# QUADSIGHT® VISION SYSTEM IN ADVERSE WEATHER

## Maximizing the benefits of visible and thermal cameras

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# INTRODUCTION & OBJECTIVE

# INTRODUCTION

- United Nations Economic Commission for Europe (UNECE) [1] recently proposed a **regulation** for SAE level 3 automated driving systems [2].
- The regulation defines the **Operational Design Domains** (ODD) that correspond to the use cases which are validated, and in which the vehicle is able to drive in autonomous mode.
- The **current research** is focused on **unusual or difficult environmental conditions** : harsh weather conditions, dense traffic scenarios, urban areas, poorly surfaced or damaged roads, abnormal behaviors of other road users, and edge-cases...

# INTRODUCTION

Two major issues remain concerning the use of vehicle perception systems (sensors and associated algorithms):

- knowing how to characterize and verify the ODD,
- to extend ODD to include new conditions.

# CONTEXT

AWARD
Scaling autonomous logistics

**This work is part of the AWARD* project:**

- 3-year innovation action
- Consortium of 29 partners.
- Scaling the autonomous logistics operation
- Safety consideration
- 24/7 availability, including harsh weather conditions
- 4 use cases

Warehouse

Port

Airport

Hub to hub

**All Weather Autonomous Real logistics operations and Demonstrations*

# OBJECTIVE

**Objective** : To test the Foresight's QuadSight vision system in foggy and rainy conditions, using the PAVIN platform.

The **novelty** of this work is to present results of 3D object detection:

- on a commercialized system,
- using visible light and thermal wavelengths,
- in controlled fog and rain conditions.

# MATERIALS

# QUADSIGHT® VISION SYSTEM

Automotive-grade, cost-effective solution.

2 pairs of stereoscopic vision channels: a visible light stereo channel in conjunction with a thermal stereo channel.

3D video analysis and advanced image processing algorithms :

- depth perception to obtain a clear 3D view of the environment.
- allowing for the detection of an object (size, location, and distance).
- hybrid detection solution for both classified and non-classified objects.
- obstacle detection in adverse environmental conditions.

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# PAVIN FOG AND RAIN PLATEFORM

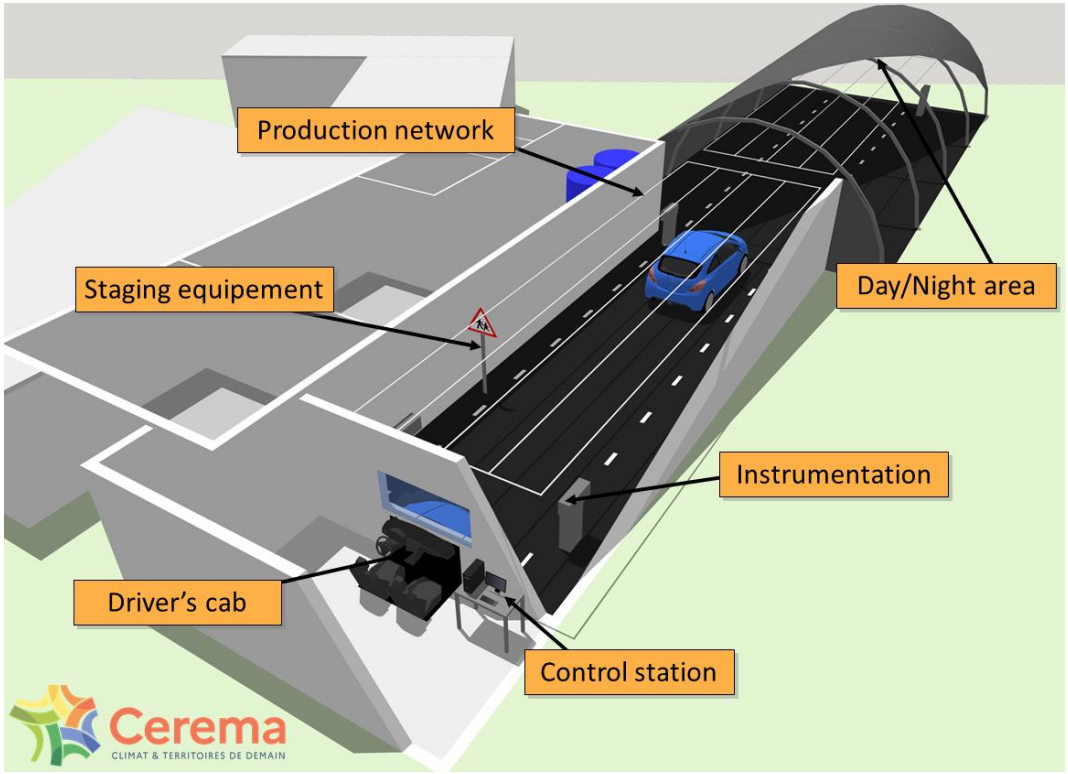
30m long, 5m wide.
(50m long in 2024)

Fog production from 10m to 1000m.

Rain production 20mm/h to 180mm/h.

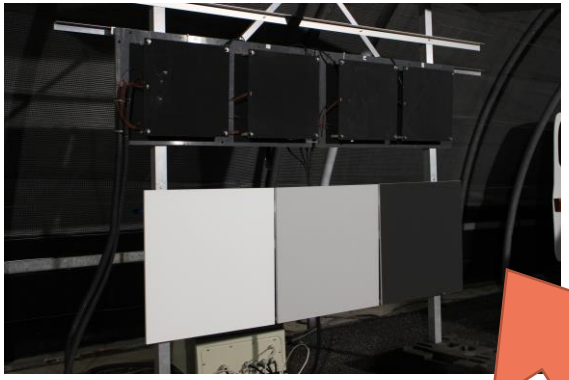
Available for public and private tests in harsh weather conditions.

*More information by contacting adweather@cerema.fr*



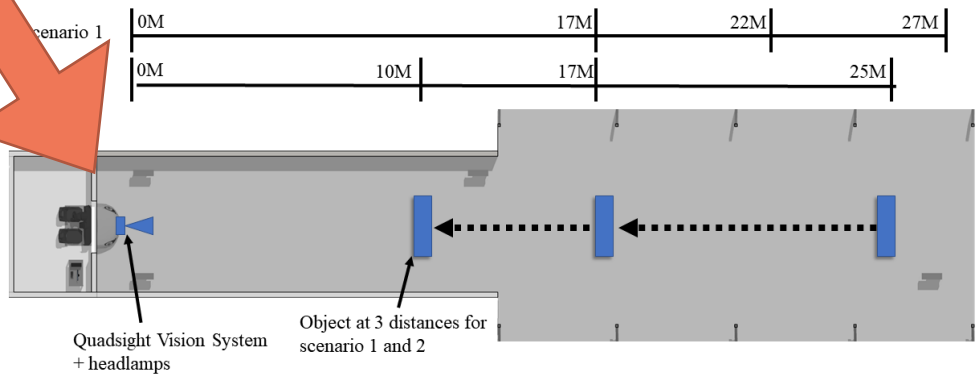
# SCENARIO 1 : CONTRAST MEASUREMENT

# SCENARIO 1 : CALIBRATED TARGETS



## Contrast measurement

$$C_i = \frac{I_{wh} - I_{bk}}{I_{wh}}$$



# SCENARIO 1 : RESULTS

## CONTRAST RESULTS SUMMARY

| | | Visible | Infrared |
|---|---|---|---|
| Day | Clear | +++ | +++ |
| | Fog | ++ | ++ |
| | Rain | ++ | +++ |
| Night | Clear | +++ | +++ |
| | Fog | + | ++ |
| | Rain | +++ | +++ |

# SCENARIO 2 : OBJECT DETECTION

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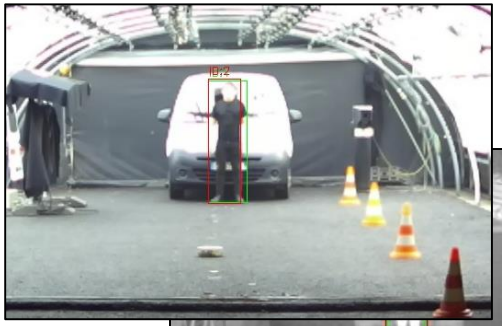
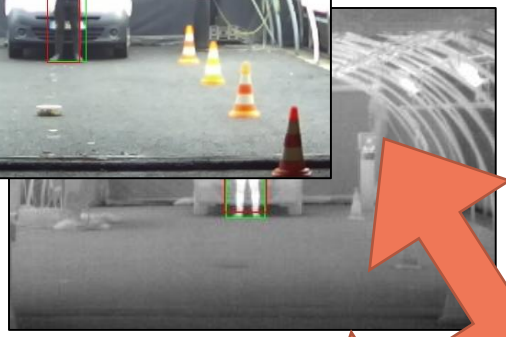
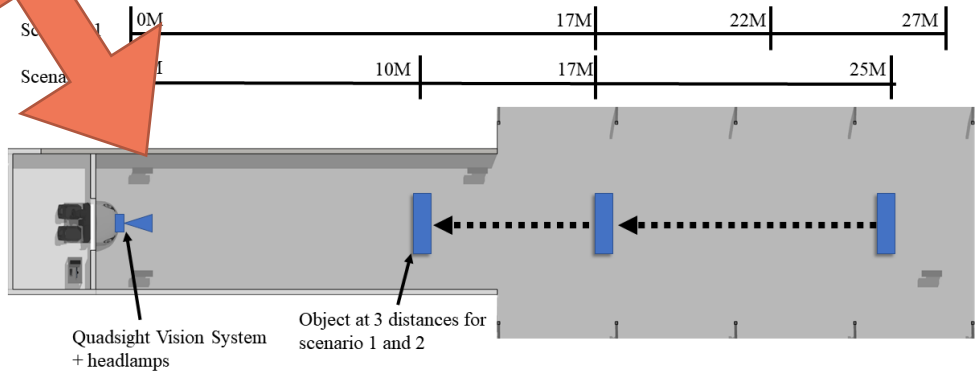




## Precision and Recall measurement

$$P = \frac{TP}{TP + FP} \qquad R = \frac{TP}{TP + FN}$$



# SCENARIO 2 : RESULTS

**OBJECT DETECTION RESULTS SUMMARY : CAR**

| | | Visible | Infrared |
|---|---|---|---|
| Day | Clear | +++ | +++ |
| | Fog | ++ | ++ |
| | Rain | +++ | +++ |
| Night | Clear | +++ | +++ |
| | Fog | + | ++ |
| | Rain | +++ | +++ |

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# SCENARIO 2 : RESULTS

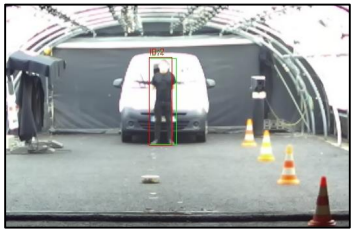
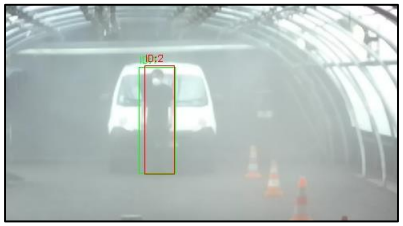
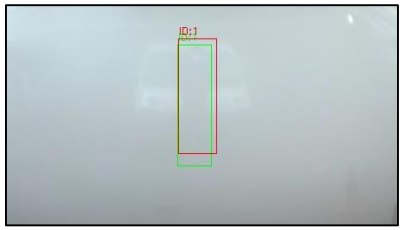
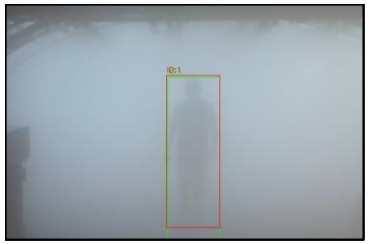
## OBJECT DETECTION RESULTS SUMMARY : PEDESTRIAN

| | | Visible | Infrared |
|---|---|---|---|
| Day | Clear | +++ | +++ |
| | Fog | ++ | +++ |
| | Rain | +++ | +++ |
| Night | Clear | +++ | +++ |
| | Fog | + | +++ |
| | Rain | +++ | +++ |

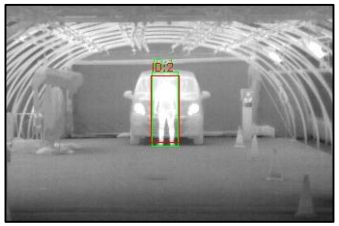
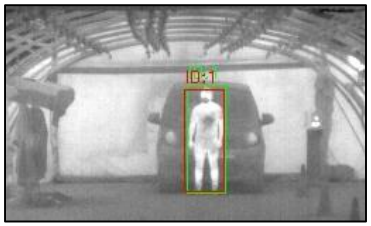
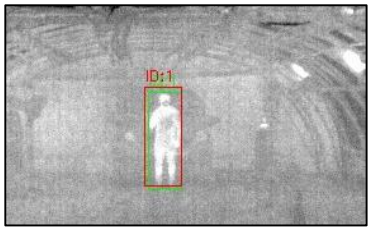
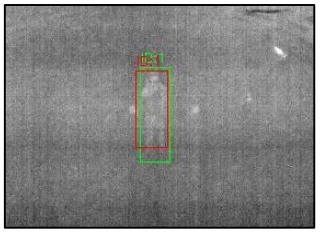
# SCENARIO 2 : RESULTS

## EXAMPLE OF IMAGES

**Visible**

**Infrared**

**Clear** | **Fog 50m** | **Fog 20m** | **Fog 10m**

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# CONCLUSION

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The QuadSight system was tested in the Cerema's PAVIN platform.

Combining the advantages of stereo systems using visible light and thermal cameras improve results, in particular in fog and night conditions.

This study demonstrate a new method to characterize an ODD under controlled weather conditions.

Further tests on tracks, within the framework of the AWARD project.

# Thank you !

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*The content of this reflects only the author's view. Neither the European Commission nor CINEA is responsible for any use that may be made of the information it contains.*

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