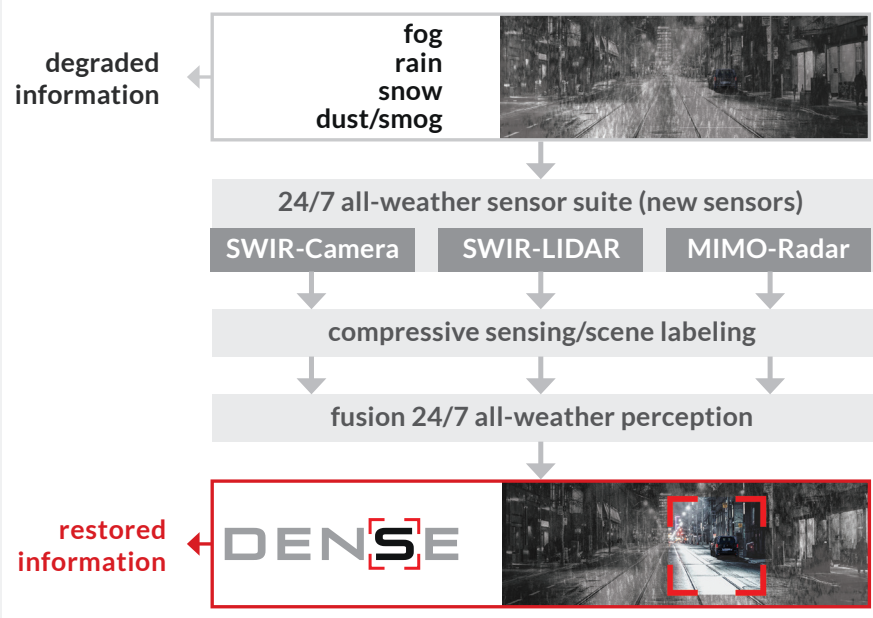# DENSE



## Reliable environment perception
## also in adverse visibility conditions

## »What happens to self-driving cars if the weather turns bad?«

Current systems offer comfort and safety in good weather. However, they often fail to sense their surroundings in visibility conditions with heavy rain, snow or fog causing the automated systems to stop their support.

DENSE addresses this key challenge of autonomous driving by developing a fully reliable environment perception technology that extends the performance of sensors in adverse visibility conditions. The project designs, tests and validates a generic and affordable sensor suite that enables driver assistance systems and autonomous driving systems to operate also in adverse weather.



▶ The DENSE 24/7 all-weather sensor suite combines Radar, a Short Wave Infrared (SWIR) gated camera sensor and LIDAR. In addition, a mobile Road State Sensor assesses the road surface conditions.

# Technology

While conventional radar technology works in adverse weather, it does not provide sufficient information to ensure safe autonomous driving. Existing sensors like cameras and LIDAR malfunction or even fail in adverse weather conditions. Only a combination of different sensors and the integration of the newest sensor technologies will fulfil the high sensory requirements for autonomous driving.

DENSE will develop an advanced radar with a high angular resolution operating in the 77-81 GHz automotive band, a Short Wave Infrared (SWIR) gated camera sensor with a pulsed laser illuminator, and a new LIDAR for improved performance in adverse weather. In addition, a mobile Road State Sensor will allow for the assessment of road surface conditions.

For maximizing efficiency, DENSE is planning to implement a low-level fusion platform integrating the individual sensors at pixel level using artificial neural networks. This will lead to an an enriched and enhanced multi-spectral image. Ultimately, the system will be integrated in a test vehicle and demonstrated under controlled conditions in a weather chamber and evaluated under real-life conditions in Central and Northern Europe.

DENSE will identify the sensor requirements for automated driving also in adverse visibility conditions.

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DENSE will specify and develop the resulting sensor technology and integrate an all-weather sensor suite.

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DENSE will test the all-weather sensor suite in a controlled environment and evaluate it under real-life conditions.

# Impact

Self-driving cars being able to operate also in adverse weather conditions will enhance mobility and safety thanks to providing a more flexible use of vehicles.

DENSE will strengthen Europe's leading position of the automotive industry and open new doors for exploiting infrared, laser and radar technologies.

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|---|---|
| **Duration:** | June 1, 2016 – May 31, 2019 |
| **Coordinator:** | Dr. Werner Ritter, Daimler |
| **Consortium:** | 16 partners from 6 countries: Belgium, France, Finland, Germany, Sweden, Netherlands. Daimler, Cerema, HITACHI Europe, Ibeo Automotive Systems, Innoluce, Modulight, Oplatek Group, Renault, Technical University Tampere, Universität Ulm, Vaisala, Veoneer, VTT, Xenics |
| **Budget:** | 14,5 M€, thereof 4,2 M€ European funding and 3,1 M€ national funding |