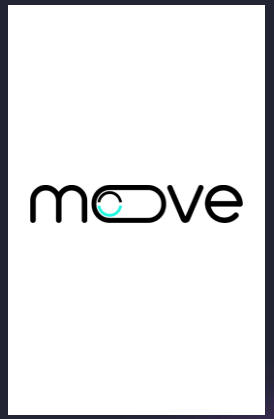
Key Partners and Customers





FOUNDED IN
2017

REVENUE 2021
€3m

SERIES A and A´2 FUNDING
€17m

Autonomous Vehicles Have a Long History in Finland

Sensible 4 is a spinoff from one of the worlds first mobile robotics research labs. Our first autonomous prototypes drove in the 1990's.

The work of our research team began at the Aalto University already in the mid 1980's.

Winter and bad weather has always been the case while developing our robots and autonomous vehicles.

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One of the Biggest Technical Challenge is Operating in Varying Weather

For autonomous vehicles to become part of everyday life, they must work in everyday driving conditions, also in the winter.

This was exactly what Holo's research paper is looking at.

Our end customers need the vehicles to work everywhere, all the time. Commercial viability requires real replacement of human drivers in some applications – not in all of them.

Most self-driving vehicles today struggle to drive autonomously in bad weather, grounding the vehicles. Their developers have chosen not to prioritize weather capabilities early on as they often have the luxury of being situated in mostly fair weather locations.

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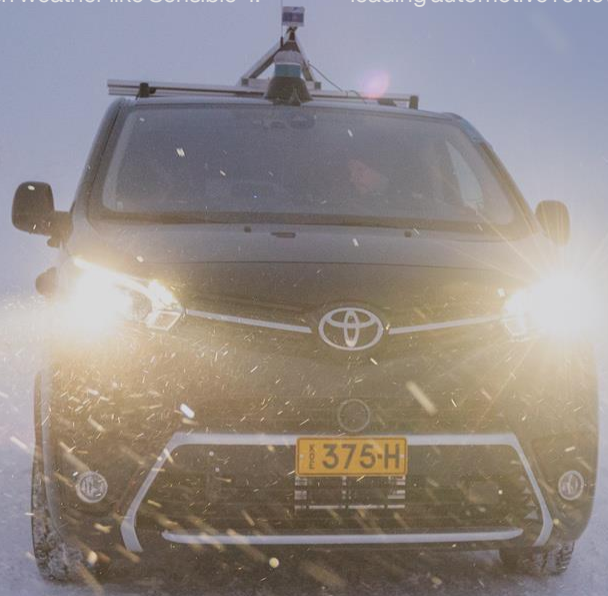
Best-in-Class Performance

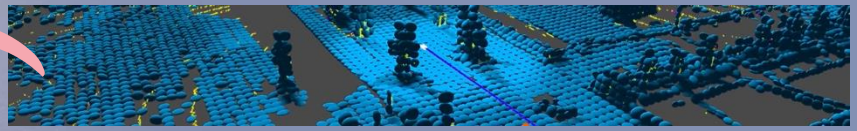
There's no other autonomous driving software performing in harsh weather like Sensible 4.

Independently Validated

Uniqueness and suitability of our solution have been validated by a leading automotive reviewer.



Sensible 4's Unique All-weather Approach for Autonomous Driving is Based on Decades of Research



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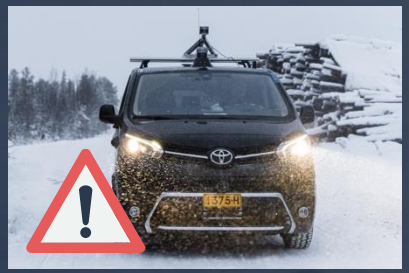
Why Weather Poses Problems for Self-Driving



Measurement Errors

Sensor measurement errors lead to problems for the vehicle's software, as the basis of vehicle steering decisions can not be trusted. Most vehicles
usually stop at this point, as they don't know what to do.

Snow Covered Lanes

Snow and dust can also cover the lane markings and traffic signs, making it very hard for a computer vision to understand their meaning.

Blocked Sensors

Sensors, (e.g. LiDAR's and cameras) are the eyes of the autonomous vehicle. Bad weather such as rain, falling leaves and snow add noise and error to their observations and measurements.

Slippery Roads

Slippery roads make it more difficult to control the vehicle.

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Snowfall, LIDAR Point Cloud and Probabilistic Mapping

Snowfall is an obstacle to some laser beams, but not all of them. The snow in the air creates noise around the vehicle (“red cloud” following the vehicle) but also buildings further away are still easy to recognise.

This ability to use LiDAR also in the snow is the key to automated driving in snowy conditions.

The Red Cloud phenomena was noted also in Winter Weather Operation report by Holo, on page 3.

Snowfall and the Obstacle Tracking

Obstacle Detection is the method of detecting and tracking other participants of the traffic, including for example the other vehicles, pedestrians and cyclists.

Sensible 4 Obstacle Tracking detects objects on and near the planned route, enabling safe driving control.

Snow as a Challenge to Automated Driving

- Snow in the air adds noise to sensor data. This usually is not an issue for automated driving.
- Snow on the ground is often ploughed into the piles or snowbanks. On the driving route or at the so called ROI-area they are usually considered as an obstacle, preventing the vehicle from driving.
- Snow on the road surface tends to transform into ice, which is slippery to any vehicle.

Yet all weather automated driving is possible, but currently it requires some careful road maintenance. And when the driving is really difficult for humans, it's really difficult also for machines.

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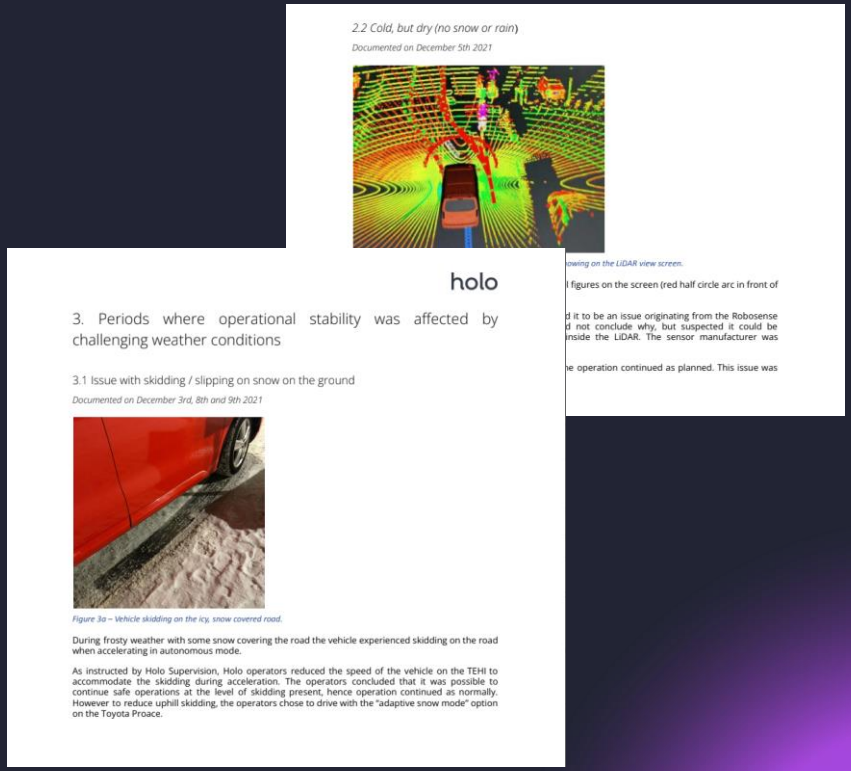
Vehicle hardware in the winter

- Icy roads and skidding are have an effect on all vehicles. This was also reported by Holo, where the safety operators lowered the driving speed due to slippery roads.
- An interesting thing to investigate further is the sensor performance in a cold but dry conditions. Ski pilot provided indications of water condensating into some of the sensors.



2.2 Cold, but dry (no snow or rain)

Documented on December 5th 2021

owing on the LiDAR view screen.

figures on the screen (red half circle arc in front of

d it to be an issue originating from the Robosense
d not conclude why, but suspected it could be
inside the LiDAR. The sensor manufacturer was

e operation continued as planned. This issue was

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3. Periods where operational stability was affected by challenging weather conditions

3.1 Issue with skidding / slipping on snow on the ground

Documented on December 3rd, 8th and 9th 2021

Figure 3a – Vehicle skidding on the icy, snow covered road.

During frosty weather with some snow covering the road the vehicle experienced skidding on the road when accelerating in autonomous mode.

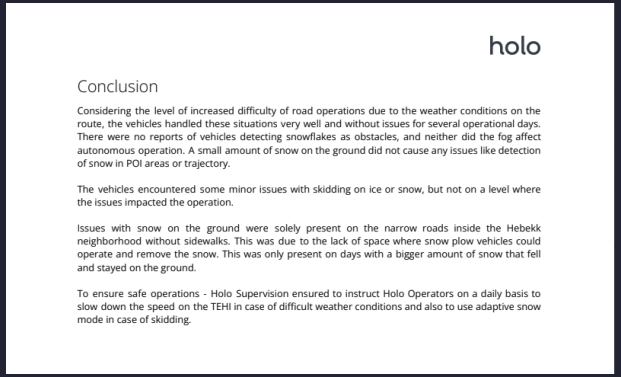
As instructed by Holo Supervision, Holo operators reduced the speed of the vehicle on the TEHI to accommodate the skidding during acceleration. The operators concluded that it was possible to continue safe operations at the level of skidding present, hence operation continued as normally. However to reduce uphill skidding, the operators chose to drive with the "adaptive snow mode" option on the Toyota Proace.

Overcoming the Automated Driving in the Winter

1. **Provide location-accurate ploughing**. For human drivers it's easy to drive along the pat, as long is it's ploughed, but automated vehicles aim to drive the same location based route throughout the year.

2. **Pile the snow away from the road.** Snowbanks may be interpreted as an obstacle for the automated vehicle and they also may encourage incorrect vehicle parking.

3. **Say no to icy roads.** Friction between the tyres and the road surface is important to all vehicles, including the automated ones, so try to prevent the road surface from icing. Luckily automated vehicles don't require special treatment here.



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Conclusion

Considering the level of increased difficulty of road operations due to the weather conditions on the route, the vehicles handled these situations very well and without issues for several operational days. There were no reports of vehicles detecting snowflakes as obstacles, and neither did the fog affect autonomous operation. A small amount of snow on the ground did not cause any issues like detection of snow in POI areas or trajectory.

The vehicles encountered some minor issues with skidding on ice or snow, but not on a level where the issues impacted the operation.

Issues with snow on the ground were solely present on the narrow roads inside the Hebekk neighborhood without sidewalks. This was due to the lack of space where snow plow vehicles could operate and remove the snow. This was only present on days with a bigger amount of snow that fell and stayed on the ground.

To ensure safe operations - Holo Supervision ensured to instruct Holo Operators on a daily basis to slow down the speed on the TEHI in case of difficult weather conditions and also to use adaptive snow mode in case of skidding.

Photo by Franz Roos on Unsplash

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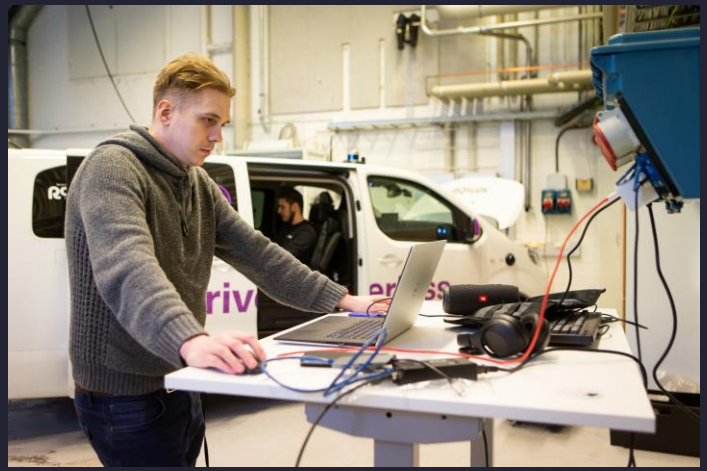
Case: Winter Pilot in Tampere

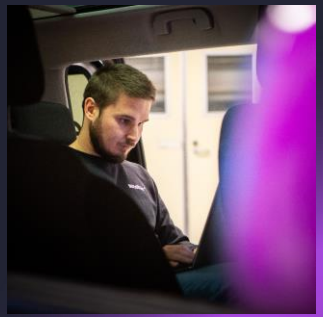
2021

1663
Passengers transported

5569
Kilometres driven

- Sensible 4 drives two autonomous Toyota Proace vans in the pilot.
- Autonomous vehicles work as a feeder transportation for the new tramline.





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SHOW

Current Pilots

Bodø

Two vehicles operating in Norway, above arctic circle.

Schaffhausen

Starting later this year in Switzerland.

Pilots with end customers and OEM's are an essential part of Sensible 4 business and R&D.

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Mange Takk!

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