

# All-weather vision for automotive safety: which spectral band?

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# AWARE: WHAT DOES IT MEAN ?

2

## All Weather

Clear weather,  
fog, rain, snow

## All Roads

Urban, country roads  
and highways  
(transportation)

Runways (aeronautic)

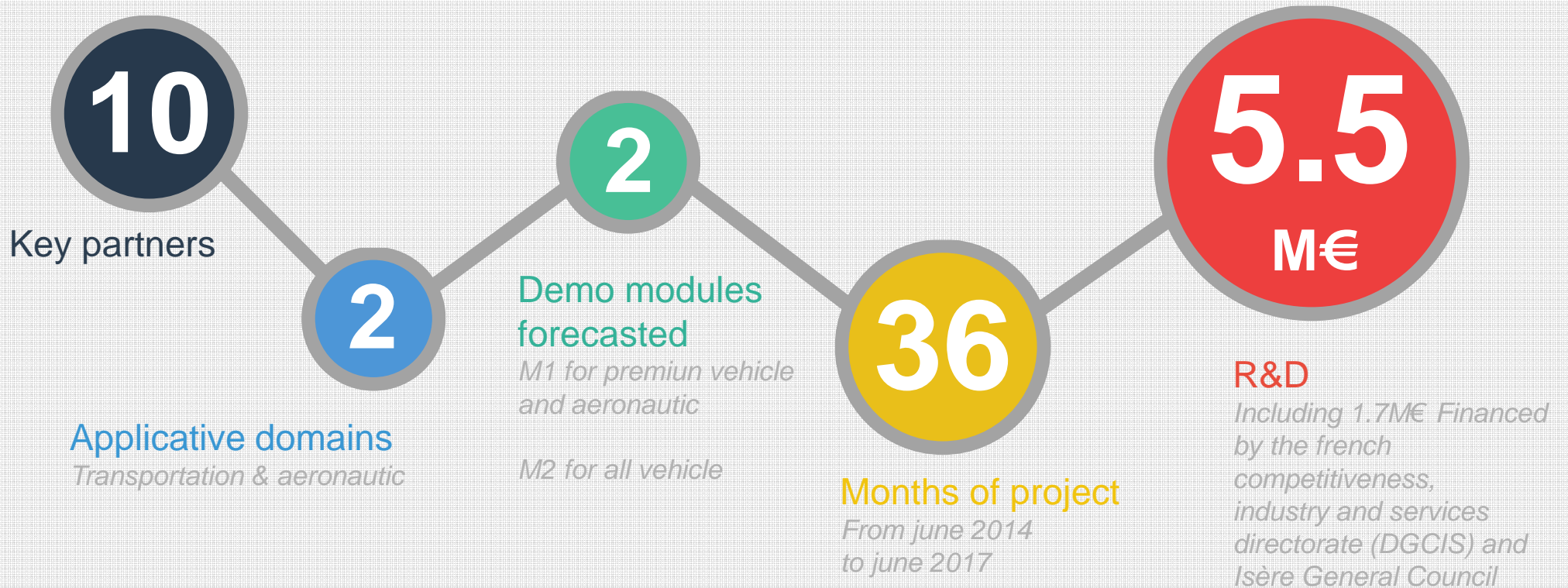


## Enhanced vision

DAY AND NIGHT

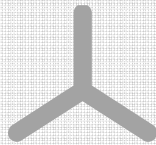
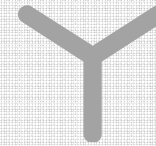
## AWARE: KEY FIGURES

3



# WE ARE AWARE

4



# AWARE ORIGIN

5

Are you able to drive  
or to operate safely  
with such visibility conditions

**OF COURSE  
NOT !**



**HERE IS, THE "AWARE"  
PROJECT ORIGIN !**



## AWARE ORIGIN

6

	INJURY CASUALTIES	FATALITIES
NIGHT	32%	41%
WET ROAD	20%	20%
ADVERSE WEATHER	21%	23%

## AUTOMOTIVE

French Road Safety Observatory (ONISR):  
*"Les accidents corporels de la circulation 2014 –  
Recueil de données brutes"*, May 2015



## AWARE: THE STAKE

7

### INCREASE ROAD SIGNS AND OBSTACLES PERCEPTION IN ALL-WEATHER BY USING A LOW COST IMAGE SENSOR



Allow the safe assisted and automated driving of vehicles, day and night.



#### ADAS FUNCTION

Pedestrian detection

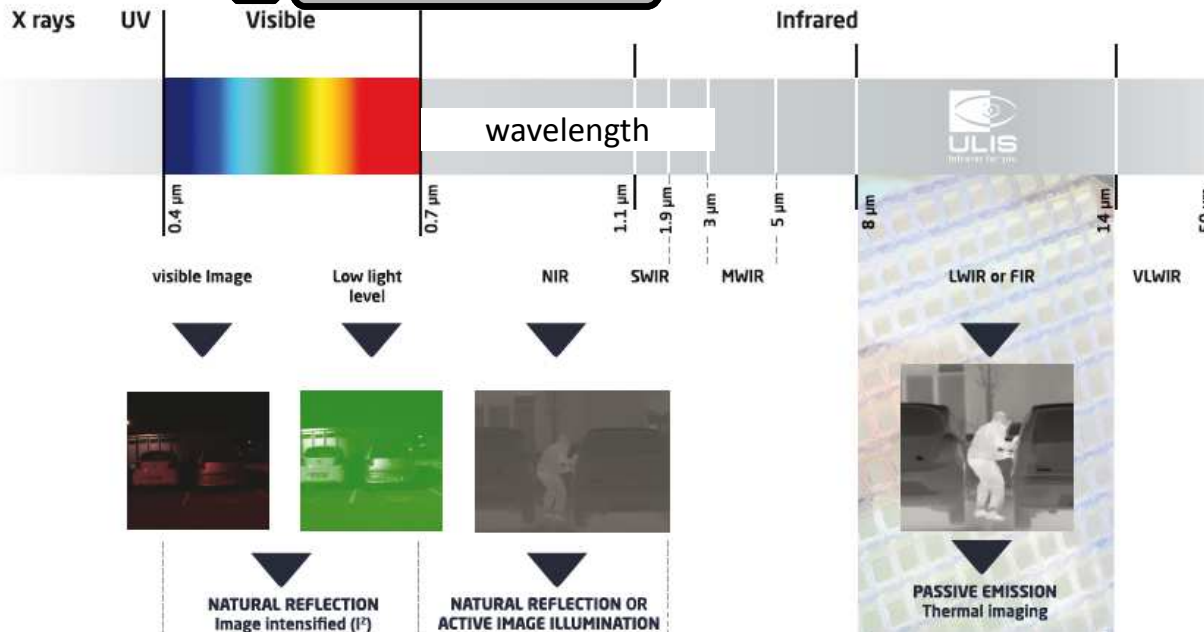
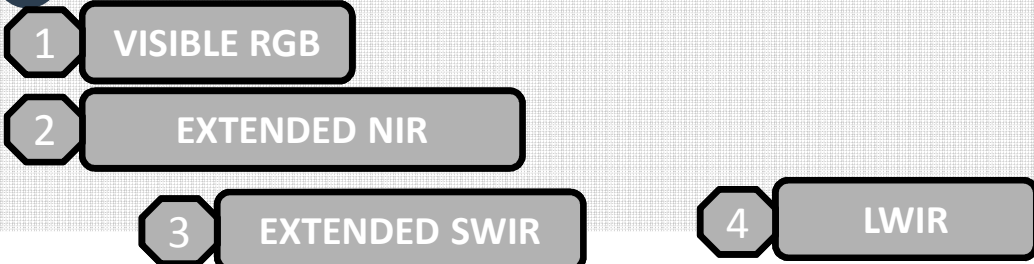
Vehicle shape recognition

Traffic signs recognition

Road marking detection

# 4 IMAGING TECHNOLOGIES UNDER EXPERIMENT

8



CAMERA	SENSOR	SPECTRAL BAND	OPTICS
<b>Visible RGB</b>	CMOS – SXGA (1280 x 966) 3x8 bits, pitch 4.2 μm	0,4-0,65 μm	HFOV = 54° VFOV = 40° F-number = 2
<b>Extended NIR</b>	CMOS – SXGA (1280 x 1024) 10 bits, pitch 5,3 μm	0,4-1 μm	HFOV = 39° VFOV = 31° F-number = 2.9
<b>Extended SWIR</b>	InGaAs – VGA (640 x 512) 14 bits, pitch 15 μm	0,6-1,7 μm	HFOV = 39° VFOV = 31° F-number = 1.8
<b>LWIR</b>	Microbolometre - VGA (640 x 482) 14 bits, pitch 17 μm	8-12 μm	HFOV = 44° VFOV = 33° F-number = 1.2



# FIELD TEST : SET-UP

9

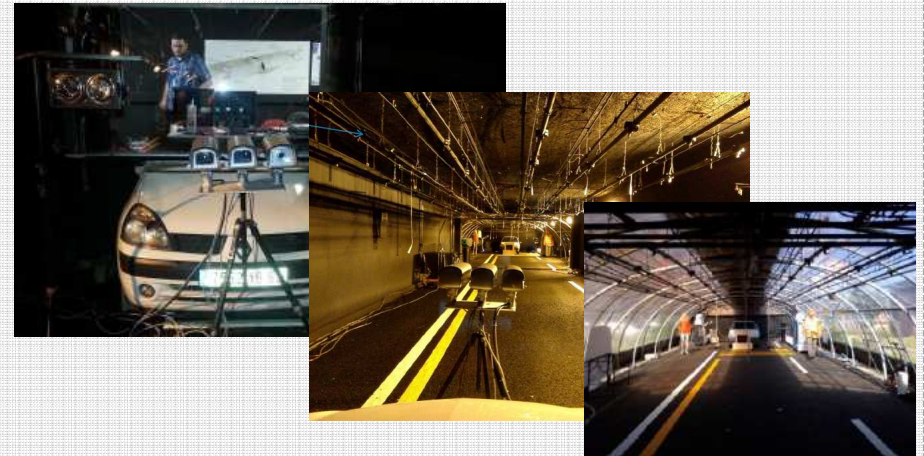
## OUTDOOR TEST

A75 – Col de la Fageole  
Cerema test's ground



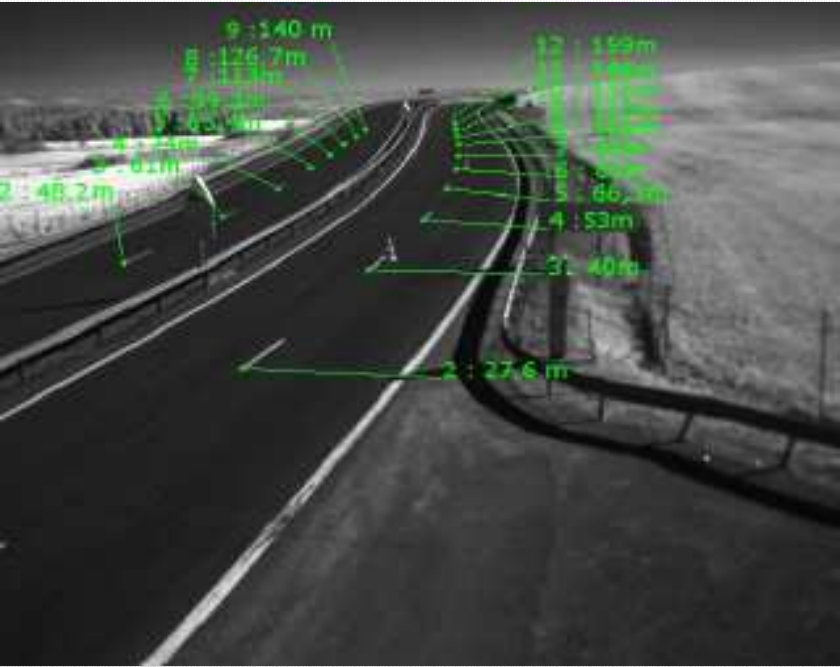
## FOG TUNNEL

Clermont Ferrand  
Cerema facility

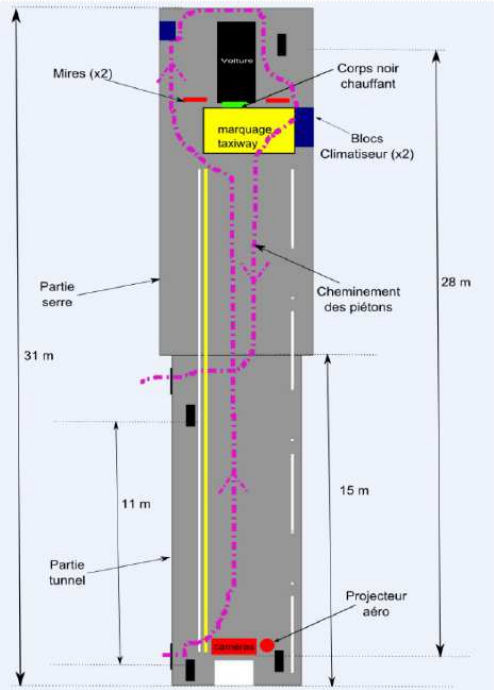


# FIELD TEST : RANGE CALIBRATION

### OUTDOOR TEST



### FOG TUNNEL



# FIELD TEST : OUTDOOR SCENARIOS

11

33 scenarios  
Under test

=> 4 most relevant

N°	Libellé	Visibilité (m)	Température (°C)	Luminosité (Lux)	Pluviométrie (mm/h)
<b>JOUR grand éclaircissement</b>					
1	Jour temps clair	2000	11.9	17354	0.00
7	Pluie faible (neige)	75	-1	5032	0.19
8	Pluie modérée	2000	6.4	10693	2.75
9	Pluie forte	2000	10.9	3359	11.44
11	Neige forte	69	-1	1096	0
<b>JOUR faible éclaircissement</b>					
12	Jour temps clair	2000	6.2	629	0.00
13	Brouillard classe 1	231	1.8	52	0.00
18	Pluie faible	2000	1.1	52	0.11
22	Neige forte	75	-0.8	104	0
<b>NUIT</b>					
23	Nuit temps clair	2000	5.5	-4	0.00
24	Brouillard classe 1	276	0.8	-12	0.00
25	Brouillard classe 2	186	0.9	-12	0.00
26	Brouillard classe 3	99	1.5	-12	0.00
29	Pluie faible	1978	0.8	-12	0.18
30	Pluie modérée	245	-0.6	-16	3.17
31	Pluie forte	2000	2.5	-12	13.68
32	Neige modérée	2000	0.8	-12	0.39
33	Neige forte	252	-0.6	-16	2.00

SCENARIO	WEATHER	VISIBILITY DISTANCE	AMBIENT LIGHT	TEMPERATURE
7	Day, heavy fog, light snow	75 m	5032 lux	-1° C
11	Day, heavy fog and snow	69 m	1096 lux	-1° C
22	Day low light, heavy fog and snow	75 m	104 lux	-0.8° C
26	Night, heavy fog	99 m	0 lux	+1.5° C

# EX SCENARIO #1 : DAY, CLEAR WEATHER

12



# EX SCENARIO #7 : DAY, HEAVY FOG, LIGHT SNOW

13



# EX SCENARIO #26 : NIGHT,HEAVY FOG,

14

Vehicle  
Front



VIS



NIR



SWIR



LWIR

Vehicle  
Back



## EXPERIMENTAL RESULTS: PEDESTRIAN DETECTION


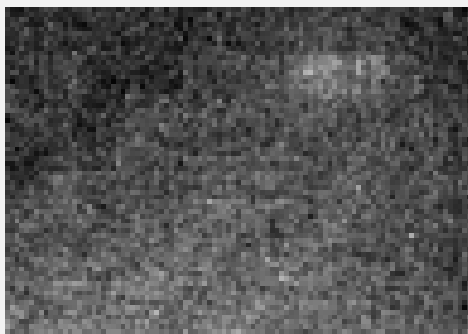

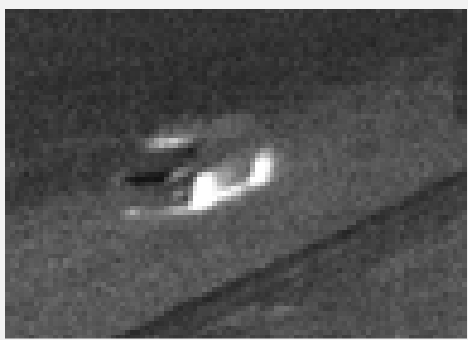


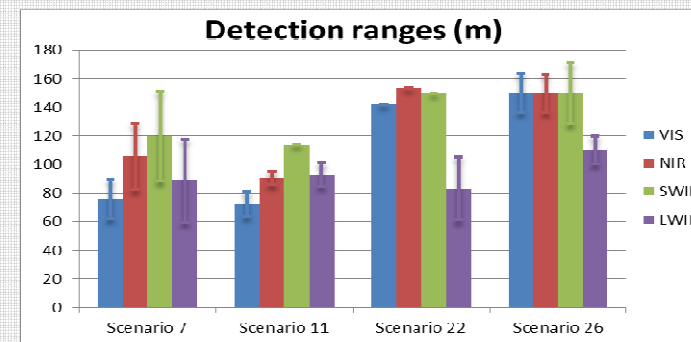
CAMERA	FOG DENSITY For "visible" pedestrian detection at 25m
Visible RGB	Moderate (visibility range = $47 \pm 10$ m)
Extended NIR	High (visibility range = $28 \pm 7$ m)
Extended SWIR	High (visibility range = $25 \pm 3$ m)
LWIR	Extreme (visibility range = $15 \pm 4$ m)

In adverse conditions:  
LWIR detect 3x times longer

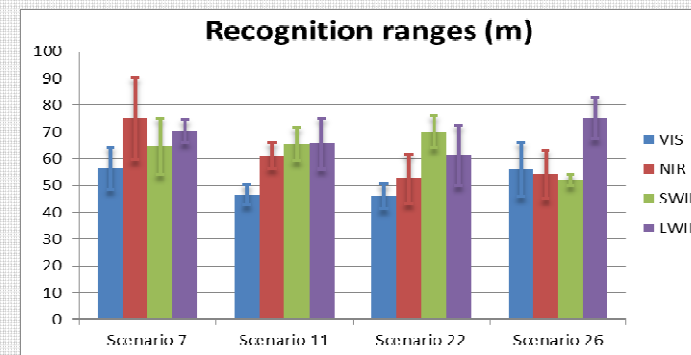
# EXPERIMENTAL RESULTS: VEHICLE DETECTION & RECOGNITION

16

<p><b>DETEC- TION</b></p>		
<p><b>RECO- GNI- TION</b></p>		
<p><b>TASK</b></p>	<p><b>VISIBLE</b></p>	<p><b>LWIR</b></p>









In adverse conditions:  
VIS/NIR/SWIR detect Headlight,  
LWIR recognize shape





# EXPERIMENTAL RESULTS: TRAFFIC SIGNS RECOGNITION

17

<p><b>#1 DAY, CLEAR WEATHER</b></p>			
<p><b>#7 DAY, HEAVY FOG, LIGHT SNOW</b></p>			
	<p><b>VISIBLE</b></p>	<p><b>NIR</b></p>	<p><b>SWIR</b></p>

In adverse conditions:  
NIR provides best SNR  
LWIR can not recognize

# EXPERIMENTAL RESULTS: ROAD MARKING DETECTION



CAMERA	SCENARIO 22	SCENARIO 26
	Visi 75m	Visi 99m
Using Headlight		
Visible RGB	53m	53m
Extended NIR	60m	53m
Extended SWIR	63m	53m
LWIR	-	-

In adverse conditions:  
VIS/ NIR /SWIR equivalent  
using additional lighting

# CONCLUSIONS

ADAS FUNCTION	CAMERA SPECTRAL BAND <b>DAY FOG, USING HEADLIGHTS</b>				CAMERA SPECTRAL BAND <b>NIGHT FOG, USING HEADLIGHTS</b>			
	VIS	NIR	SWIR	LWIR	VIS	NIR	SWIR	LWIR
Pedestrian, detection	+	++	++	++++	+	++	++	++++
Vehicle lights detection					+	++	+++	--
Vehicle shape recognition	+	++	++	++	-	-	--	++
Traffic signs recognition	+	++	-	--	+	++	-	--
Road marking detection	+	++	++	-	+	++	++	-

In adverse conditions:

**Visible RGB extended to NIR combined with LWIR** provide the best spectral bands to improve ADAS performances of detection or recognition such as vehicle, pedestrian, road marking, and traffic signs.

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