Valeo LiDAR
Securing Performance and Safety in Adverse Environmental Conditions

SMART TECHNOLOGY FOR SMARTER MOBILITY

Performance and Safety in Adverse Environmental Conditions
Agenda

1. **Adverse** environmental **conditions**: definition & testing

2. **Detection**: the key to ensure **Safety** in all conditions

3. Robust **Algorithms + Heating** & **Cleaning**: the road towards high **Availability**

LiDAR performance degradation under adverse environmental conditions

LiDAR performance degradation under adverse weather conditions

Adverse conditions: where environment impacts sensor performance

Atmospheric conditions

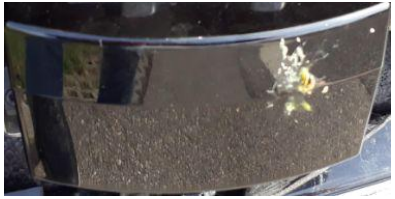
- Rain & water (puddles)
- Fog
- Dust
- Snow
- Sunlight





Sensor contamination

- Dirt / dust
- Droplets
- Scratches

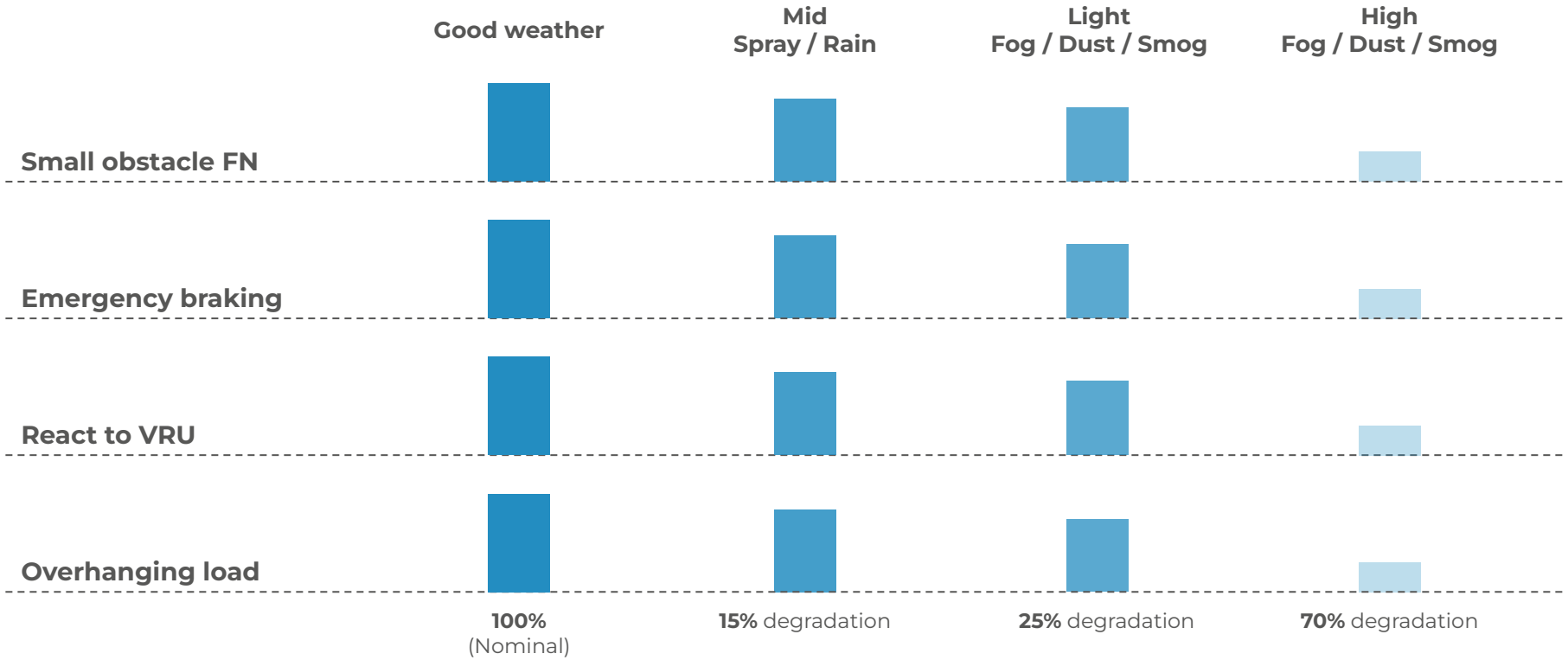

Other challenges

- Exhaust gas

No mature standard defining adverse environmental conditions for LiDAR sensors

LiDAR performance degradation under adverse weather conditions

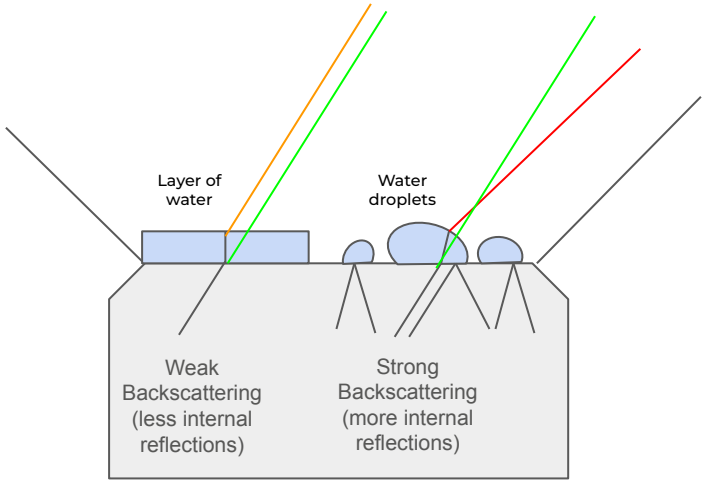
Orders of magnitude of performance degradation



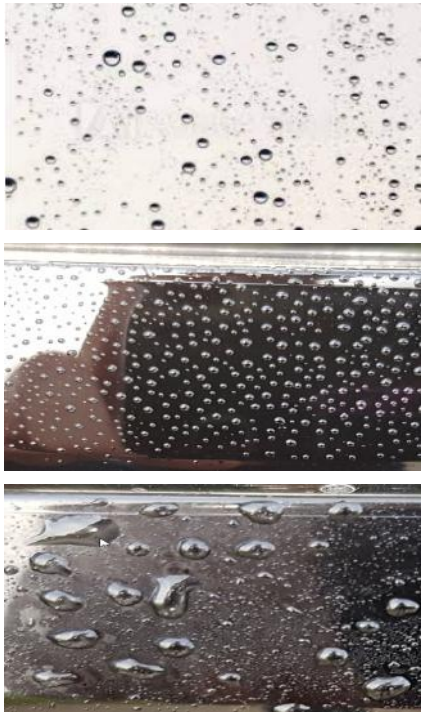
LiDAR performance degradation under adverse weather conditions

Layer of water vs. droplets

Layer of water



Layer of water will have more of a refractive behavior compared to droplets leading to different impacts on point cloud quality and accuracy



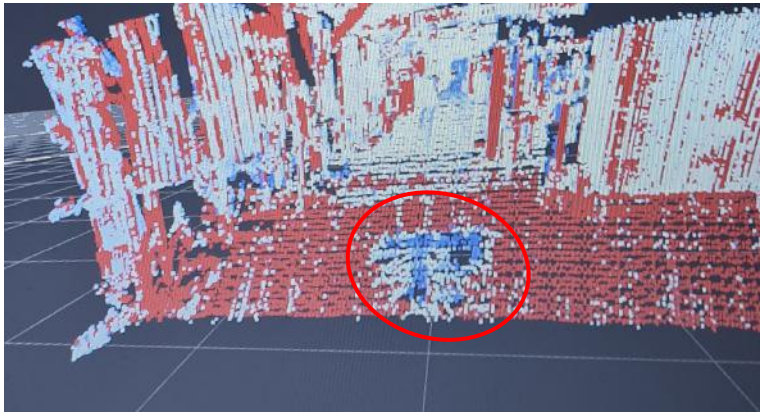
Water droplets

LiDAR performance degradation under adverse weather conditions

Water impact on 1,550nm wavelength LiDARs

1,550nm sensitivity to water - Water puddles *Example*

Water puddles on the floor



Missing points and lower amplitude

1,550nm wavelength LiDAR performance strongly degraded under wet conditions

Detection

The Key to ensure Safety in all conditions

Performance and Safety in Adverse Environmental Conditions

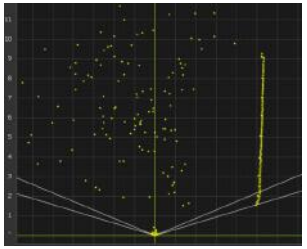
Atmospheric perception

Precipitation & Environmental Conditions

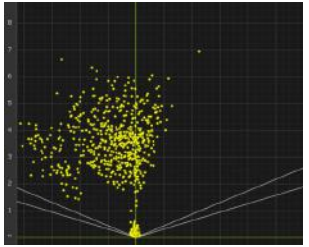
- Detection of different types of precipitation
  - Rainfall
  - Snowfall
  - Fog/Mist
- Influence of precipitation on the sensor performance
  - Reduced detection of the range of objects and lanes
  - Reduced range of sight
  - Sensor blindness

Spray & Road Conditions

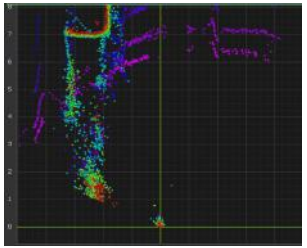
- Detection of vehicle spray on the highway
- Detection of dynamic particles in the air (e.g. dust cloud, smoke)
- Implicit detection of road wetness
- Influence of precipitation on the sensor performance
  - Reduced detection of the range of objects and lanes
  - Reduced range of sight
  - Sensor blindness



Snow



Fog



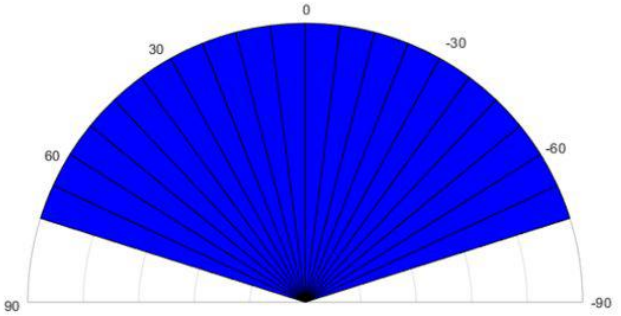
Spray

Performance and Safety in Adverse Environmental Conditions

Blockage detection - Principle

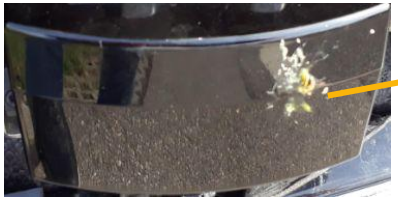
Blockage detection is a “perception” function that monitors front cover and reports to other LiDAR functions and to the vehicle when the optical path is disturbed by contamination or damage

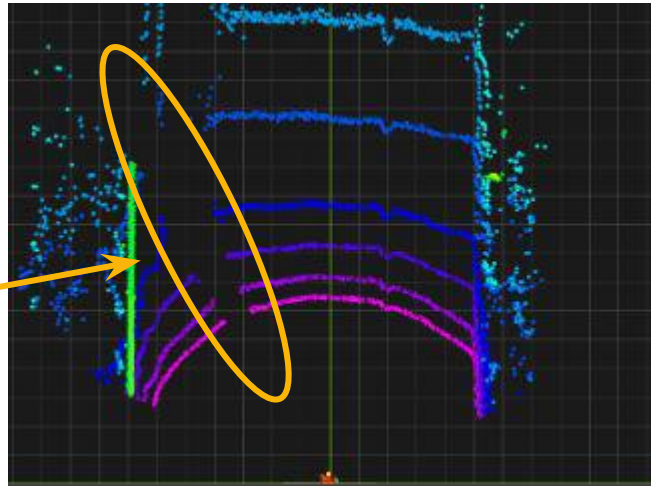
- **Safety** critical function
- Able to **locate** the dirt location on the front cover
- Related to sensor contamination **standards**
- Connected to the **cleaning** functions



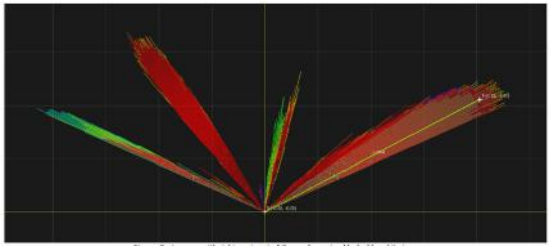
Performance and Safety in Adverse Environmental Conditions

Blockage detection - Examples

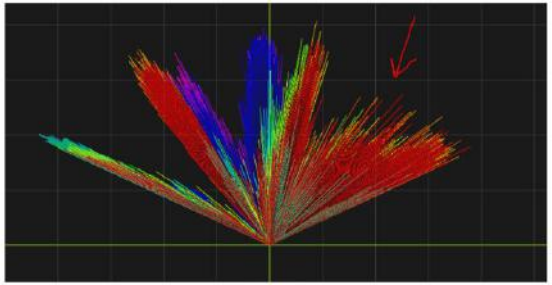




Point cloud in top-down view from recording with contaminated front cover (bug)
A gap in the FOV is clearly visible



Clean sensor - internal reflections

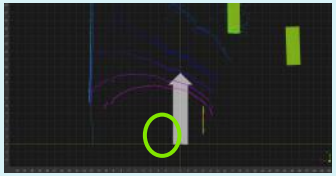
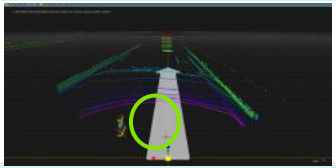
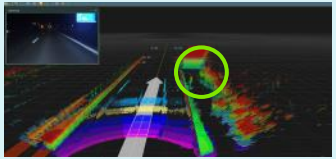
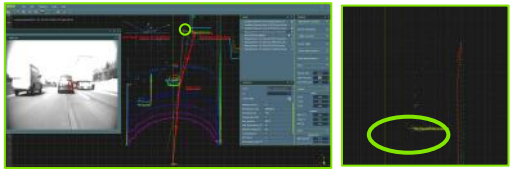


Contaminated sensor

Valeo has 12 years experience to deliver blockage detection with high reliability

Robust Algorithms + Heating & Cleaning for high system availability

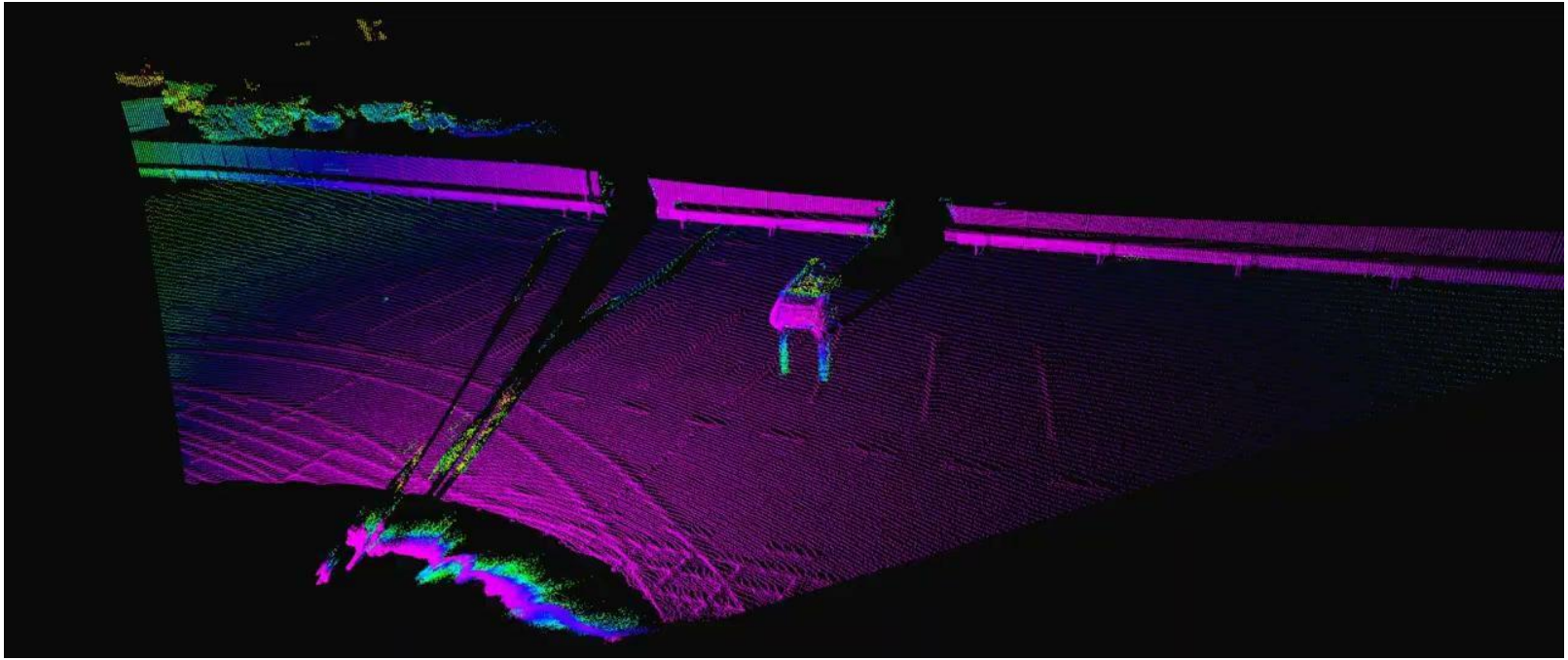
Ensure algorithms robustness against adverse conditions

Effect on pointcloud		Algorithm countermeasure
Sparse points caused by spray/rain/fog/sparsity		Clustering neglection through time validation
Dense cloud of points caused by spray/smoke		Identify low energy points, track and invalidate
Ghost points extending real objects (i.e. blooming)		Track and discard non plausible size extensions
Ghost points caused by multipath reflections from wet surfaces		Stable points → potentially validated as object → algorithm to identify and avoid merge with object

Perception solutions to enable safe driving in adverse weather conditions

Robust Algorithms + Heating & Cleaning for high system availability

Water spray environment effect



Point Cloud echoes filtering to see “beyond” water spray

Robust Algorithms + Heating & Cleaning for high system availability

Automatic Heating & Cleaning

Sensor Heating System

Automatic Heating:

- Used in cold weather: outside temperature ≤ 5°C, permanent light heating to avoid dew
- Melt overnight-frost within 3 minutes (thickness ≃ 1mm)
- Works best in combination with cleaning: faster visibility recovery, removal of mud and salt

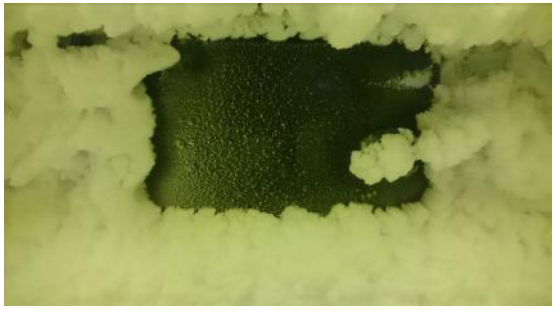
Sensor Cleaning System

Automatic Cleaning:

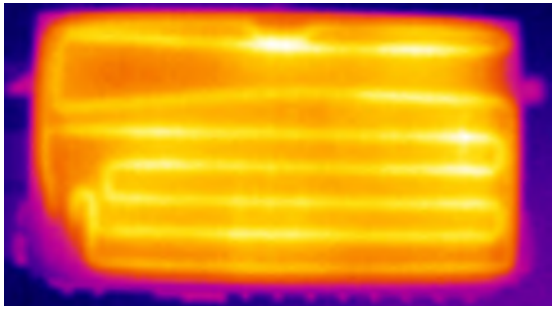
- Sensor self-detects its blockage state
- Environment assessment from point-cloud and vehicle bus information
- Adaptive cleaning requests: several consecutive attempts, variable spray duration

Robust Algorithms + Heating & Cleaning for high system availability

Front Cover Heating - Testing



Defrosting



Infrared Thermography of SCALA® gen2 front-cover while heating

Parameter Tests for Heating Function in Climate / Wind Tunnel

Sensor Cleaning for high system availability

Key Characteristics & Benefits

Lidar Fluid Cleaning - Telescopic Ramp with Heated function

KEY CHARACTERISTICS

- **Telescopic Ramp (5 spraying nozzles) with Fluid heated function**
- Moving Flat Fan with Heating combination spray pattern

CUSTOMER BENEFITS OF VALEO SOLUTION

- **High level of cleaning efficiency with low liquid consumption**
- Working with standard washer pumps
- **Full cleaning surface coverage** thanks to the stroke of telescopic ramp
- Performances in static and Dynamic conditions (up to 140 km/h)

SOP 2022

Valeo Lidar & Lidar Cleaning solution : System offer providing Sensor & Standard Cleaning component integrating an Innovative Heated Function to increase Cleaning Efficiency in cold condition

Sensor Cleaning for high system availability

Telescopic Ramp with Heated function

Sensor Cleaning for high system availability

Fluid Telescopic Ramp Data Sheet

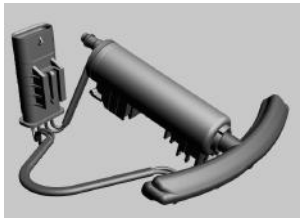
(*) Including pump activation time

Technical Data

5 Deflected Jet nozzles
Protected from the environment (debris, dirts, shocks ...)

Check-valve function integrated
Quick-connector connection
Working with standard washer pumps, standard washing liquid
Adjustable to match your application

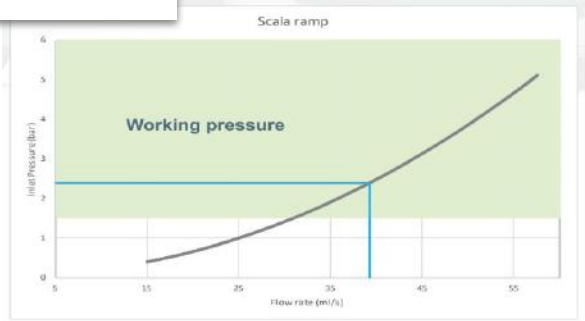
Service pressure
Minimum working pressure: 1,5 bar
Proof pressure: 6 bar



Materials
Plastic parts : ABS-PC; POM
Seals : VMQ

General data
Ambient temperature: -30°C to +85°C
Stroke: 41 mm
Weight : 80 g (with Heating function)

FLOW Curves



Optimal Performances

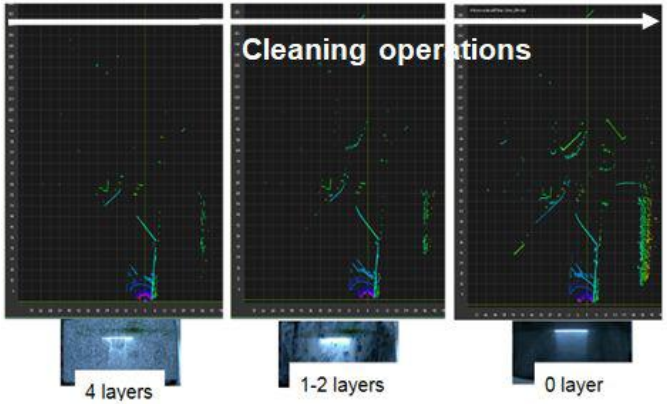
Low liquid consumption	Cleaning cycle 35-40 ml
Quick cleaning operation	Complete cycle (*) < 2 Seconds
Good performances in static & dynamic conditions	Validated up to 140 km/h

Sensor Cleaning for high system availability

Fluid Telescopic Ramp Data Function

CLEANING FUNCTION

- Remove hard layer of mud even at high speed
- 3 times 1 second of cleaning can remove 4 layers of ECE 45 -> blockage is defined by 3 layers
- Removal of snow layer



Speed range [km/h]	Pump activation time [ms]	Associate consumption [ml/cycle]
0 to 50	500	19.2
51 to 100	700	26.9
101 to 130	1000	38.4
131 to 140	1300	49.9
141 to 250	1500	57.6

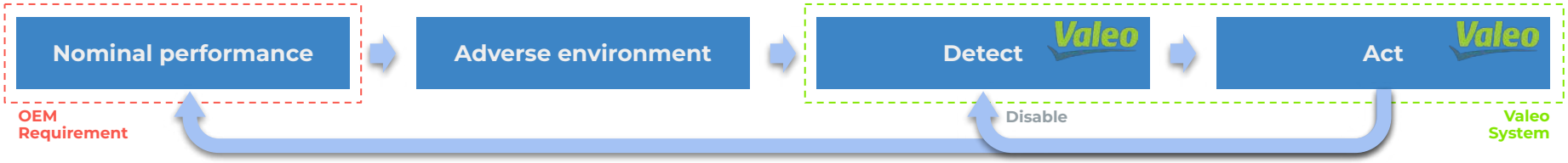
Performance and Safety in Adverse Environmental Conditions
Conclusion

Leading automotive LiDAR mass-market deployment requires to tackle adverse environmental conditions

- **Expertise** in performance alteration and testing standards
- Atmospheric & contamination **detection** to fulfill **safety** requirements
- **Countermeasures** at algorithms and sensor cover levels to ensure maximum **availability**

Valeo offers a broad range of solutions to bring LiDAR to a **mass-market sensing modality**

Combining detection, algorithm, heating and cleaning, Valeo can deliver **off the shelf system solutions** to accelerate LiDAR deployment to a wide range of customers.



Question: convergence pace for testing standards for adverse environments?

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