2.3 Impact Studies

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Introduction

Sophie Bourdy-Liébart (URCA)

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Impact studies

Aims

- Evaluation of C-ITS implemented in the InDiD project from a technical, social and economic point of view.
- Users' experience, and data base
- Assess the benefits of C-ITS
    - On pilote site,
    - In laboratory,
    - With simulation,
    - Or theoretical studies.

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Impact studies

Working Group

- 2.3.2 Exposure to electromagnetic waves
- 2.3.3 Technical and functional evaluation
- 2.3.4 Behaviour, Distraction and Road Safety
- 2.3.5 Acceptability and Organizational Impacts
- 2.3.6 Socio-economic impact and Business Model
- 2.3.7 Traffic and Environment
- 2.3.8 Legal Studies

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Working Group (WG)

Exposure to electromagnetic waves (Divitha Seetharamdoo)

- Impacts on health
- Exposure to electromagnetic waves (EM)
- Increase of emitter = increase of number and duration of exposure to waves ?

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Working Group (WG)

Technical and functional evaluation (Hasnaa Aniss)

- ✓ Functional aim of services
- ✓ Functional aim for large-scale deploiement

- ✓ Numeric network
- ✓ Data security
- ✓ Précision de la géolocalisation
- ✓ Geolocalisation of precision

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Working Group (WG)

Behaviour, Distraction and Road Safety (Laura Bigi)

- Issues about road safety.
- Situations accident-prone:
  - ✓Use of Coopits application
  - ✓Level crossing
  - ✓Lane merging for an autonomous vehicle

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Working Group (WG)

Acceptability and Organisational Impacts (Mehdi Chahir)

- ✓ Coopits application → General public
- ✓ Acceptance of C-ITS and Connected and Automated Vehicle (CAV) → operations managers

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Working Group (WG)

Socio-economic impact and Business Model (Jamel Chakir)

- ✓ Usa cases → Urban environment
- ✓ Positive economic model to deployment

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Groupes de travail (GT)

Traffic and Environment (Pierre-Antoine Laharotte)

- ✓ Gains on traffic regulation
- ✓ Energy consumption
- ✓ Pollutant Emissions
- ✓ Scale-up simulation model

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Working Group (WG)

Legal Studies (Lexing law firm)

- Responsabilities incurred by various actors involved.
- Use cases→ Connected and Autonomous Vehicle

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2.3.2 Exposure to electromagnetic waves

Divitha Seetharmdoo (University of Gustave Eiffel)

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Regulatory framework

Recommendations 1995/519/EC on the limitation of the level of exposure of the public

- The aim is to define limit values in order to prevent direct biophysical risks and known indirect effects.
- These recommendations are based on those of the ICNIRP (International Commission on Non-Ionizing Radiation Protection) - Recommendation pass in France - Decree 2002-77.
- European Directive 2013/35/EC of the European Council on the limitation of the level of exposure of workers - Recommendation pass in France - Decree 2016-1074 coming into effect on 1 January 2017.
- IEEE/IEC 62704-1-2017 (standard) - Numerical method for determining the specific absorption rate (SAR) in the human body from wireless communication devices, 30 MHz - 6 GHz.

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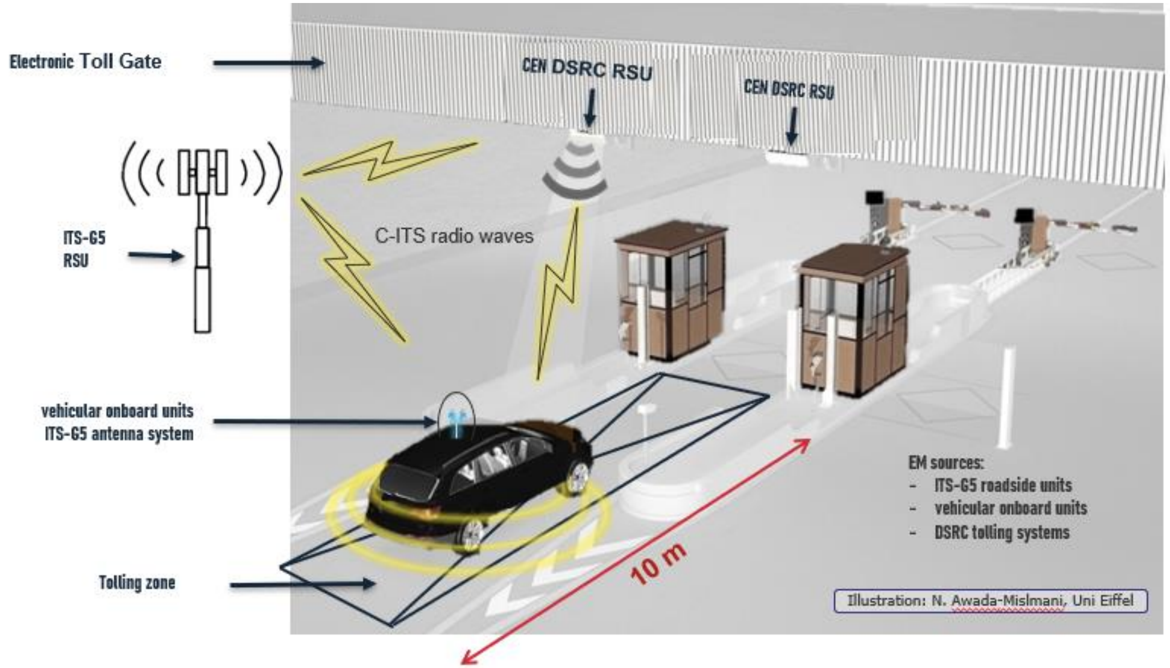
Use cases considered

Scenario: Automated Vehicle (AV) approaching a toll

- Sending a specific message to AV when approaching
- Assistance to the AV in selection of a toll lane
- Constraints
  - Risk of electronic disruption for electronic toll equipment
  - Coverage: presence of metal obstructions
  - Technological choices that take into account EM exposure



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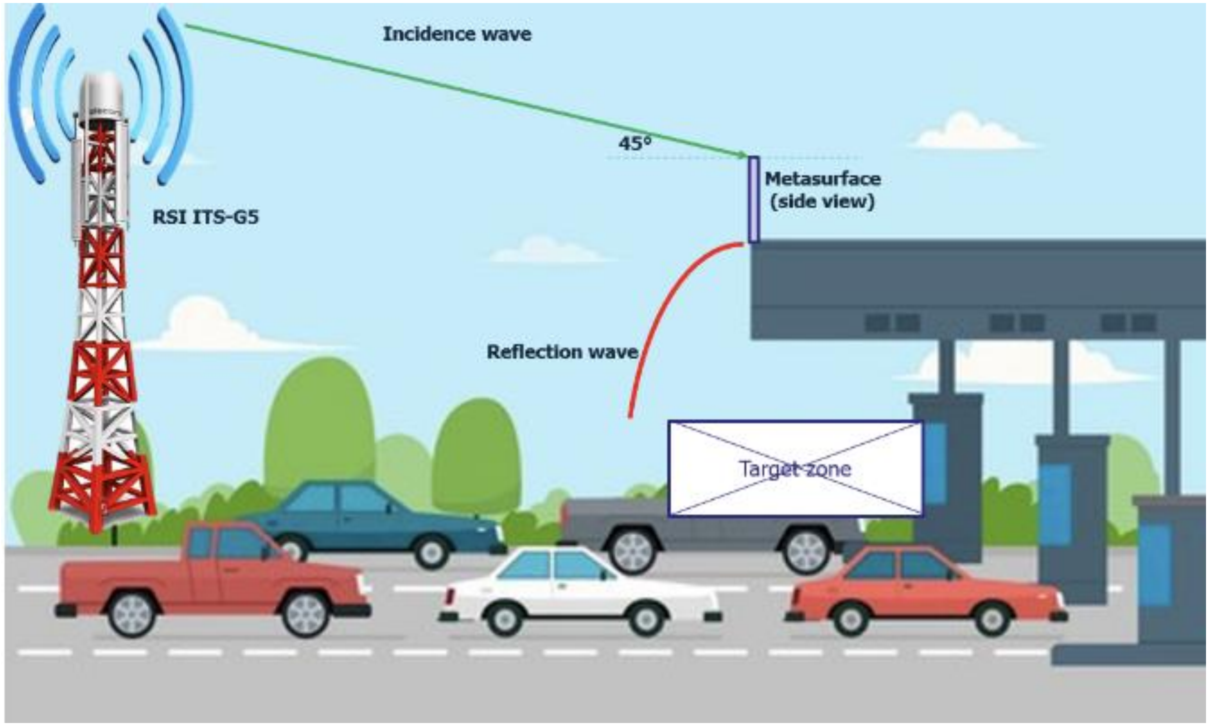
Proposed solution

Reflector with holographic properties

- Reflectors with specific properties can reduce the number of OBU deployed, especially near the toll station
- Requires a curvature of the reflected radius
  - Relies on holography theory
  - Based on a low-cost technology made of a composite of metal and dielectric (insulating material)
- Solution that takes into account jointly
  - The coverage and performance of the ITS-G5 system
  - Minimizes exposure to electromagnetic waves



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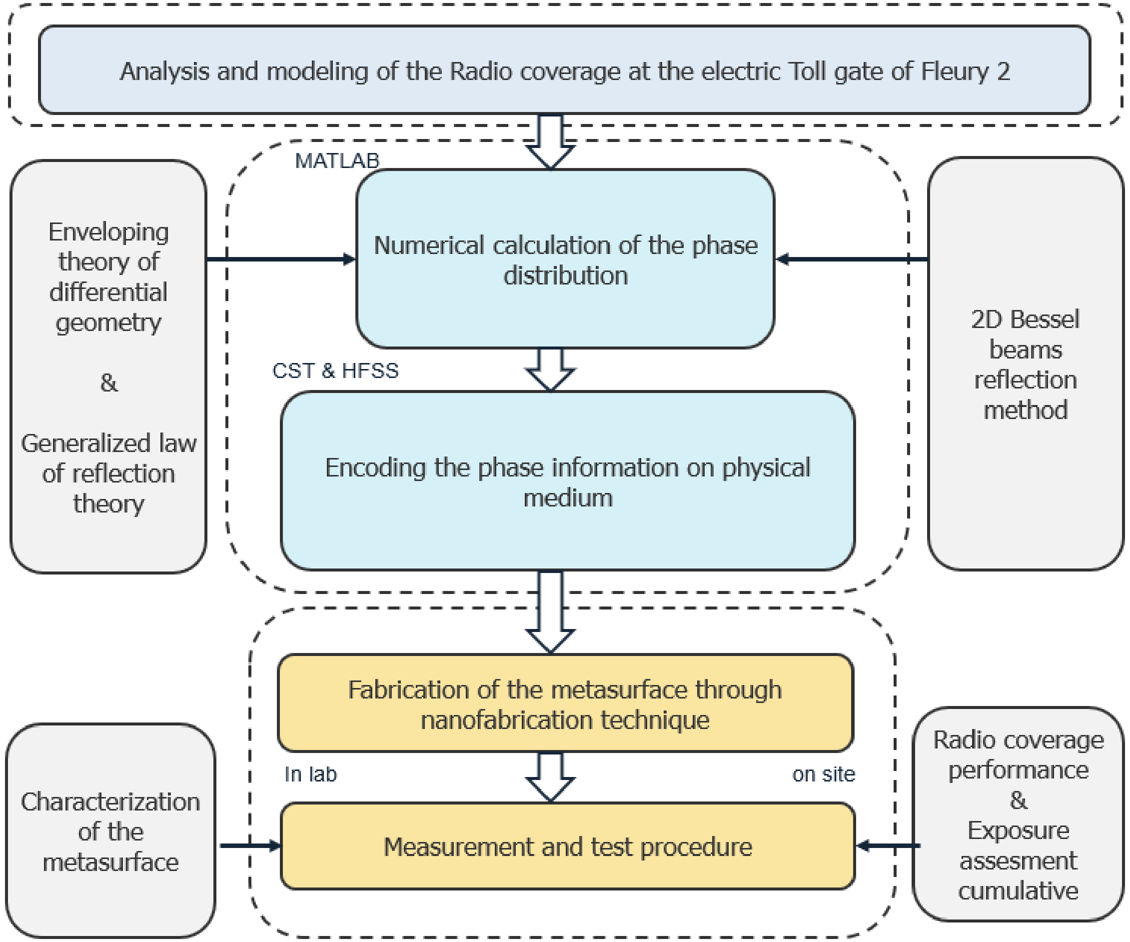
Proposed methodology

How integrate such a reflector into this environment?

- Analysis of the coverage of the toll station
- Calculation of all the parameters required for the characteristics of the reflector
  - In particular the phase laws
- Implementation of this phase law
- Design of the holographic reflector
- Prototyping, testing and experimental verification of the reflector characteristics
- Analysis/calculation of the coverage with the proposed solution
- Analysis of the exposure to EM waves with the proposed solution



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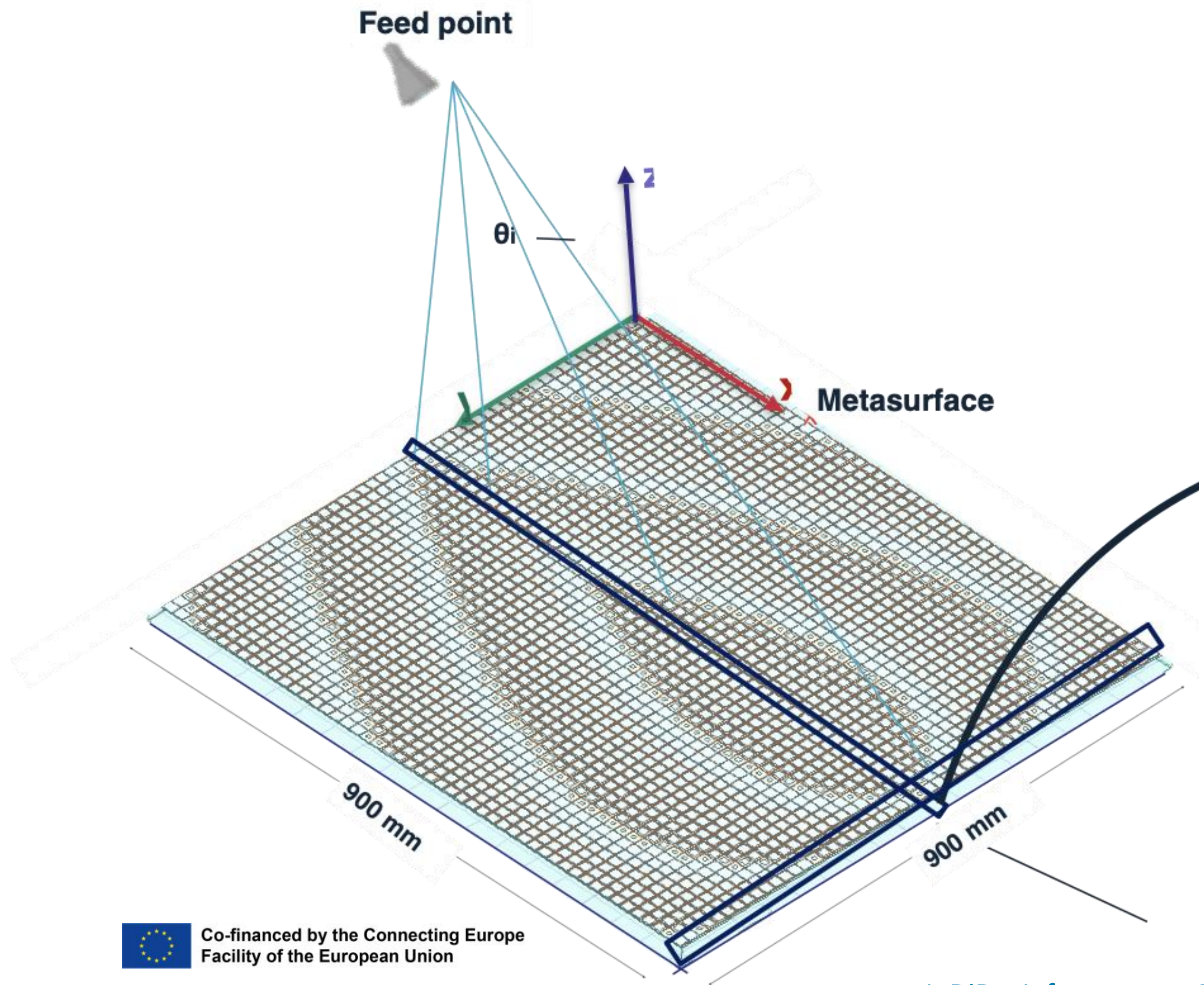
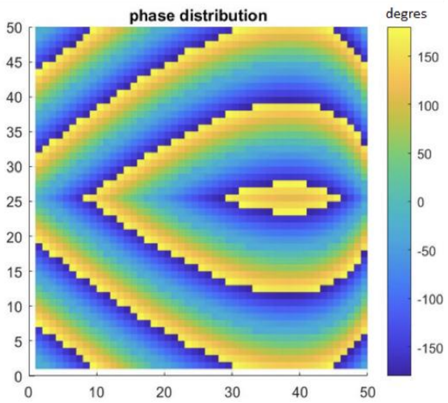
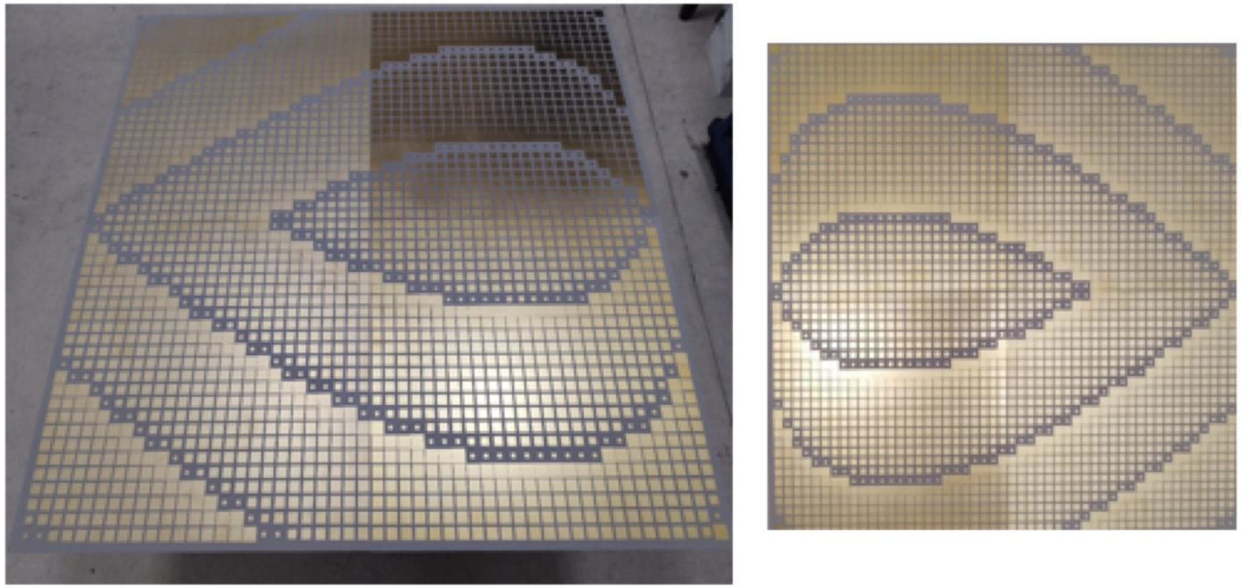
Proposed reflector metasurface

Form concept to prototype







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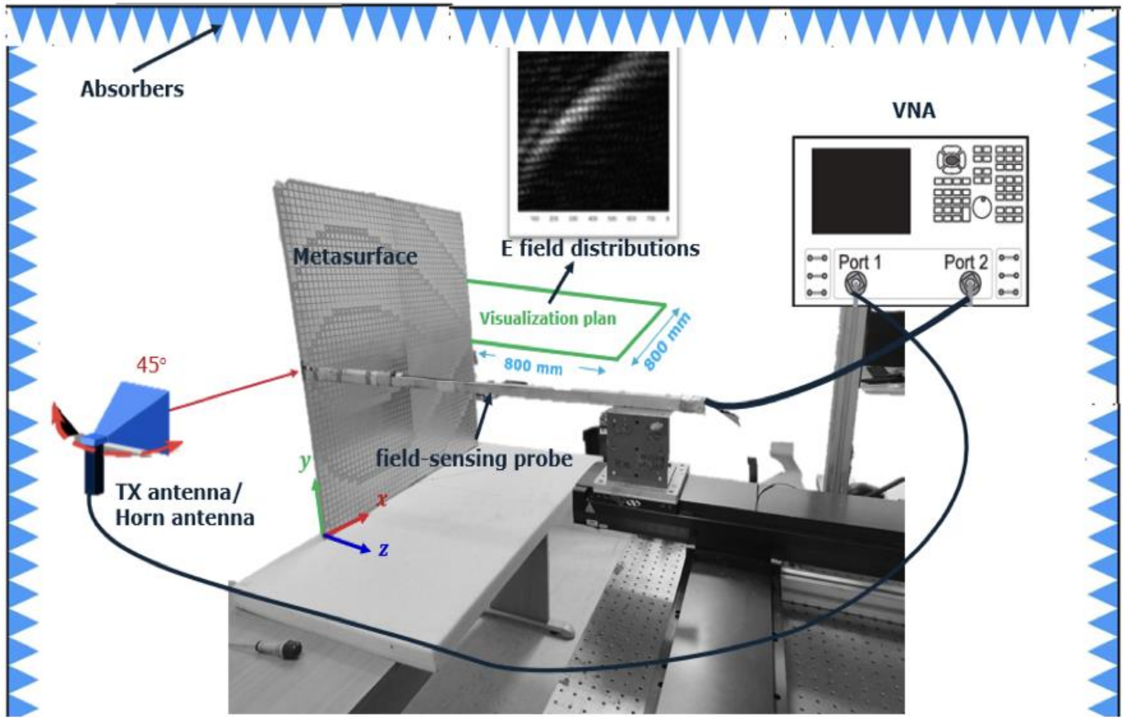
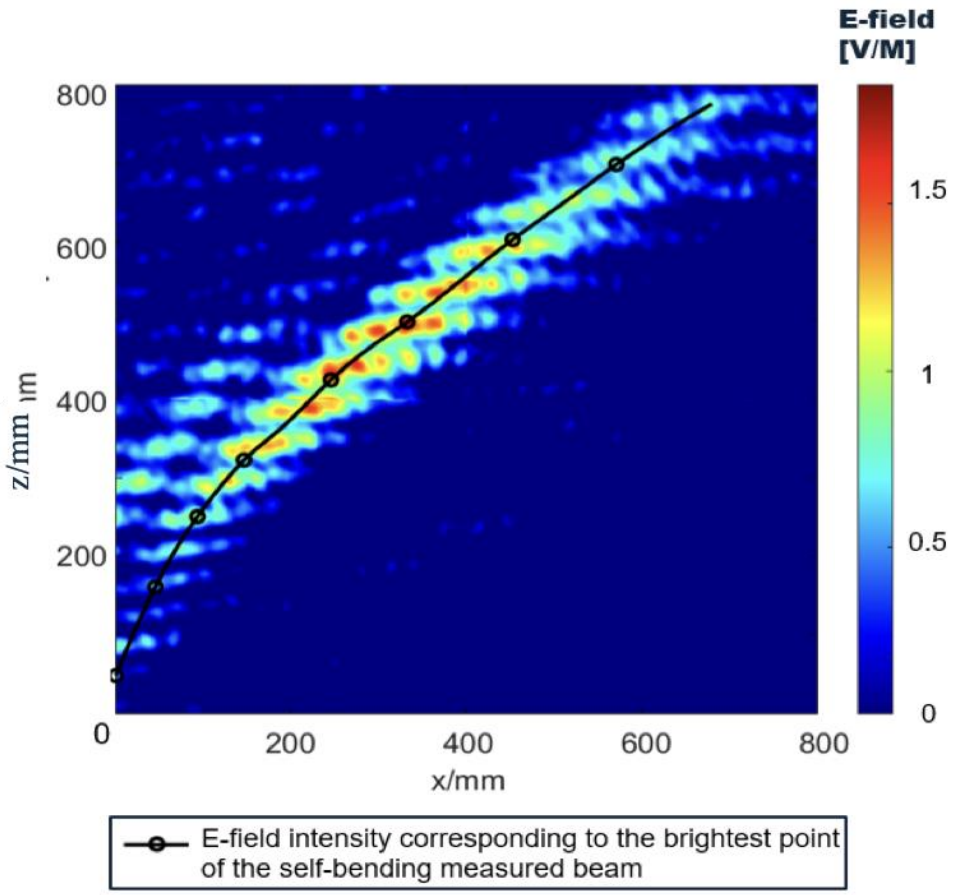
Experimental results (1/3)

Near field measurements



Near Field setup



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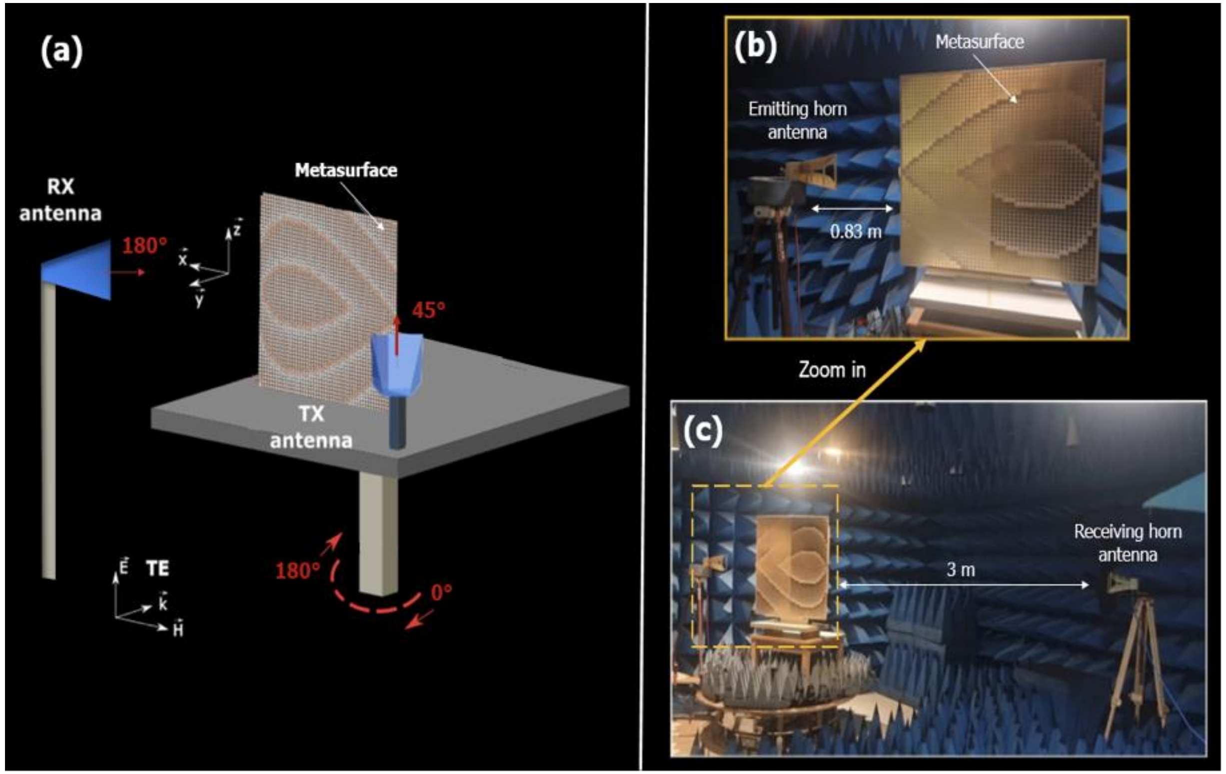
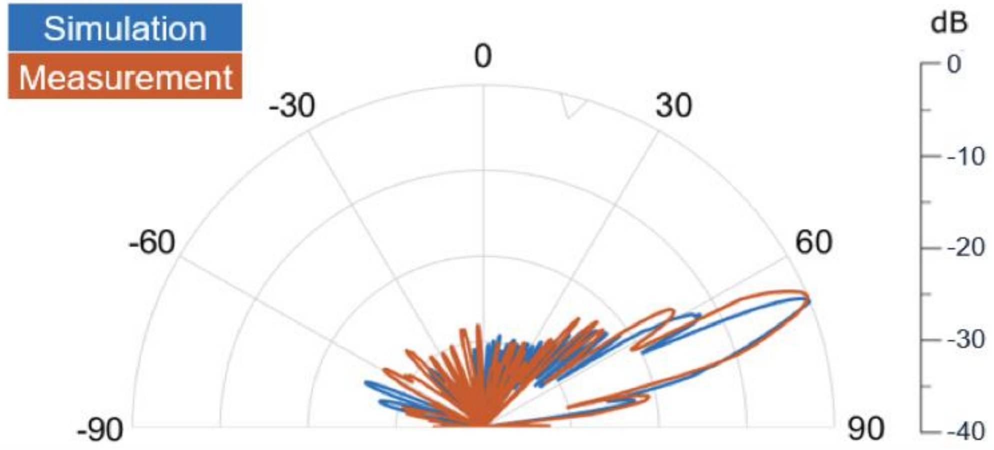
Experimental results (2/3)

Far-field measurements in anechoic chamber



Far Field setup



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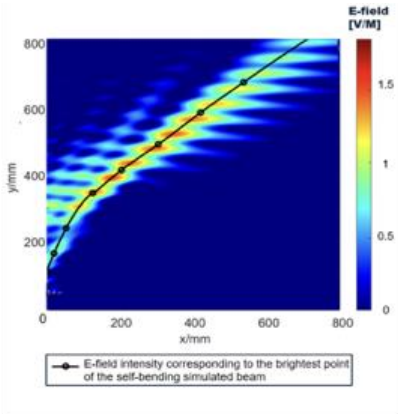
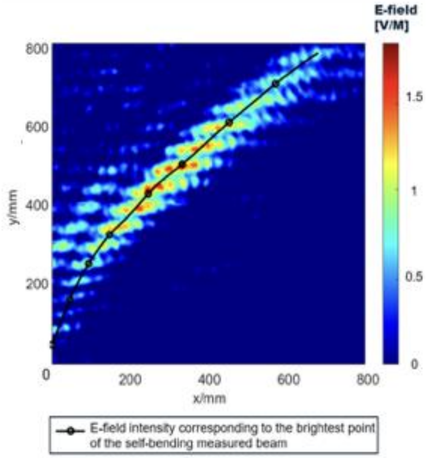
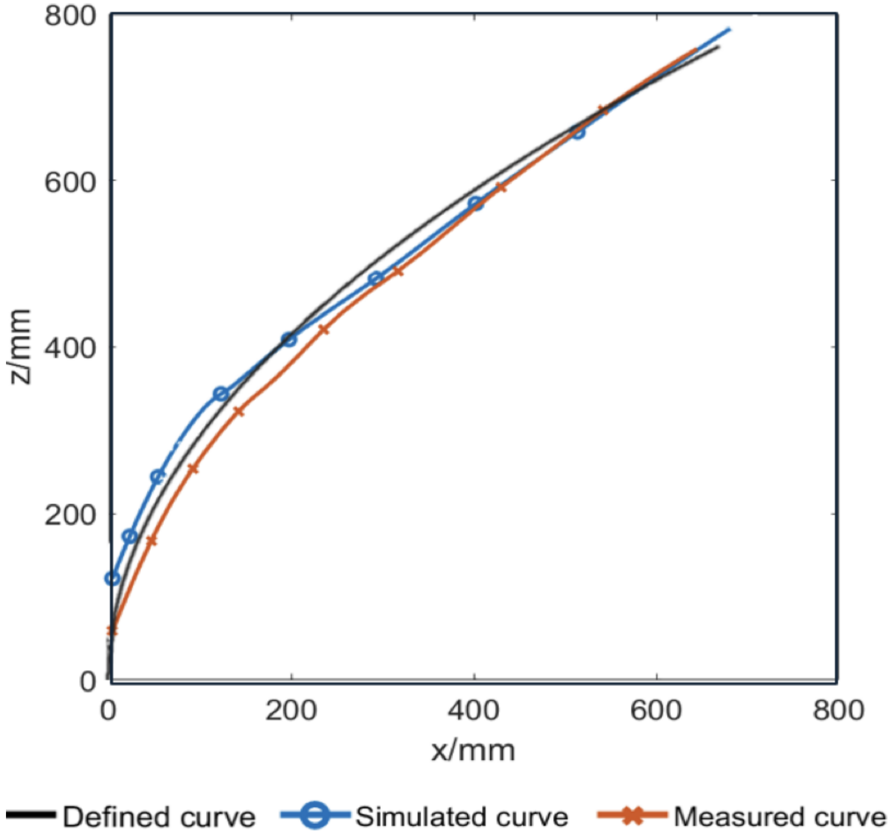
Experimental results (3/3)

Analysis of curved beam: measurement/calculation comparison







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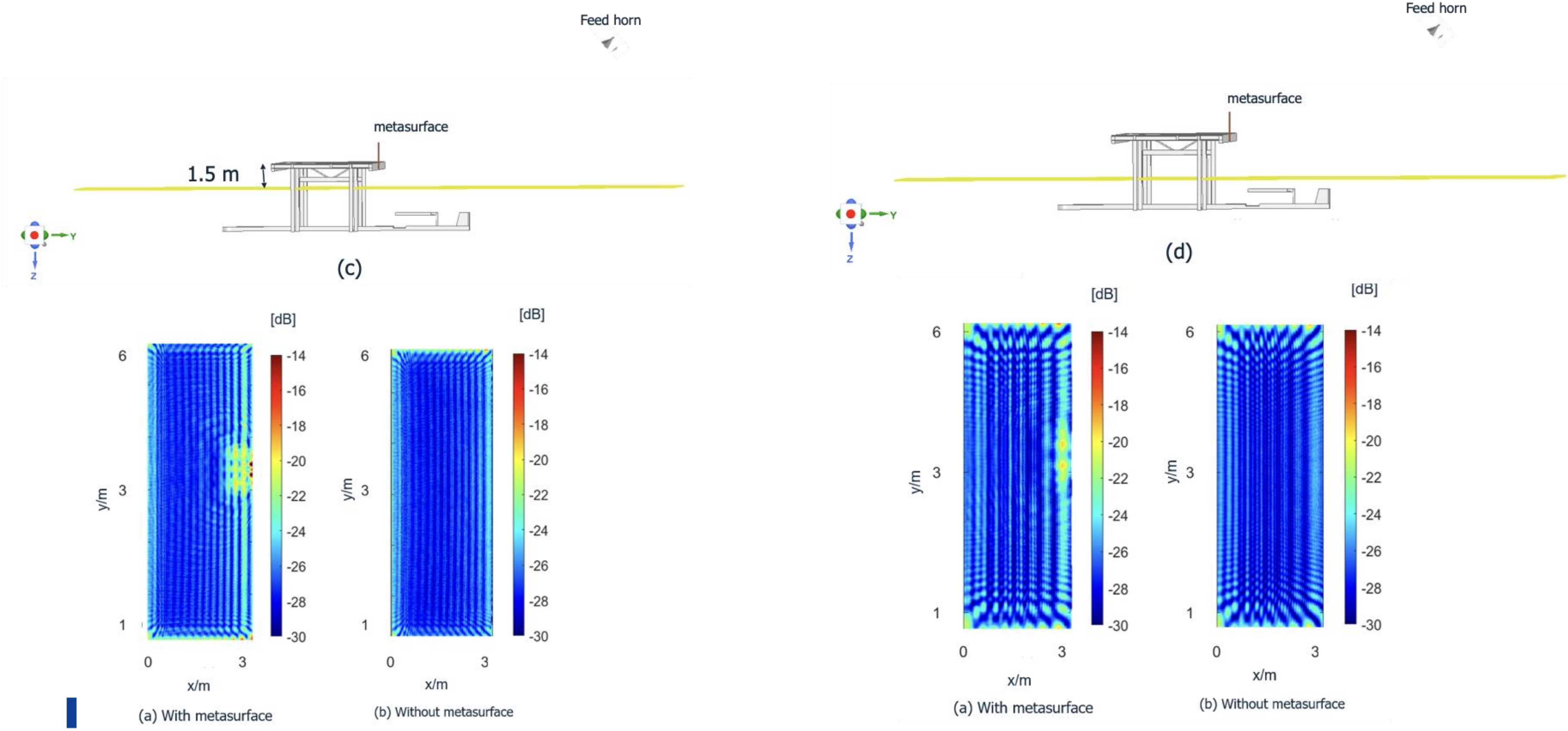
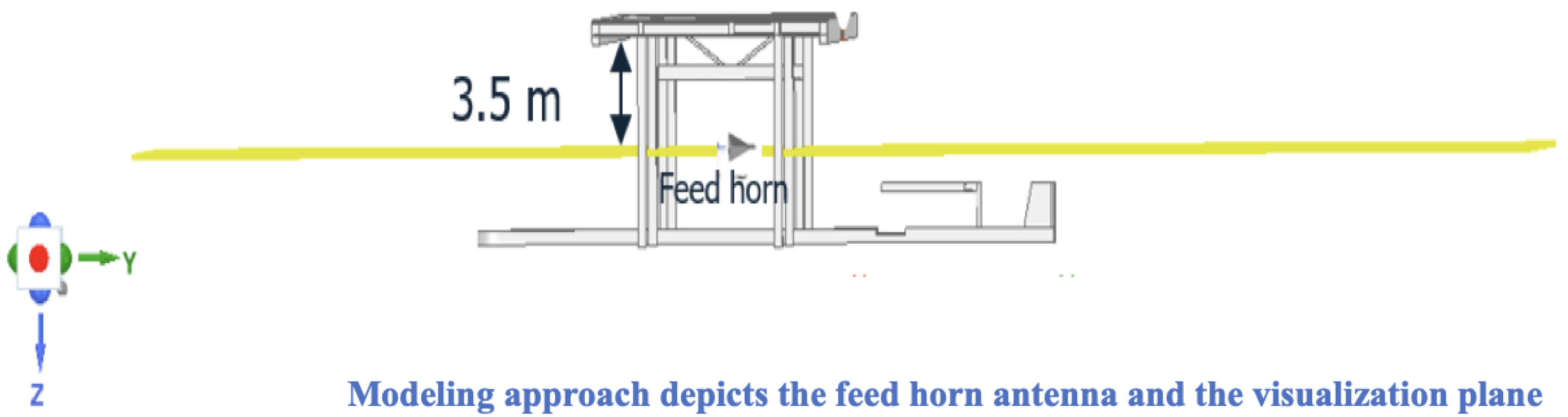
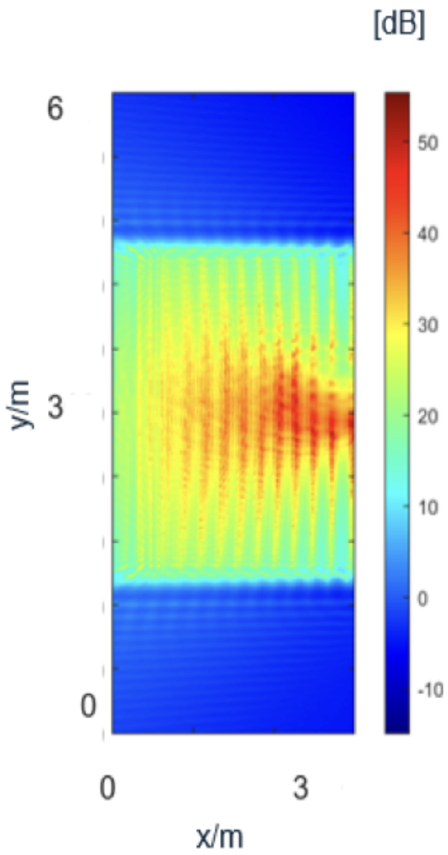
Simulation coverage assessment



Evaluation of exposure to electromagnetic waves by simulation



Modeling approach depicts the feed horn antenna and the visualization plane positioned under the toll station.



:Difference in the electric-field distribution (in dB) levels at z=3500 mm in x0y plane, under the toll gate at 5.9 GHz.

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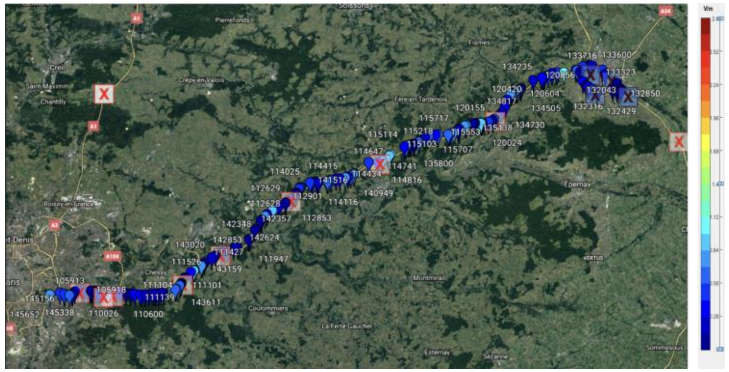
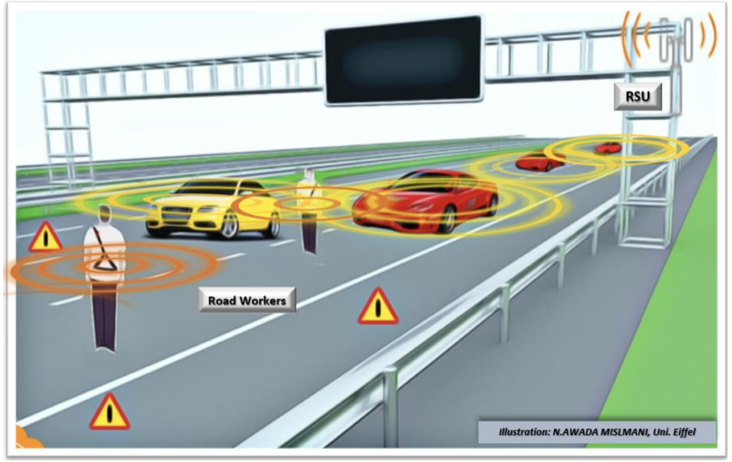
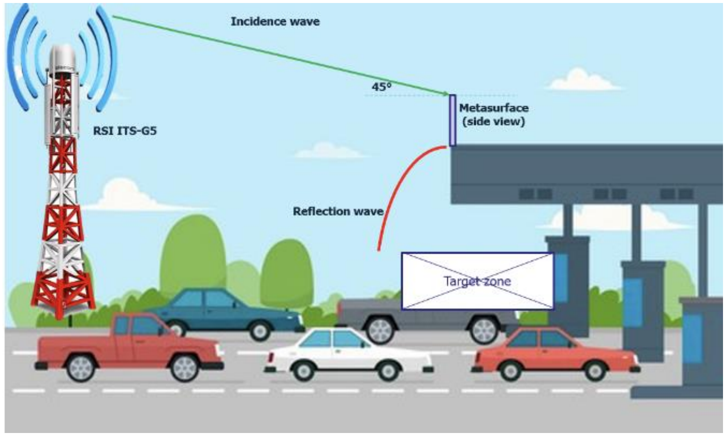
Conclusion

Exposure to EM waves to C-ITS deployment

- There is a legal framwork for Exposure to EM waves
- Several use cases have been analysed in this special context of C-ITS deployment for many years.
  - Use cases of RSU and OBU deployment (Scoop@F Project)
  - Motorway use cases on a connected road with ITS-G5 device. (C-ROADS)
  - Use cases of autonomous vehicle approching a toll station (InDiD)
- Le niveau d’exposition des personnes aux ondes est nettement inférieur au seuil recommandé dans tous les cas d’usages étudiés.
- The level of waves exposure is cleary below the recommanded threshold for every studied use cases.
- Nous démontrons également que des méthodologies peuvent être mis en œuvre afin d’étudier et de réduire le niveau d’exposition tout en garantissant une bonne qualité de service du système G5 dans des cas d’usages qui semblent les plus difficiles au regard de la propagation et/ou de l’exposition aux ondes
- We established that methodologies can be implemented to evaluate and reduce the level of exposure while guaranteeing a good quality of ITS-G5 services in use cases that seem difficult in terms of propagation and/or exposure of waves.







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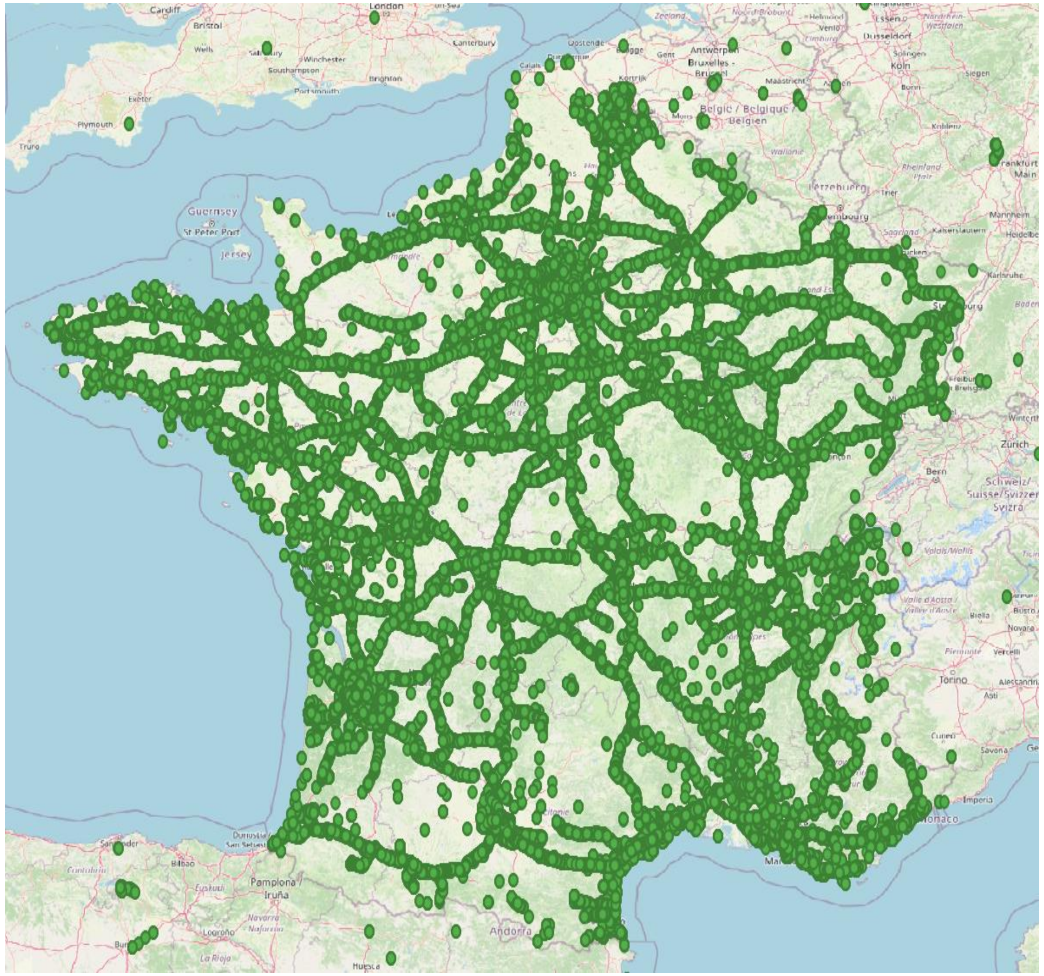
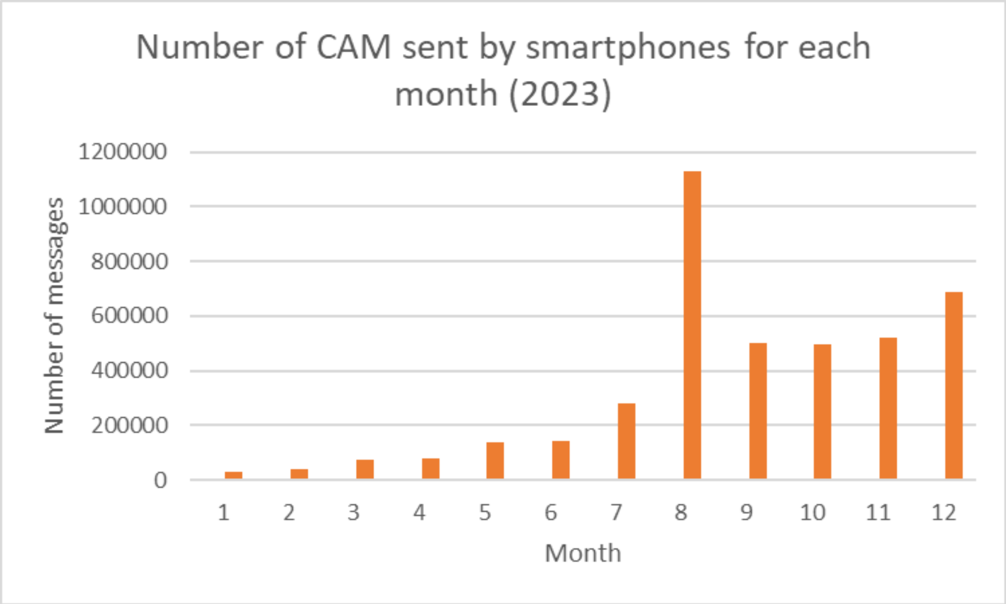
2.3.3 Technical and functional evaluation

Hasnaa Aniss (University of Gustave Eiffel)

Geographical distribution of CAM





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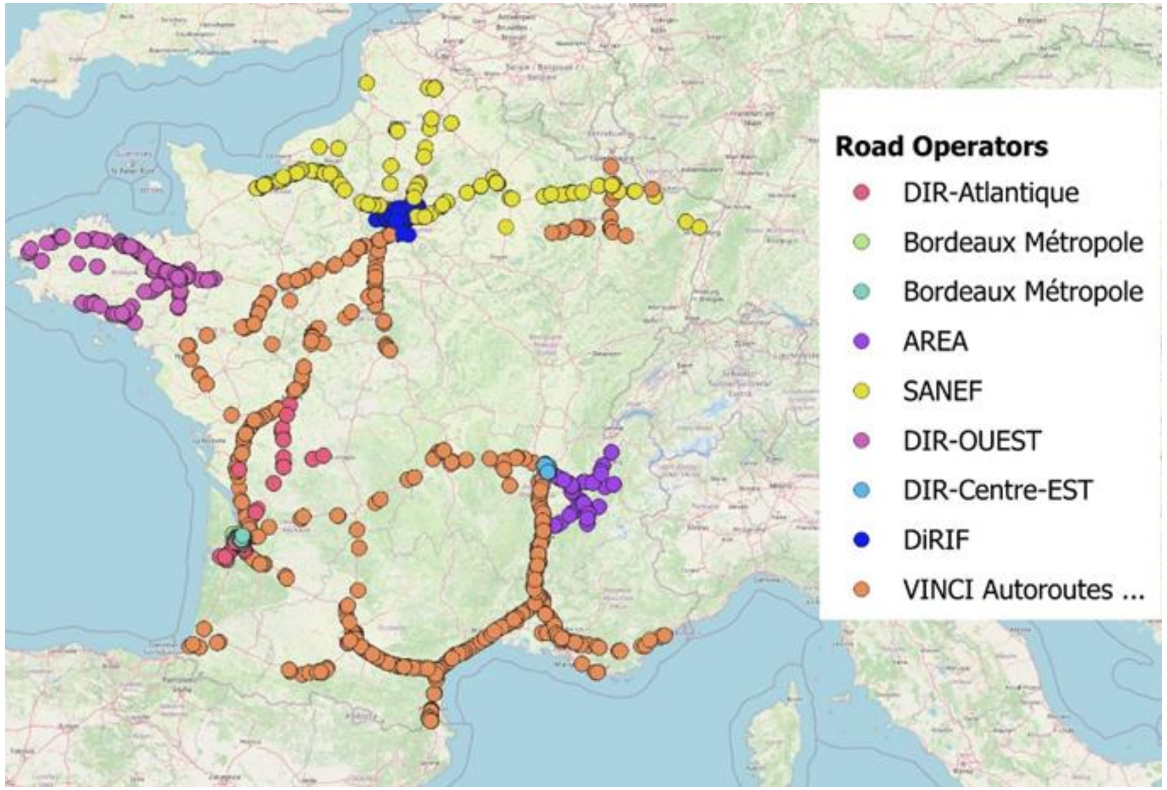
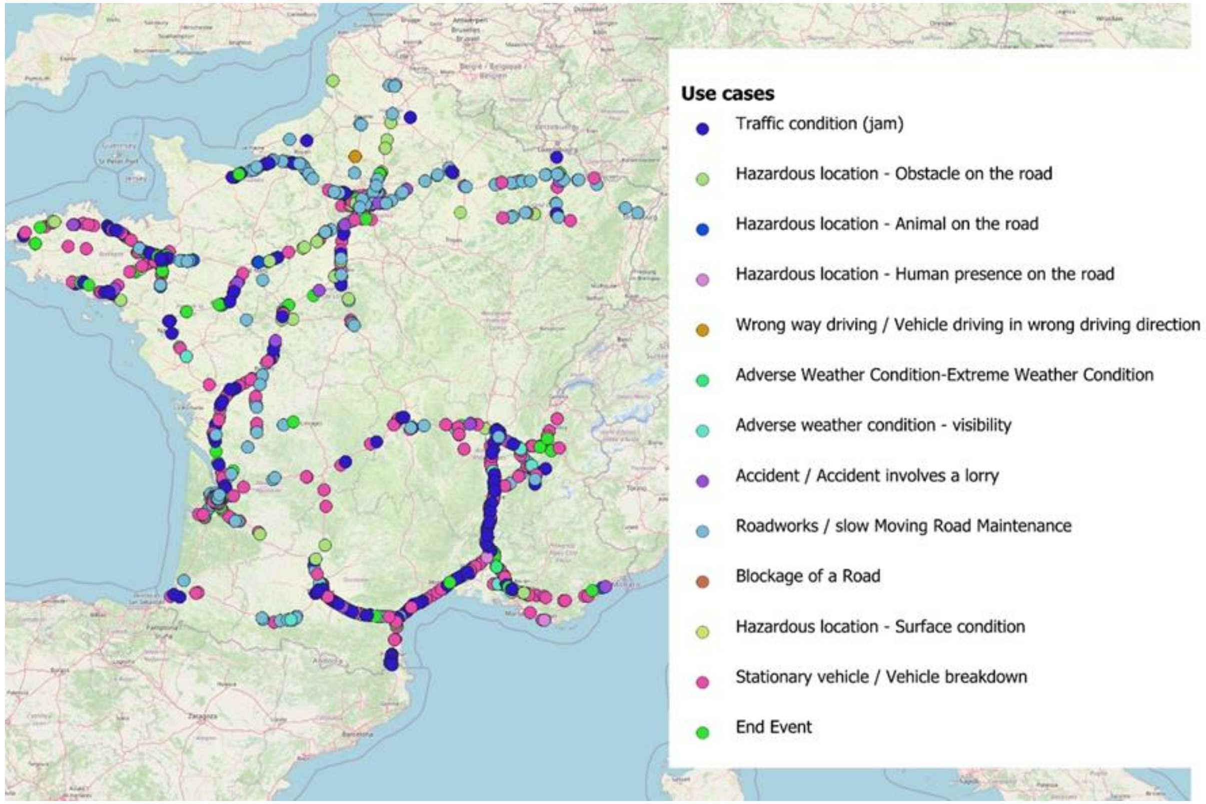
Geographical distribution of DENM





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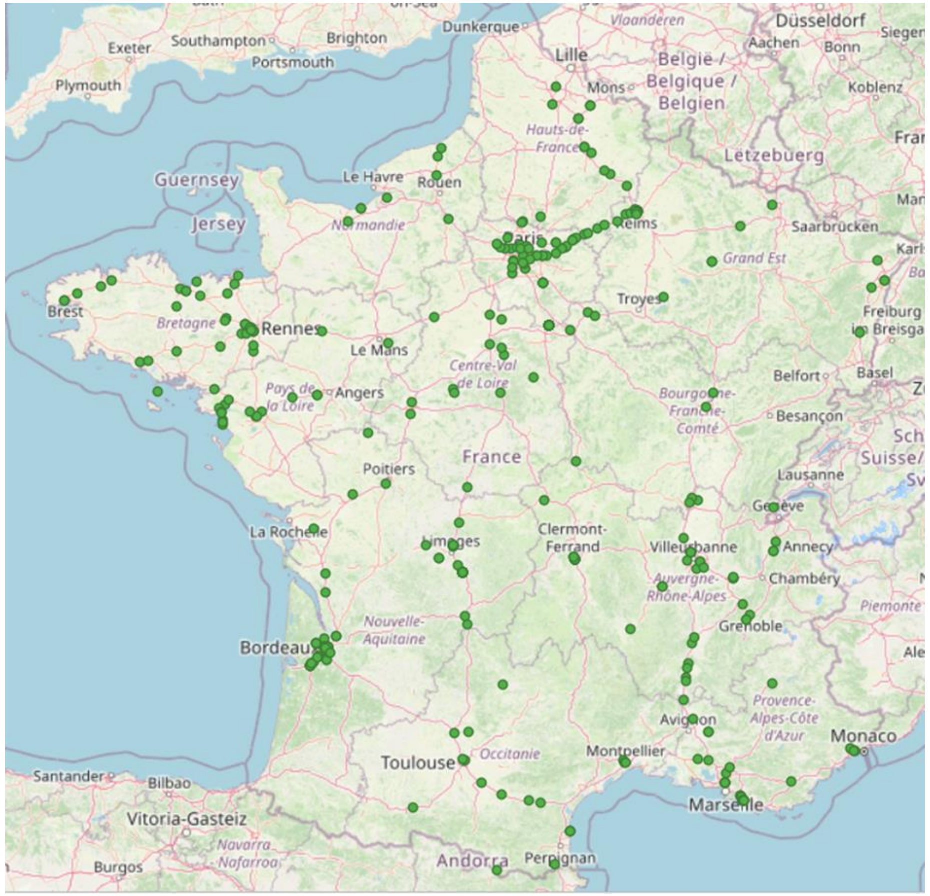
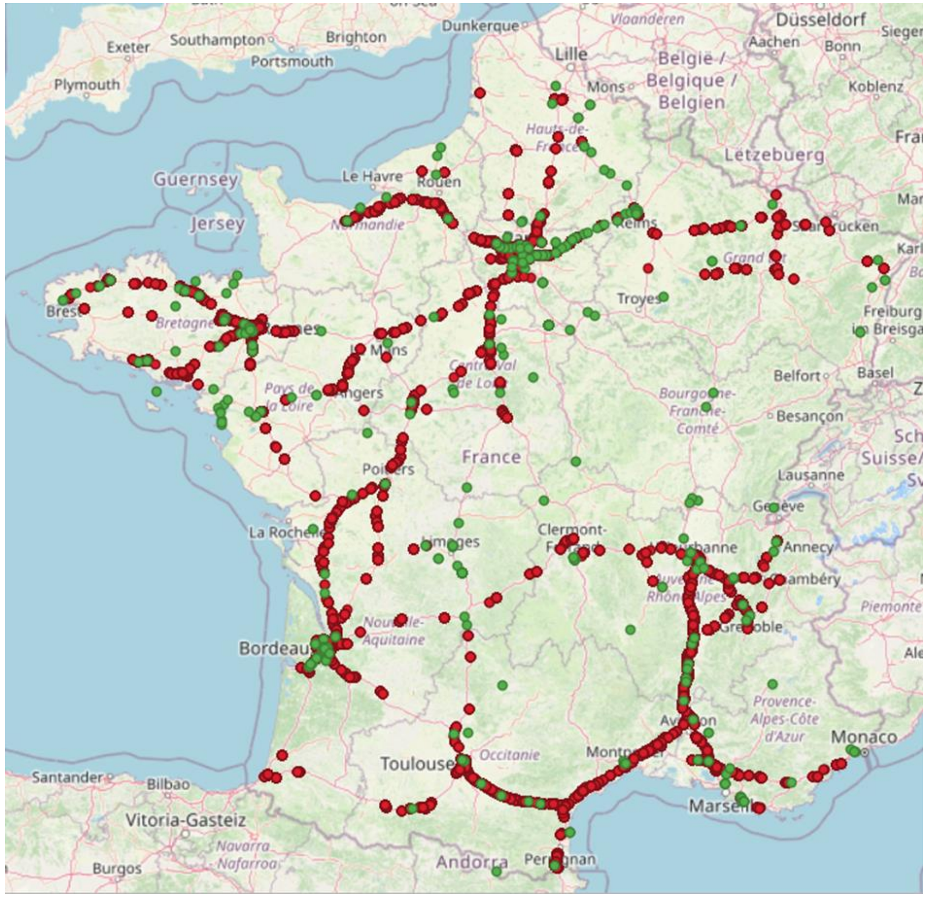
DENM sent by smartphones





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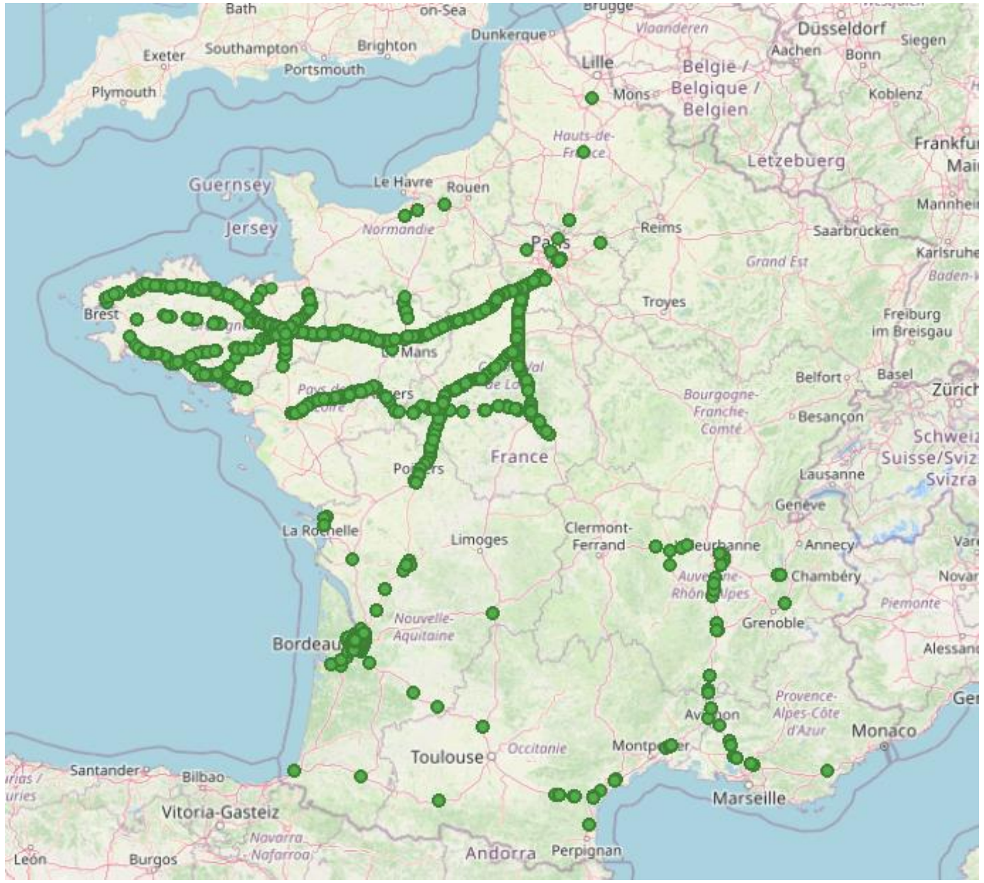
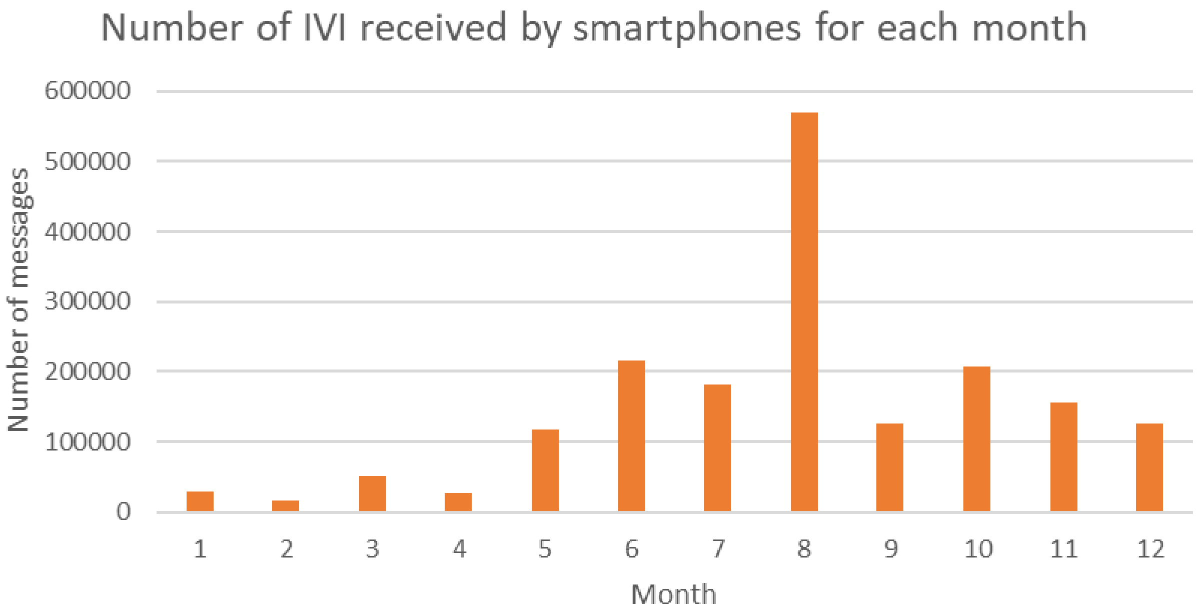
IVI messages





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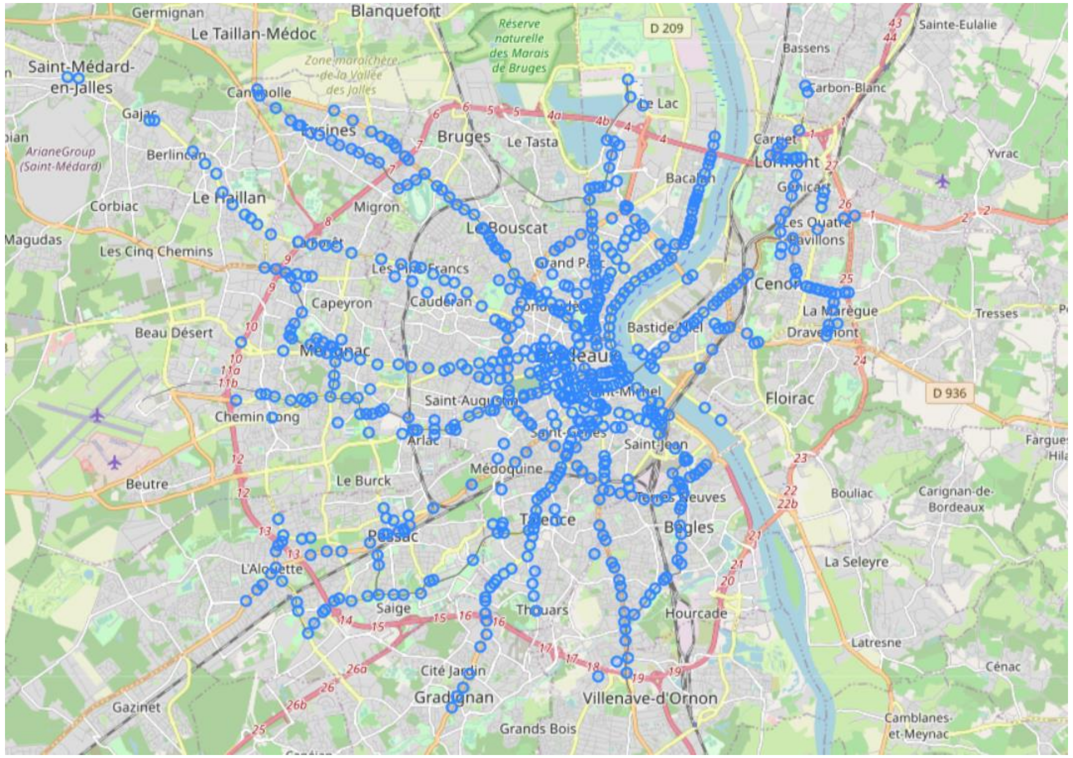
MAPEM SPATEM

	Number of messages	Number of intersectionids	Number of log_StationIDs
MAPEM	1 412 261	674	5704
SPATEM	634 653	585	3086



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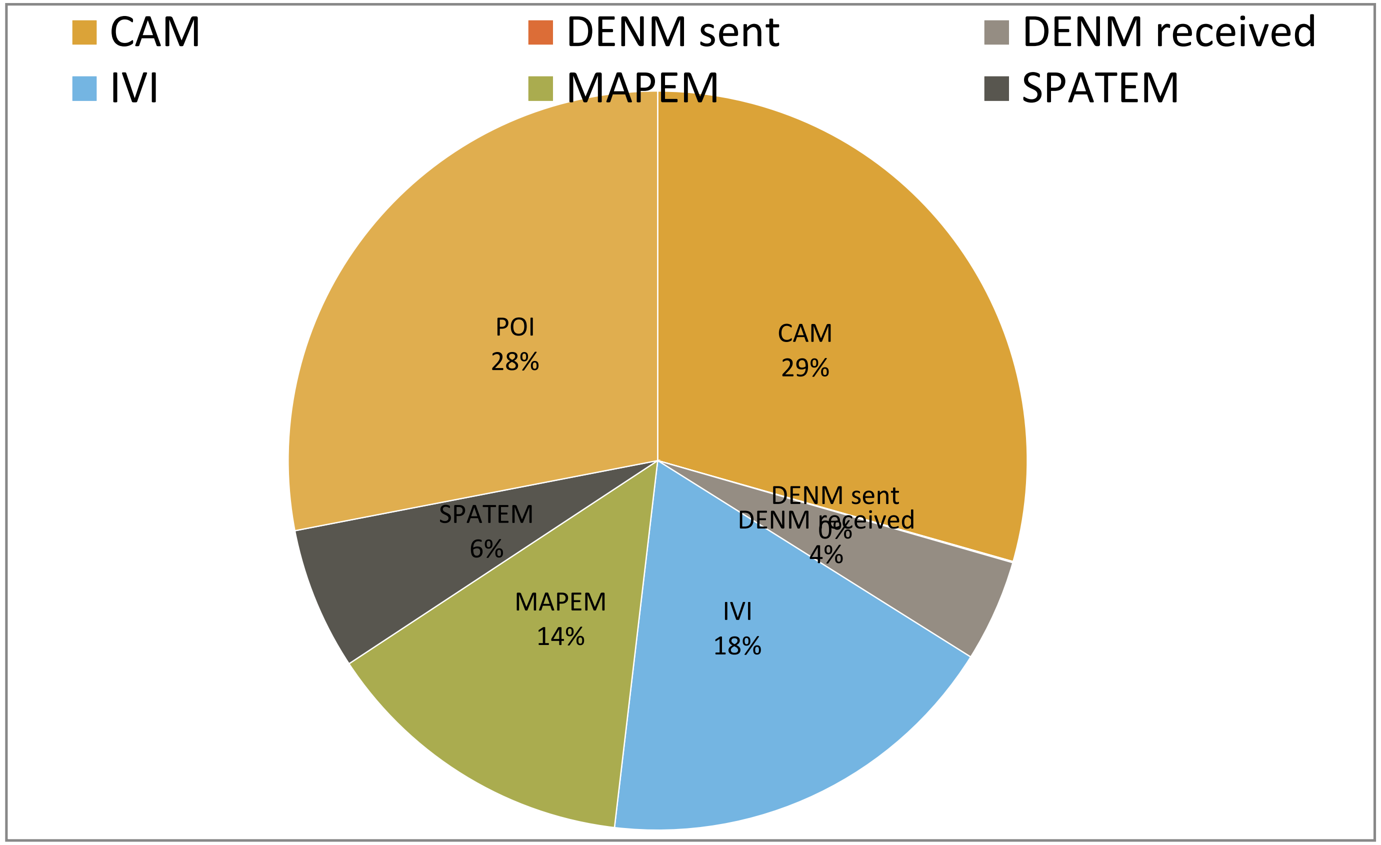
Technical Evaluation

Exchanged messages



Message Type	Received messages	% of message received
CAM	4920516	0,03
DATEX2	3262174	0,02
DENM	4271360	0,03
IVIM	29498432	0,20
MAPEM	31130375	0,21
POI	7932214	0,05
SPATEM	14850797216	99,46
Total	14931812287	100,00

Received by the Nfr-ITS-S

More than 10 millions of messages exchanges

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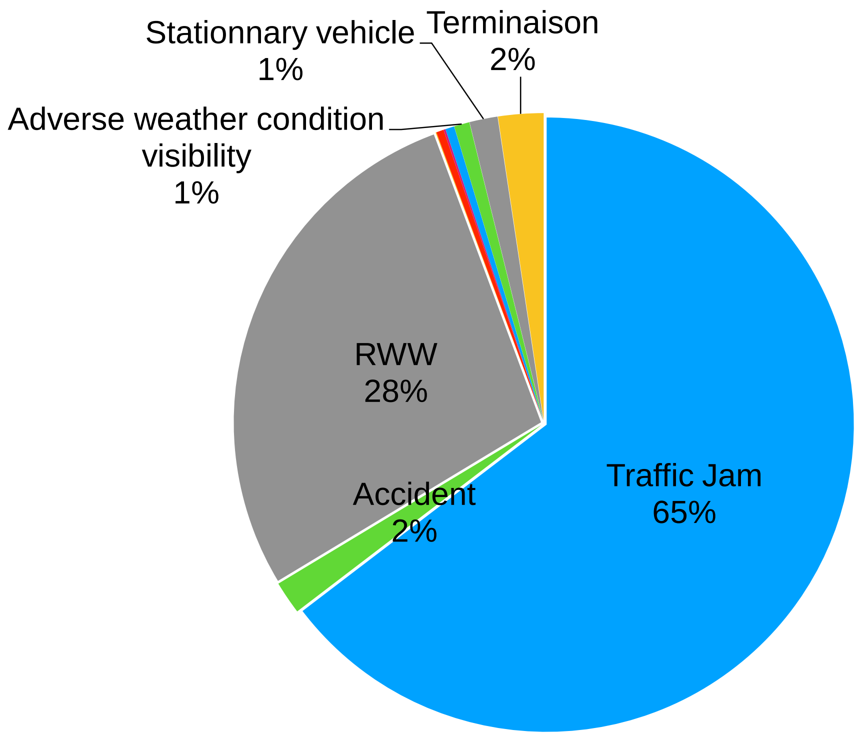
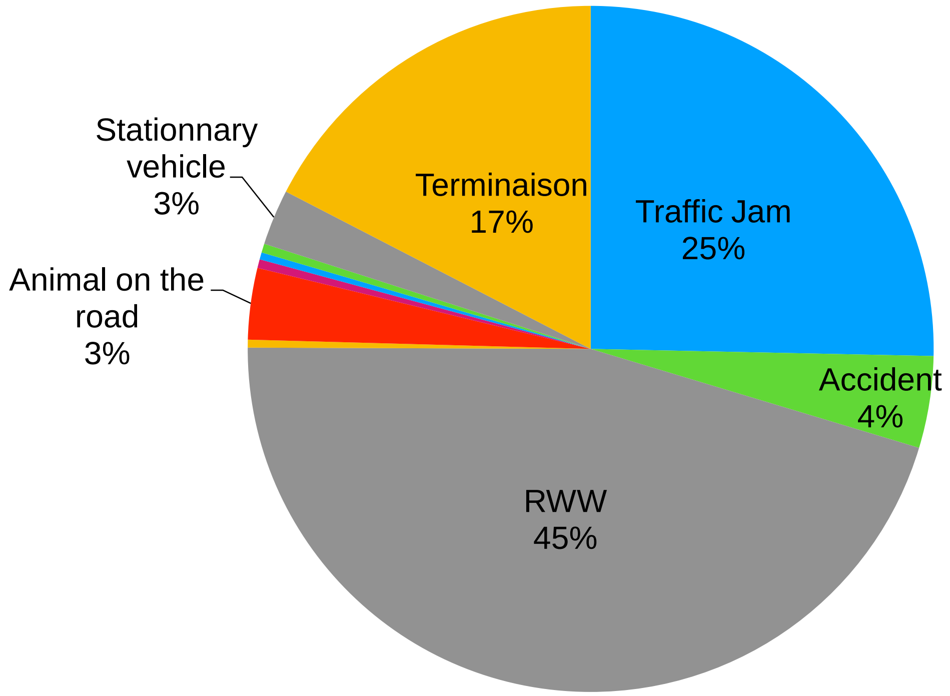
Hasnaa Aniss

Use cases



Received Messages

- Traffic Jam
- RWW
- Animal on the road
- Wrong way driving
- Stationnary vehicle



Events

- Accident
- Obstacle on the road
- Human presence on the road
- Adverse weather condition visibility
- Terminaison

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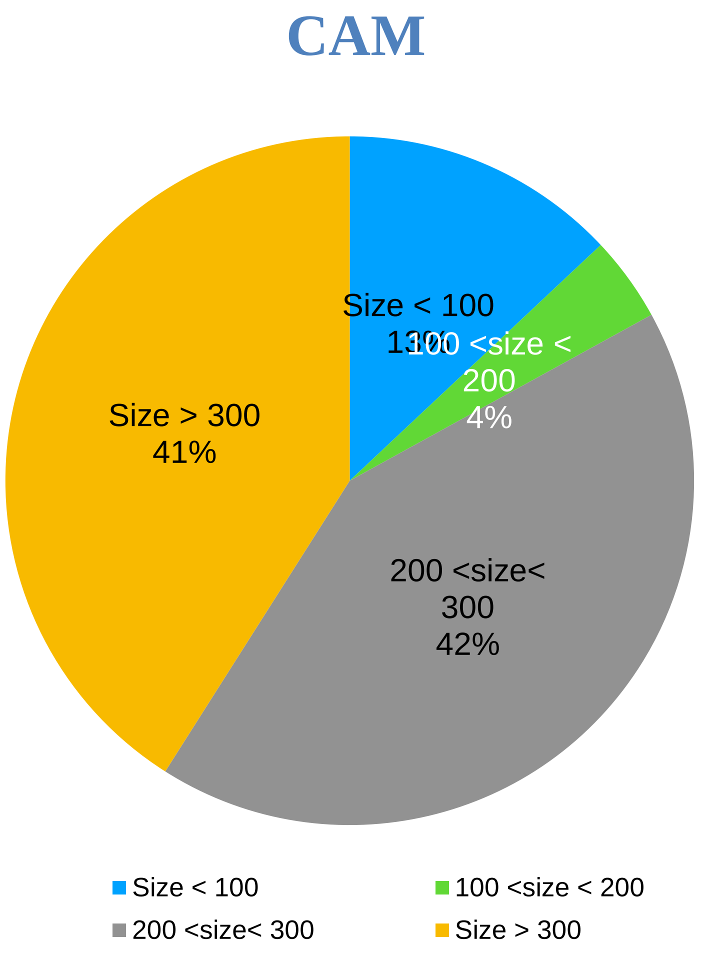
Messages size

Message	Total packet size (MB)	Min (byte)	Max (byte)	Average (byte)	Standard deviation (byte)
CAM	880.61	50	304	264.09	80.63
DENM (sent by smartphones)	1.41	41	307	138.24	102.99
DENM (received) (sent by road operators)	348.10	43	1355	508.16	351.16
IVI	741.31	72	1005	254.39	65.73
MAPEM	366.43	55	979	272.43	132.99
SPATEM	61.07	31	156	70.19	20.48



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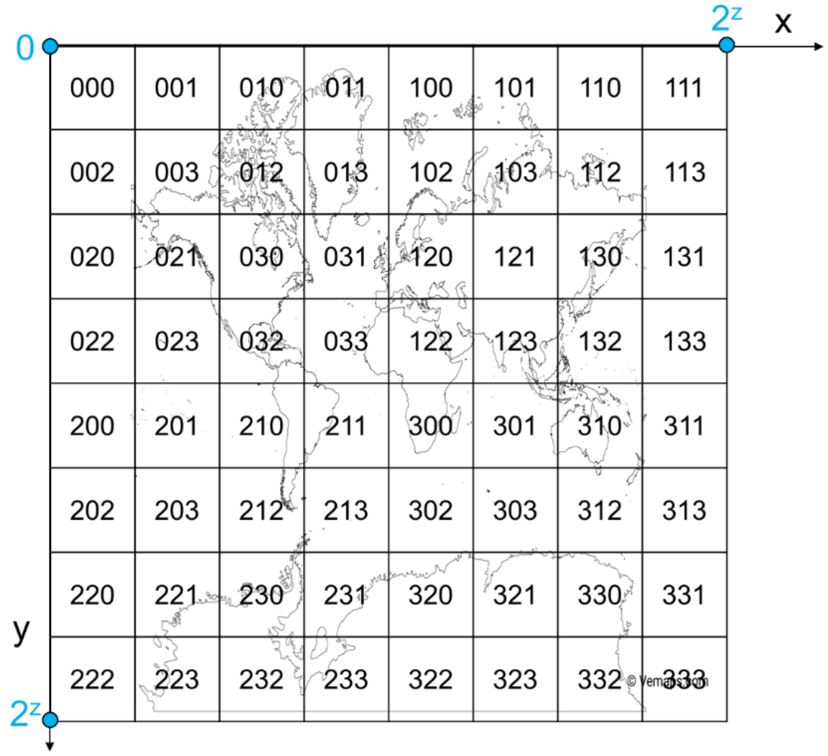
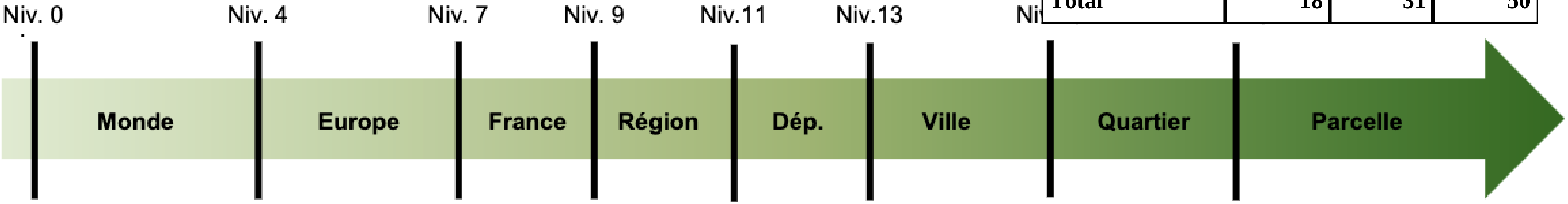
Zoom level of tiles

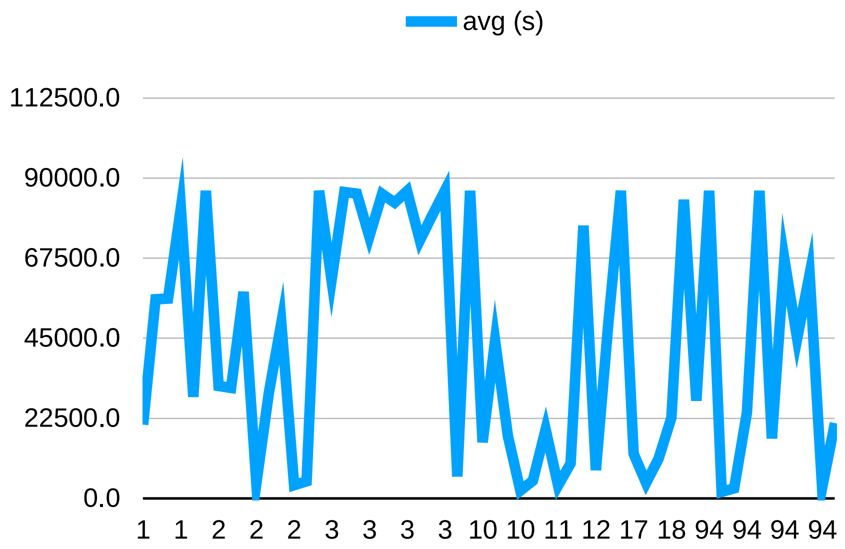


message	zoom_level	count
DENM	14	14363
DENM	15	17955
DENM	16	46903
IVI	14	14363
IVI	15	17955
IVI	16	46903
map	14	14363
map	15	17955
map	16	46903

Speed Group \ Zoom level	% zoom 14	% zoom 15	% zoom 16
0 - 30	0	5	94
30 - 50	0	44	55
50 - 70	9	84	8
70 - 90	72	26	2
90 -110	56	1	43
110 - 130	8	1	91
130 - 150	2	1	97
> 150	0	0	100
Total	**18**	**31**	**50**



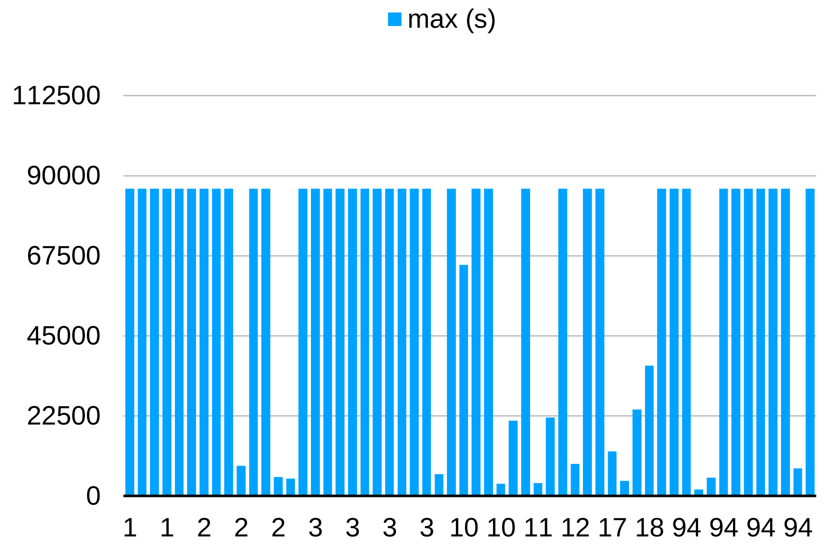
Validity duration



Traffic jam can be sent for at max 24 hours, at mean 13 hours.

The minimum validity duration : 600s (10 min) for RWW.

Obstacle on the road, animal on the road and human presence on the road : between 1H30 and 24H.



for Traffic jam 84% of messages have a validity duration up to 3600s.

among the 685 events of traffic jam, only 13 were canceled and none with a validity duration of 86400.

For accident 6 terminaisons were sent for 123 events. This leads to a validity duration of maximum 7239s. No event of 86400s were canceled.

For stationary vehicle, 124 messages with a validity duration of 24H were received and only 2 were canceled.

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Functional Evaluation

Is the App used only when driving or also as a pedestrian?

<u>Condition for a pedestrian</u> :
- The total travel distance (the distance between the first and the last CAM) is less than or equal to 10 meters
- The maximum speed is less than or equal to 13 km/h
- The average speed is different than 0.

<u>Conditions for a cyclist</u>:
the total travel distance is greater than 10 meters, the maximum speed is less than or equal to 13 km/h
The average speed is different than 0
The number of messages is greater than or equal to 100
The ratio of the duration to the distance is less than or equal to 1.5

	Number of IDs
Pedestrian	3155
Cyclist	81
Vehicle	30991

11964 vehicles among 34227 do not show well-precised vehicle position behaviors. In other words, approximately 35% of the application users do not propose appropriate data.

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Distance of the event when a DENM is received

distance_group	count	percentage
less_than_20m	98	1 %
less_than_1km	11453	68 %
less_than_5km	4687	28 %
less_than_10km	352	2 %
greater_than_10km	151	1 %
Total	16741	100 %

Use case	Distance min (m)	Distance avg (m)	Distance max (m)
Traffic Jam	27,01	3 275,41	24 429,03
Accident	55,89	1 372,94	4 033,10
RWW	0,90	705,56	13 456,47
Obstacle on the road	13,39	1 186,88	3 694,87
Animal on the road	98,91	381,67	664,43
Human on the road	629,32	2 224,15	5 034,12
Wrong way driving	1 438,74	1 438,74	1 438,74
visibility	1 839,63	13 943,58	19 785,51
Stationnary vehicle	10,36	951,55	3 036,23
Terminaison	30,62	857,19	15 072,45

Use case	less_than_20m	less_than_1km	less_than_5km	less_than_10km	greater_than_10km
Traffic Jam	0,0	15,9	66,9	12,0	5,2
Accident	1,2	51,5	46,7	0,6	0,0
RWW	0,6	77,6	21,1	0,6	0,2
Obstacle on the road	1,8	55,0	41,3	1,8	0,0
Animal on the road	0,0	27,3	72,7	0,0	0,0
Human on the road	0,0	56,3	37,5	6,3	0,0
Wrong way driving	0,0	0,0	100,0	0,0	0,0
visibility	0,0	0,0	24,0	24,0	52,0
Stationnary vehicle	0,0	61,4	38,6	0,0	0,0
Stationnary vehicle	1,7	63,7	34,6	0,0	0,0
Terminaison	2,8	75,0	20,9	0,9	0,3
Total	0,6	68,4	28,0	2,1	0,9

Number of displayed messages/number of received messages/events

Type	Number of messages	Displayed event	%
DENM	454781	2822	0,62
IVIM	1829515	6241	0,34

min_ratio_display_to_received	avg_ratio_display_to_received	max_ratio_display_to_received
0,00%	1,61%	100,00%

	Number of display	Number of event	% of display
Traffic Jam	813	2706	30,04
Accident	85	302	28,15
RWW	1540	14690	10,48
Mobile RWW	2	8	25,00
Obstacle on the road	43	248	17,34
Animal on the road	7	53	13,21
Human presence on the road	15	89	16,85
Wrong way driving	0	6	0,00
Adverse weather condition - extreme weather condition	0	1	0,00
Adverse weather condition visibility	5	39	12,82
Stationnary vehicle	22	76	28,95
Stationnary vehicle	281	810	34,69
	2822	19028	14,83

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Distance when a SPATEM/MAPEM is received

SPATEM

Distance to event (m)		
min	avg	max
1,49	194,88	1016,16

distance to event	count	percentage
less_than_20m	186	1 %
less_than_1km	16060	99 %
less_than_5km	6	0 %
Total	16252	

MAPEM

Distance to event (m)		
min	avg	max
1,13	971,85	14395,58

Distance to event	count	percentage
less_than_20m	141	0 %
less_than_1km	63586	57 %
less_than_5km	46620	42 %
less_than_10km	3	0 %
greater_than_10km	14	0 %
null	534	0 %
Total	110898	

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Distance when IVIM is received

	Distance to event (m)		
serviceprovideridentifier	min	avg	max
1003	30,38	532,30	2514,64
1005	64,33	983,70	1894,49
1011	15,35	794,59	2308,48
3303	1,17	861,51	3039,35
3305	32,48	1046,84	2800,17
10000	5,54	3834,89	28686,71
10033	7,66	1062,57	2913,55

	Distance to event				
serviceprovideridentifier	**less_than_20m**	**less_than_1km**	**less_than_5km**	**less_than_10km**	**greater_than_10km**
1003	0,0	89,9	10,1	0,0	0,0
1005	0,0	56,8	42,6	0,0	0,0
1011	0,2	70,2	29,5	0,0	0,0
3303	0,1	64,3	35,6	0,0	0,0
3305	0,0	56,3	43,6	0,0	0,0
10000	0,2	48,4	36,6	3,9	10,9
10033	0,0	50,9	48,9	0,0	0,0
Total général	0,1	60,0	38,5	0,4	1,0

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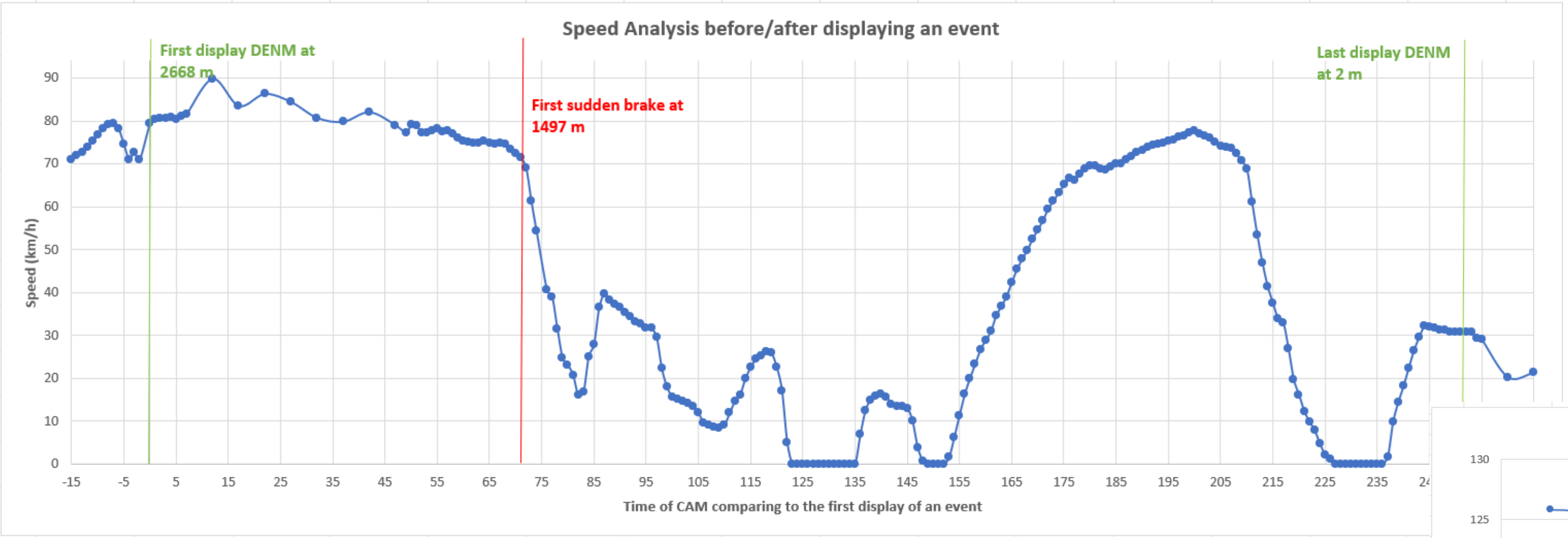
Distance/duration to event when displayed

	Distance to event (m)		
	min	**avg**	**max**
Traffic Jam	22	1603	3774
Accident	24	1291	3774
RWW	3	497	3774
Mobile RWW	270	305	339
Obstacle on the road	62	911	2732
Animal on the road	12	245	344
Human presence on the road	38	1411	3533
Adverse weather condition visibility	241	264	302
Stationnary vehicle	144	252	369
Stationnary vehicle	1	1020	3774
Terminaison	38	1349	3539

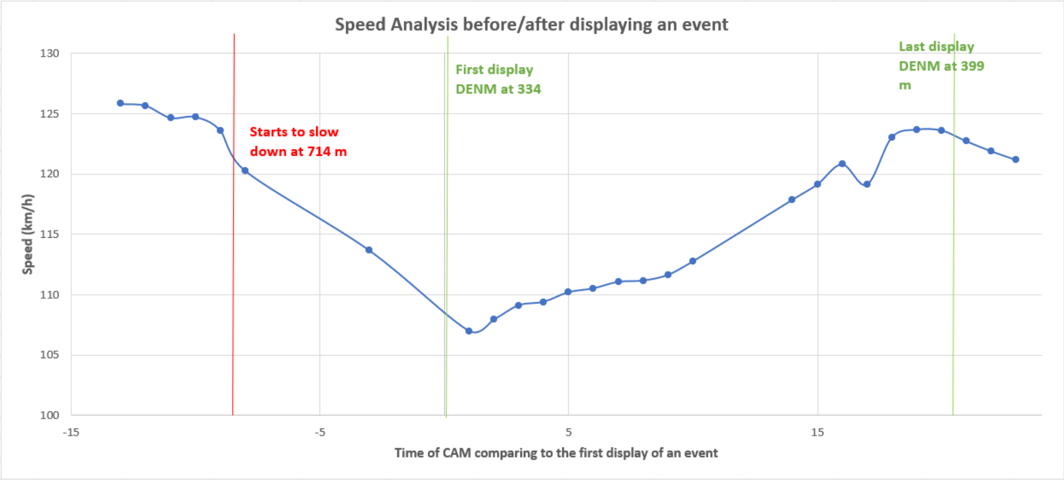
	Display duration (s)		
	avg	min	max
DENM	20,90	0,01	622,23
IVI	27,32	0,96	603,84

Display duration (s)	avg	min	max
Traffic Jam	42,0	0.014	598,20
Accident	18.8	0.899	252.046
RWW	11.0	0.475	256.062
Mobile RWW	10.0	10.007	10.007
Obstacle on the road	9.7	1.001	17.005
Animal on the road	13.3	11.95	18.002
Human presence on the road	17.9	1.163	60.133
Adverse weather condition visibility	10.2	11.001	13.016
Stationnary vehicle	10.4	7.952	16.97
Stationnary vehicle	15.2	0.858	270.418

Variation of speed approaching an event

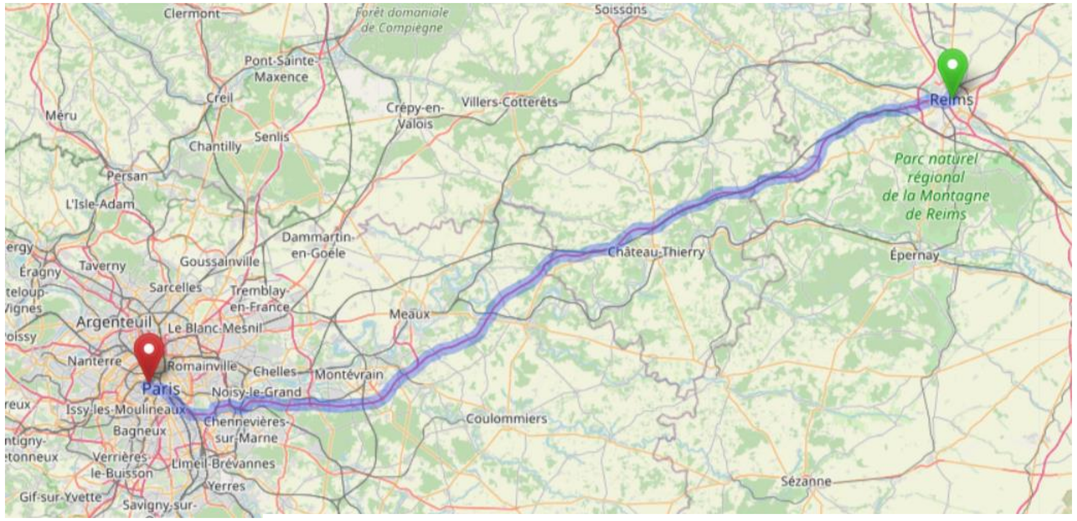


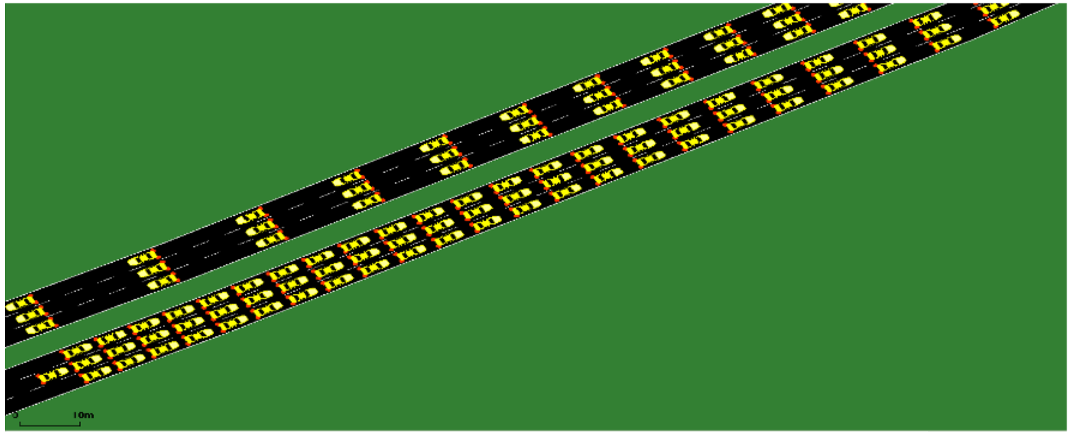
Speed analysis of a vehicle upon reception of a DENM - Traffic Jam

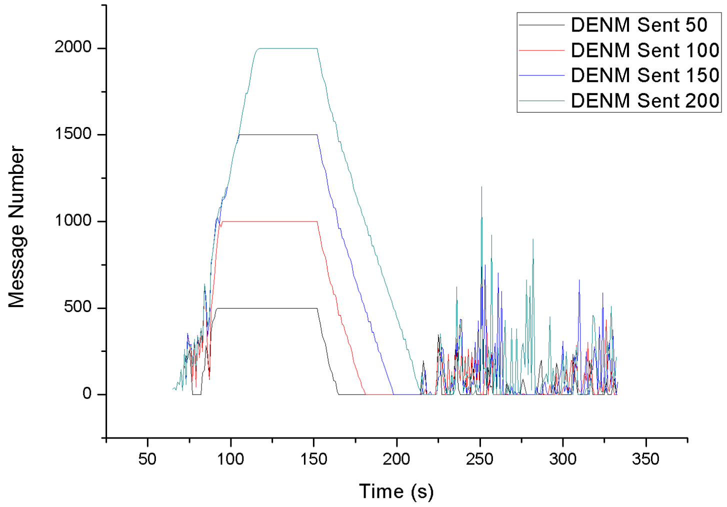


	nb_station_msg	nb_station_suddenbrake_before	nb_station_suddenbrake_during an event	nb_station_suddenbrake_after an event	nb_station_slowdown
	2241	2,0	19,0	4,0	929,0
% of station for an action		0,1	0,8	0,2	41,5

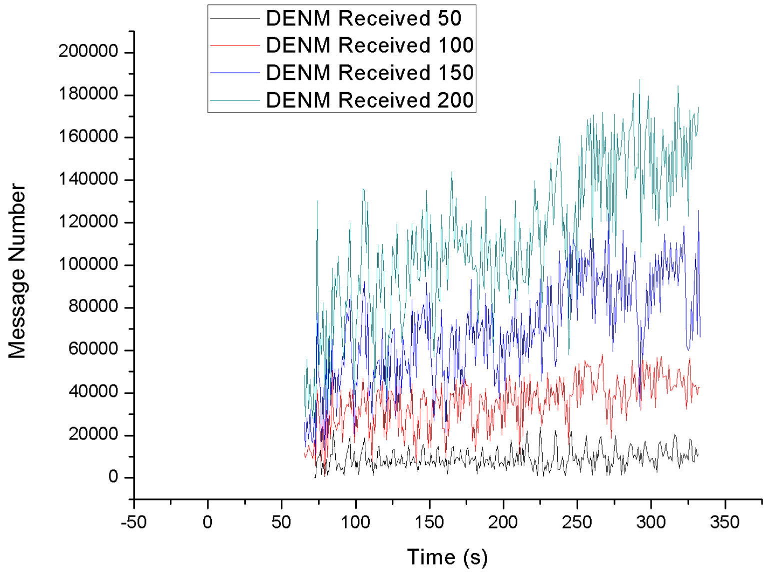
Scaling Up







(a) *DENM sent in the four scenarios*



(b) *DENM received in the four scenarios*

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Conclusion

Conclusion

- More than 8 millions of message.
- 41% of vehicles slow down after displaying a hazardous event.
- Sometimes a too short alert was displayed to well understand the event.
- To well define the right level of messages repetition, messages dissemination areas and validity duration in order to avoid any non useful messages, false information and avoid unnecessary network overloading.
- Better data quality and a real data sobriety with a high service quality.
- scaling up and the influence of security on the trafic network : C-ITS messages are properly disseminated and vehicles receive enough data to ensure efficient functioning of the C-ITS services.

Next steps :

- Act on message reduction for data sobriety
- Provide courses on C-ITS for road operators to well understand C-ITS philosophy

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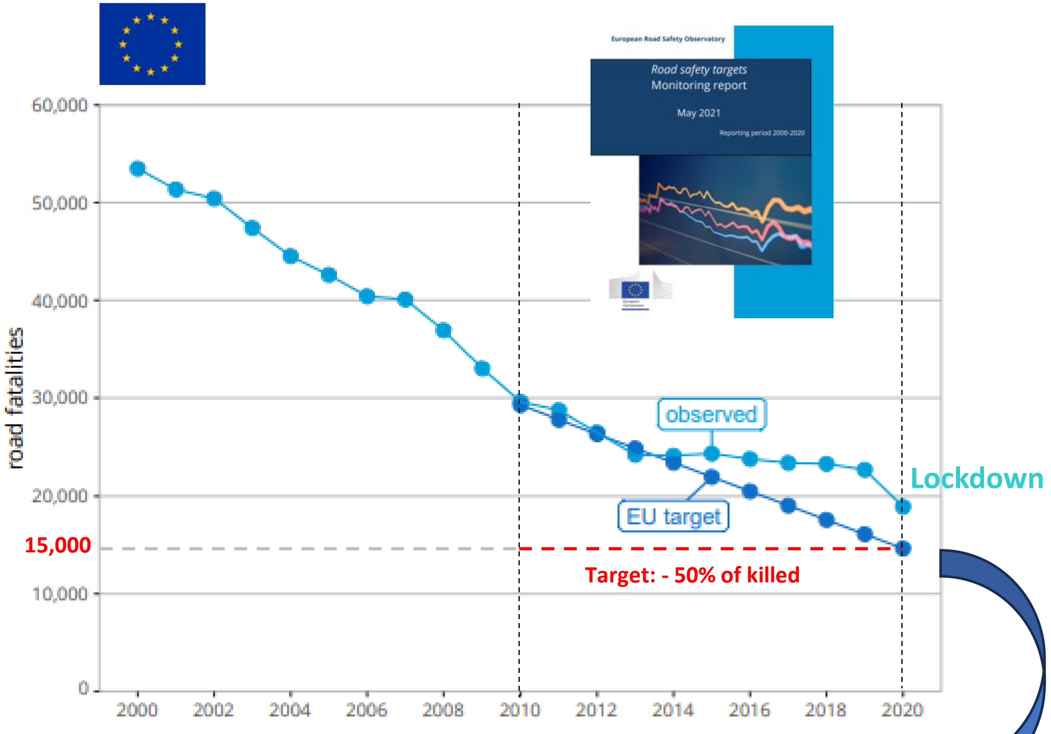
2.3.4 Behaviour, Distraction and Road Safety

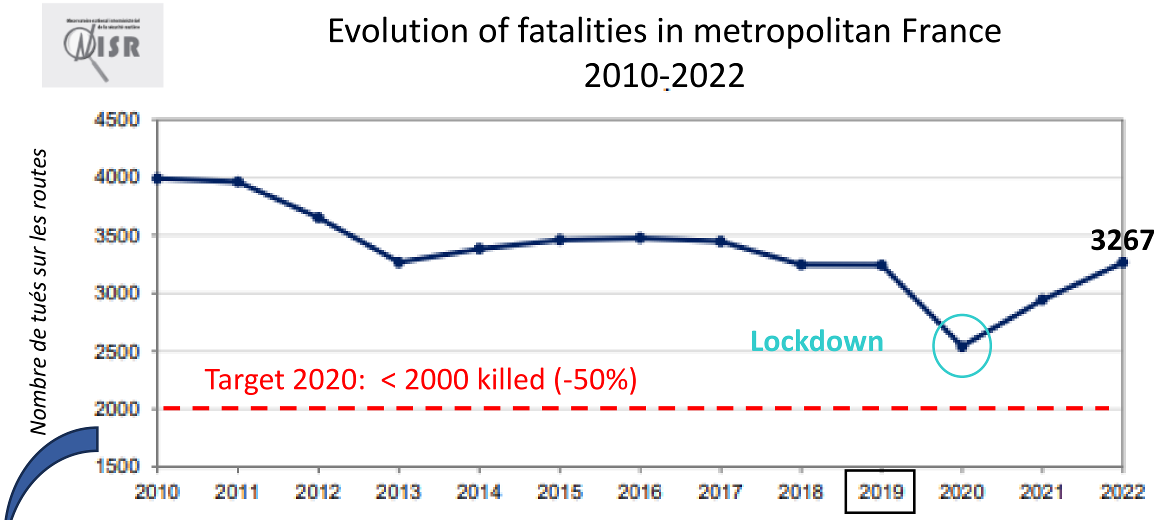
Road safety stakes

Laura Bigi (LAB)
Presented by Sophie Bourdy-Liébart (URCA)

Introduction: European and French context



EU [2010 – 2020]: -36% of fatalities
with lockdown as a biais.



FR [2010 – 2020]: -37.5% of fatalities
FR [2010 – 2022] : -18% of fatalities
with lockdown as a biais.

2019 = reference year of the [2020-2030] decade with the same target : -50% of fatalities (EU, FR)

FR [2019 – 2022]: + 0.7% of fatalities…

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Macroscopic evaluation

Frequency and Severity of injured accidents

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Accidentology stakes of InDiD use cases: principle

- For each use case of road safety interest:
  - Analysis of injured accidents* recorded before the rolling out of connected services
    - Frequency (number of accidents)
    - Severity (number of severely injured and fatalities)

*Accidents with at least one injured person or one fatality

French C-ITS Deployment Coordination committee

C-ITS French use cases catalog functional descriptions

Deliverable 2.2

Activity 2: Studies | Sub Activity 2.2 > Use cases

Version 5.70, Approved

Publication Date: 09/10/2023

The contents of this publication are the sole responsibility of the SCOOP@F project consortium, C-ROADS France project consortium, InterCor project consortium (French beneficiaries only) and InDiD project consortium and do not necessarily reflect the opinion of the European Union.

- 25 evaluated use cases:
  - Probe vehicle data: A4, A5
  - Road works: B1a, B4, B5
  - Signalization : C2, C4, C8
  - Hazardous events: D11, D12
  - Traffic information: E1, E7
  - Intersection : G1a, G1b, G2, G5, G6, G7
  - Vulnerable road users (pedestrian) : I4, I5
  - Level crossing: K1, K4, K6
  - Law enforcement: L2, L5b

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Methodology

- Use of 4 accident databases (DB):

- VOIESUR : in-depth DB, representative of the accidentology in France (2011)
- BAAC : French national DB (2018-2021)
- SNCF DB (2011 and 2018-2021)
- OCSTI DB / Gendarmerie (2018-2020)

- Continuity with SCOOP project: analysis of the inter classification (frequency, severity) of InDiD use cases.
- BAAC: to check the evolution of the inter classification over recent years (when possible).
- SNCF DB: to analyse « K » use cases.
- OCSTI DB: to anlyse « L » use cases.

NB: each accident database has certain limits for addressing the different use cases, leading to gaps and/or grouping.

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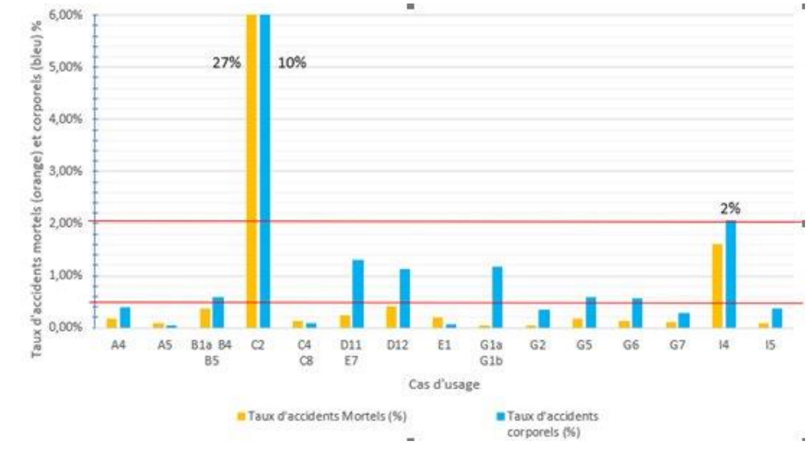
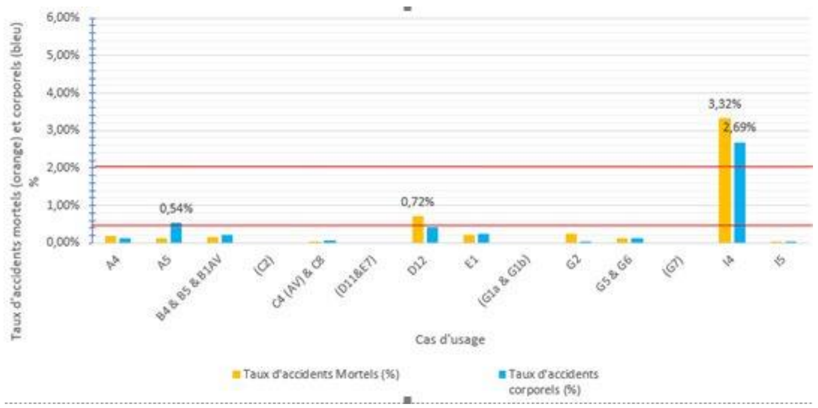
Results - frequency: use cases A, B, C, D, E, G, I

VOIESUR (2011) « All road users »



BAAC (2018-2021) « All road users »



All road users

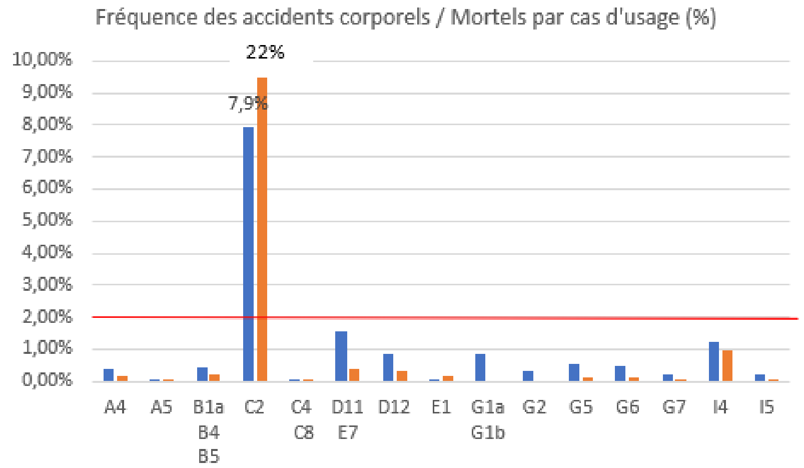
-C2 (overspeed) and I4 (pedestrian out of crossing): higher and important accident frequency (≥ 2%).
-Then, D11&E7 (traffic jam), D12 (emergency vehicle), G1a&1b (intersection with traffic lights), road works (B) with intermediate stakes (0,5-2%)

More recently: I4 has a tendency of increase, then D12 and A5 (wrong-way).
NB: C2 is non-applicable but overspeed is still an issue when we look at accidentology studies.

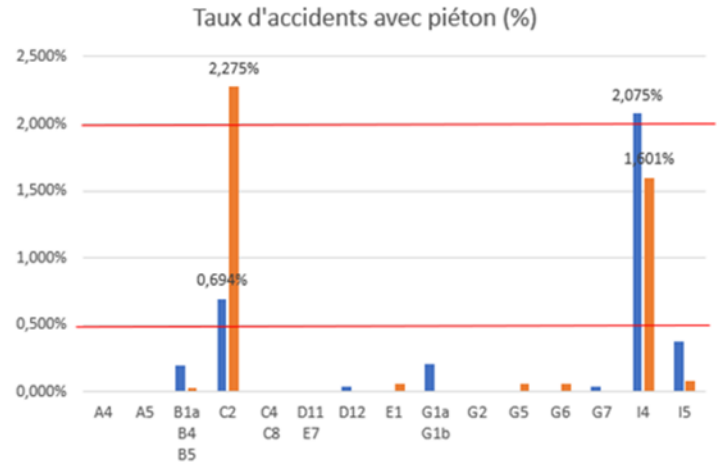
PC / Pedestrian

C2 is mainly an issue linked to PC with and in a least extend to pedestrian.
I4, is of course linked to pedestrian victims.
More recently, BAAC shows a tendency of accident increase in I4 and A5.

VOIESUR (2011) « PC»



VOIESUR (2011) « pedestrian»



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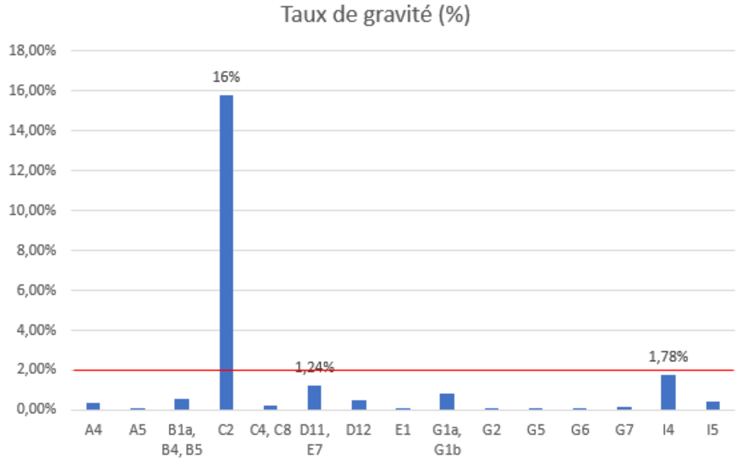
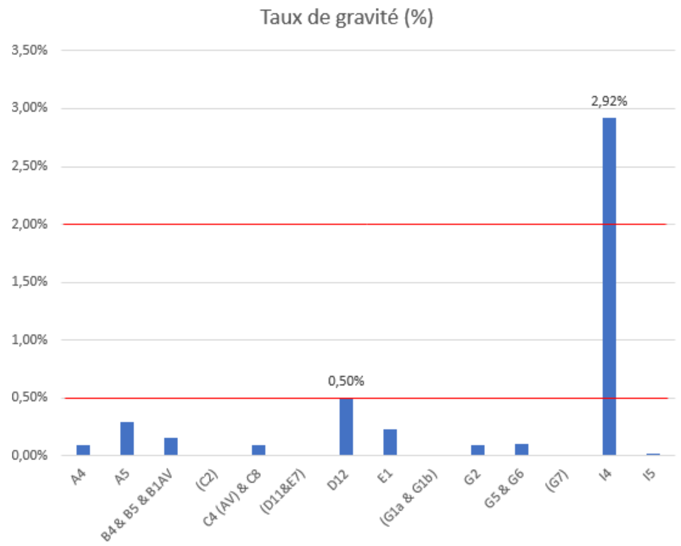
Results – severity: use cases A, B, C, D, E, G, I

VOIESUR (2011) « All road users »



BAAC (2018-2021) « All road users »



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All road users

-C2 (overspeed): higher and important accident severity (≥ 2%).
-Then, I4 (pedestrian out of crossing), D11&E7 (traffic jam), G1a&1b (intersection with traffic lights), road works (B) with intermediate stakes (0,5-2%).

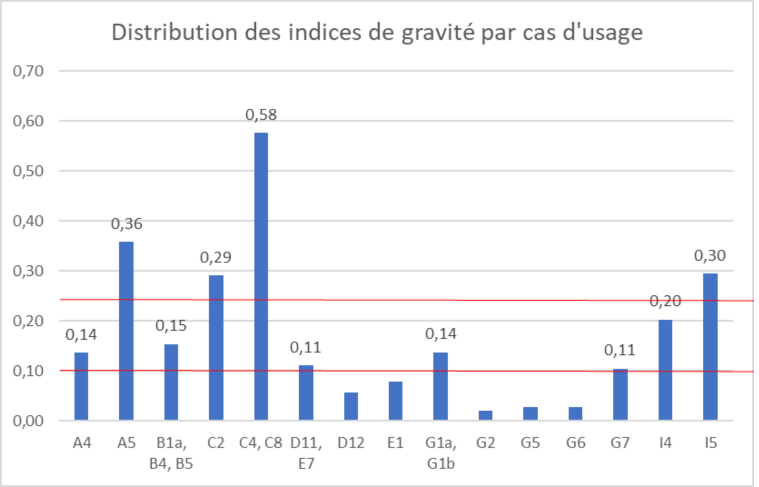
More recently: I4 has a tendency of increase with higher severity, then D12 and E1 (snow), A5 (wrong-way).
NB: C2 is non-applicable but overspeed is still an issue when we look at accidentology studies.

Intrinsic severity index of use case

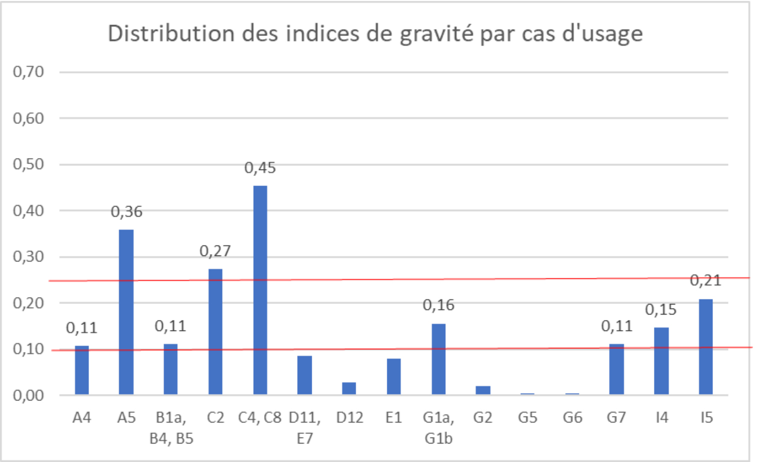
Totally different figure compared to severity ratio.

-Accidents at toll (C4&C8), in wrong way situation (A5), at bus station (I5) are more severe when occuring but less frequent.
-Zoom on PC accidents: A5, C2, B keep the same level, meaning that these use cases are more sensitive to PC issues.

VOIESUR (2011) « All road users » - Severity index (intrinsic)



VOIESUR (2011) « PC» - Severity index (intrinsic)



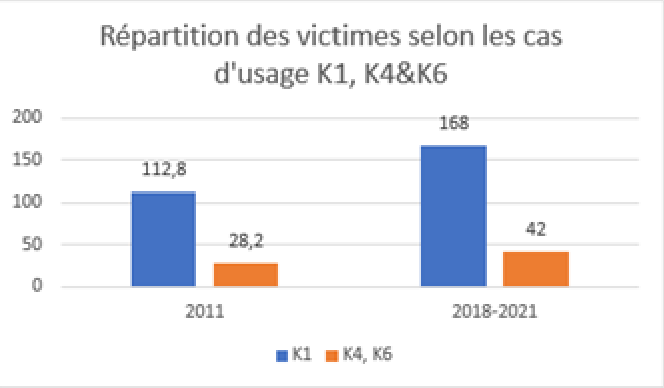
Results – frequency & severity: K, L

- Use cases « K » (SNCF)

➢ 53% of accidents occur without casualties

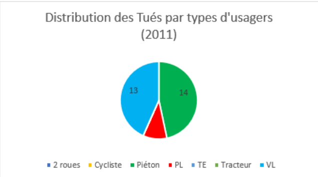
➢ As for 47% remaining:

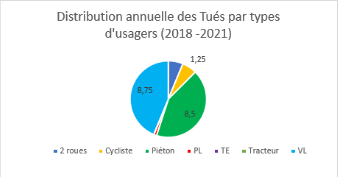
➢ **Frequency/Severity:**
80% of accidents = « K1 »
Casualties: injured / fatalities

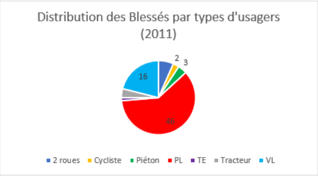


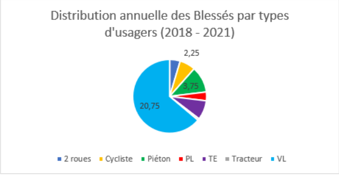
➢ The train adverses:
PC occupants & Pedestrian

➢ VRU casualties:
increase of cyclists over time

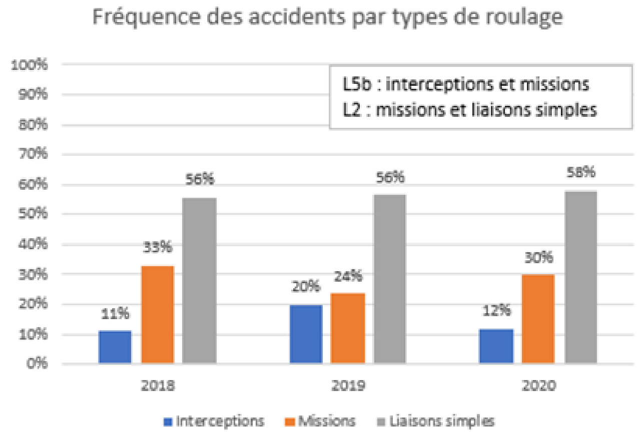








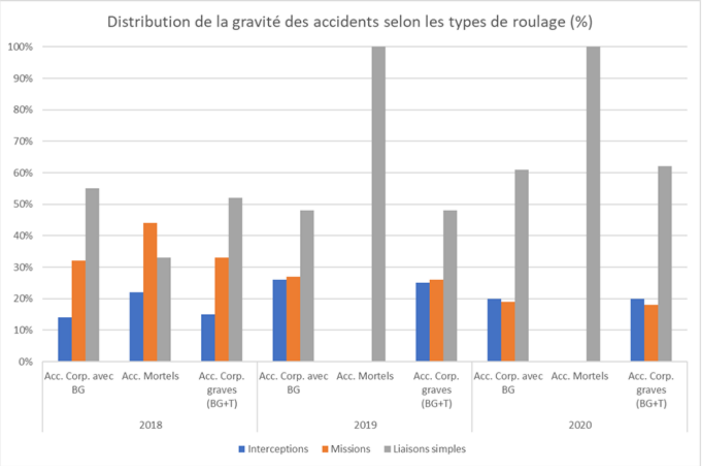
- Use cases « L » (OCSTI)



➢ **Higher frequency /** « Simple commutes »
=> 60% of injured accidents.

➢ **Higher severity /** « Simple commutes »
=> 48-61% of accidents with severely injured persons.

=> until 100% of accidents with fatalities.



« L2 » has higher accidentology stakes

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Results – frequency & severity: K, L

- Use cases « K » (SNCF)

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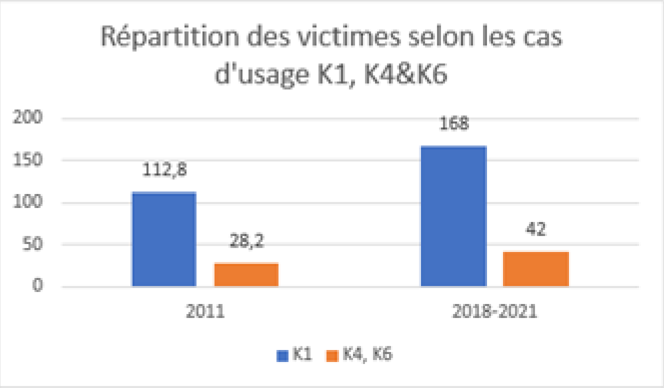
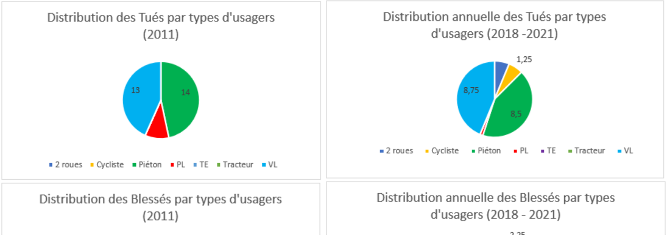
➢ As for 47% remaining:

➢ **Frequency/Severity:**
80% of accidents = « K1 »
Casualties: injured / fatalities



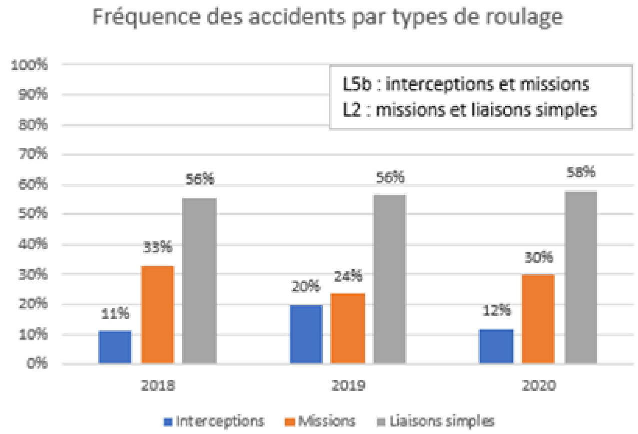
➢ The train adverses:
PC occupants & Pedestrian



➢ VRU casualties:
increase of cyclists over time

	2011		2018-2021 yearly average	
	Pedestrian/PC	Cyclist/PC	Pedestrian/PC	Cyclist/PC
Fatalities	107%	**0%**	97%	**14%**
Injured	24%	**2,80%**	18%	**11%**

- Use cases « L » (OCSTI)



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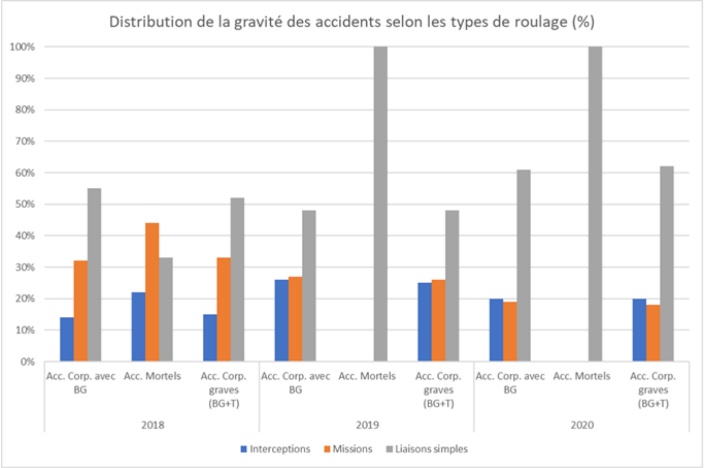

« L2 » has higher accidentology stakes

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Microscopic evaluation

Accidentology stakes of use cases:
Human functional failures of drivers
Location of accidents related to use cases « All »

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Methodology

- Human Functional Failure (HFF) of drivers and Use cases

➢ VOIESUR (2011)

➢ Use of methodology developped by Pierre Van Elslande and co (2001)

  ➢ Grid of HFF for accident coding

➢ All use cases except « K » and « L »

- Accident location related to uses cases « All »

➢ VOIESUR (2011) and BAAC (2018-2021)

  ➢ Infrastructure types: urban / motorway / rural

➢ Use cases « All », deployed at all locations (urban, motorway, rural)

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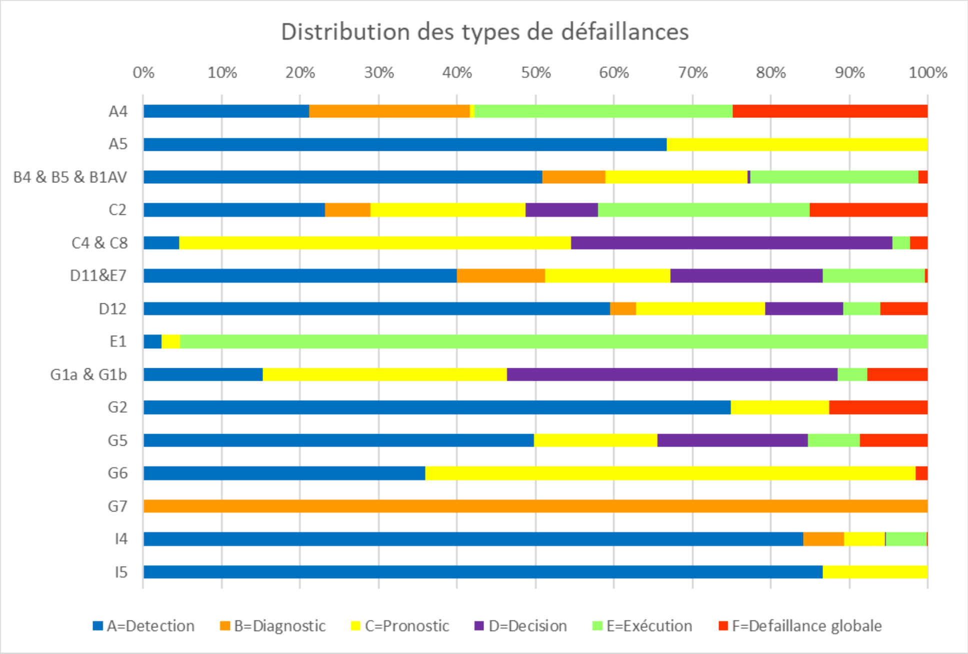
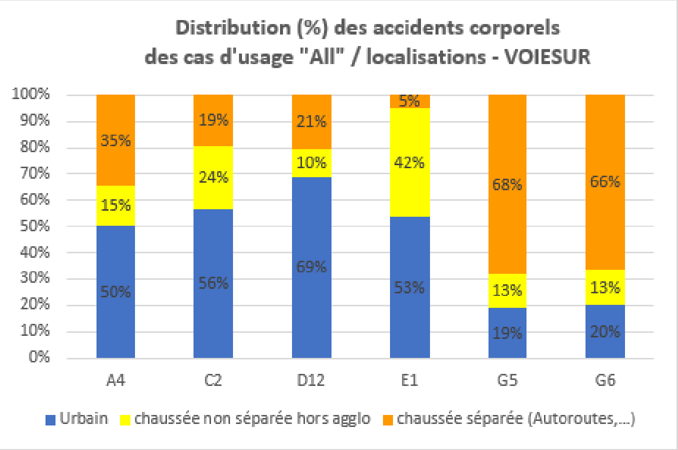
Results

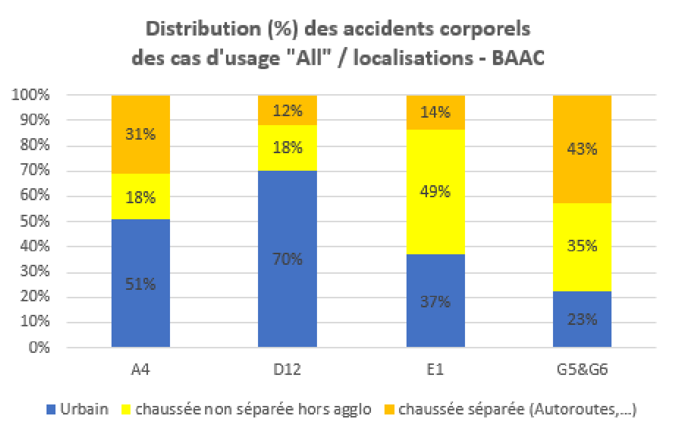
Distribution of Human functional failure of drivers



- **Detection failure** is the major one, especially for I4 and I5 (pedestrian).
- **Prognosis failure** is an issue for almost all UC and especially for C4&C8 (Toll) and G6 (insertion).

Distribution of accidents / location: urban, … Use cases « All location »





- A4 and D12 (urban), E1 (rural): same proportions between the locations, meaning stability over time, with some possible fluctuations for D12, E1 (events dependent).

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Conclusion

- Ex ante evaluation of road safety-related InDiD uses cases: good way to range the use cases, from existing accidentology, to give a tendency before rolling out of connected services.
  - Tendency in terms of injured accident frequency (number of accidents)
  - Tendency in terms of injured accident severity (number of casualties)
  - Tendency in terms of human functional failure causing the accidents
  - Tendency in terms of accident location for large-deployed use cases (« All »)

- Nevertheless, this study should bring some help for decision making: to orientate the choices, the priorities in terms of road safety improvement thanks to C-ITS services.

- Connectivity should participate to avoid accidents and/or to reduce the severity when they occur, considering:
  - Relevant information for safer driving (speed, wrong way, …)
  - Anticipation possibility of hazardous events (traffic jam/end of queue, emergency vehicle, …)
  - Vulnerable road users (i.e. pedestrian) identification

  which should act on the driver behaviour and on automated vehicles later on (from a level of automation designed for direct interaction with C-ITS communication).

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Thank you for your Attention

On behalf of Laura Bigi: 
Grateful thanks to Sophie!

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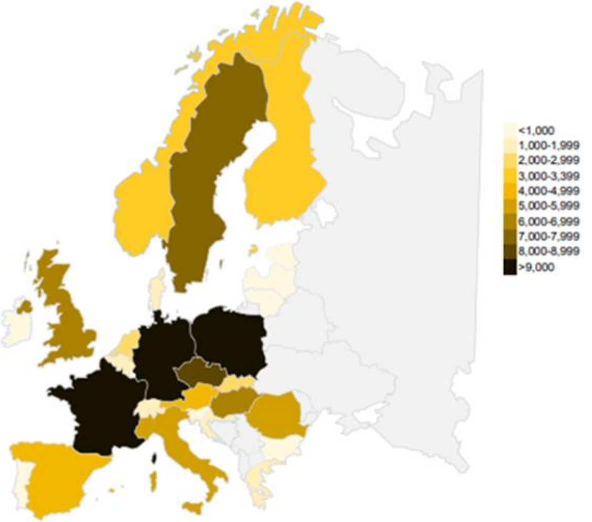
2.3.4 Behaviour, Distraction and Road Safety

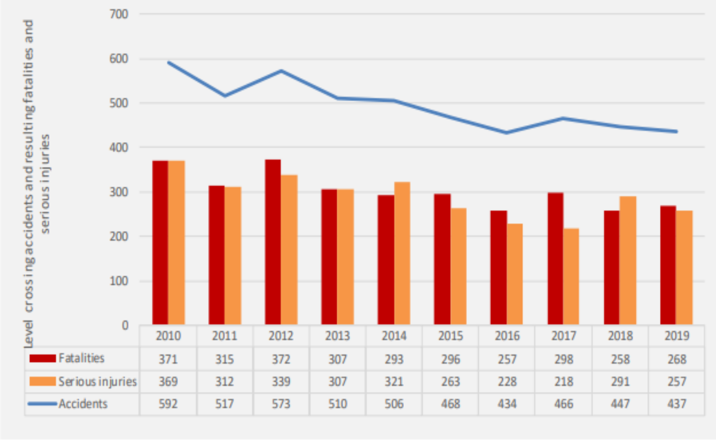
Cognitive and behavioral approach to C-ITS at level crossings

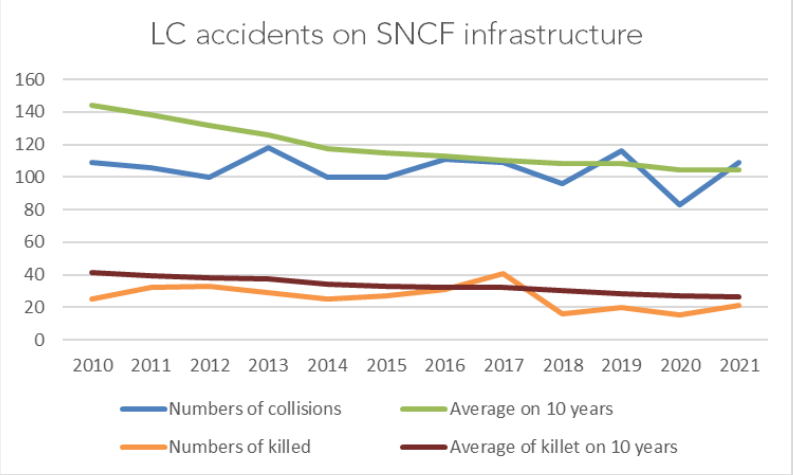
Virginie Taillandier (SNCF)

Co-financed by the Connecting Europe Facility of the European Union

Level crossings in Europe and France







- In Europe, France, Germany and Poland have the highest number of level crossings (15,400 in France).
- Level-crossing collisions account for less than 1% of all road collisions.

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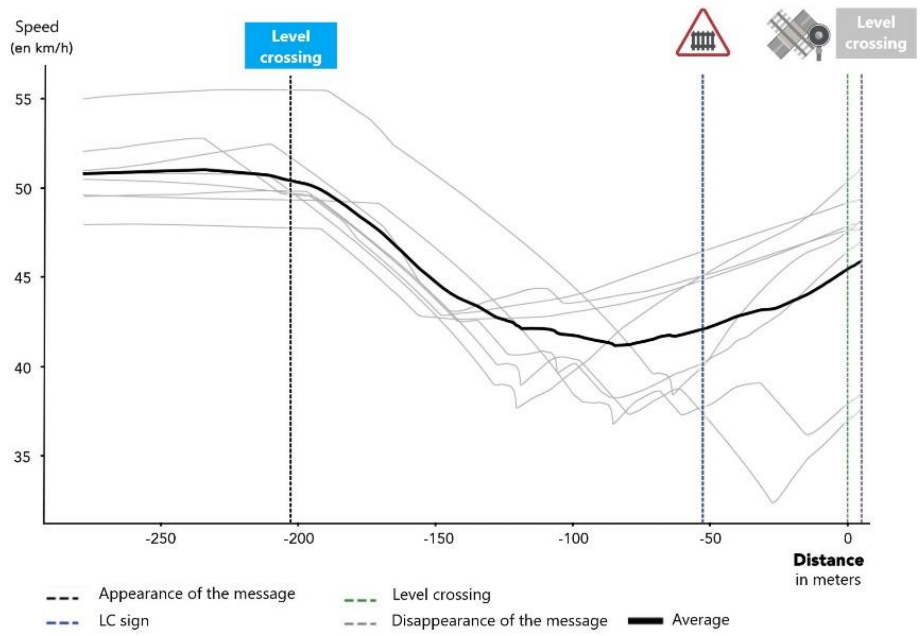
Simulator

Co-financed by the Connecting Europe Facility of the European Union

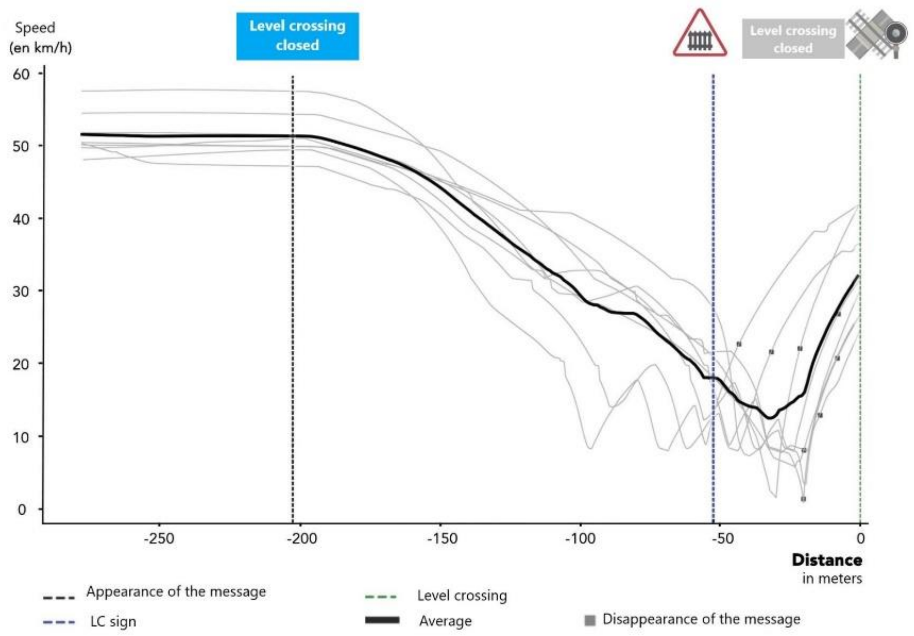
- 31 subjects (16 women and 15 men) aged 18 to 65 years
- 40 minutes on driving simulator:
  - 1st run: duration between 7 and 10 minutes - 2 reference situations with a level crossing (open and closed)
  - 2nd run with C-ITS messages: duration between 20 and 30 minutes - 12 C-ITS situations including 5 ITS LC situations (open, closed, out of order, no message and work)
- 1 hour interview with a mental effort evaluation scale

Results: open/closed LC situation

Message Level crossing at xxx meters



Message Level crossing closed at xxx meters



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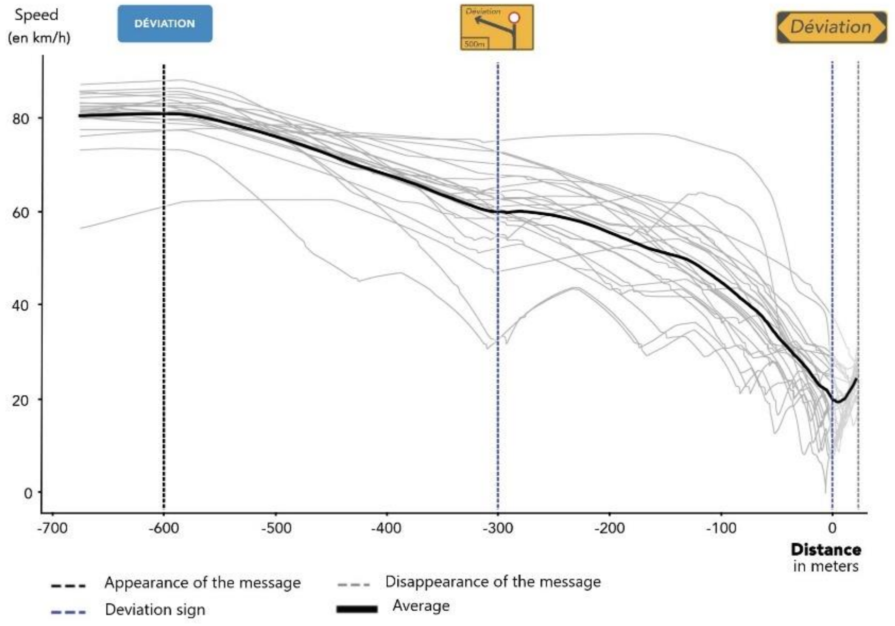
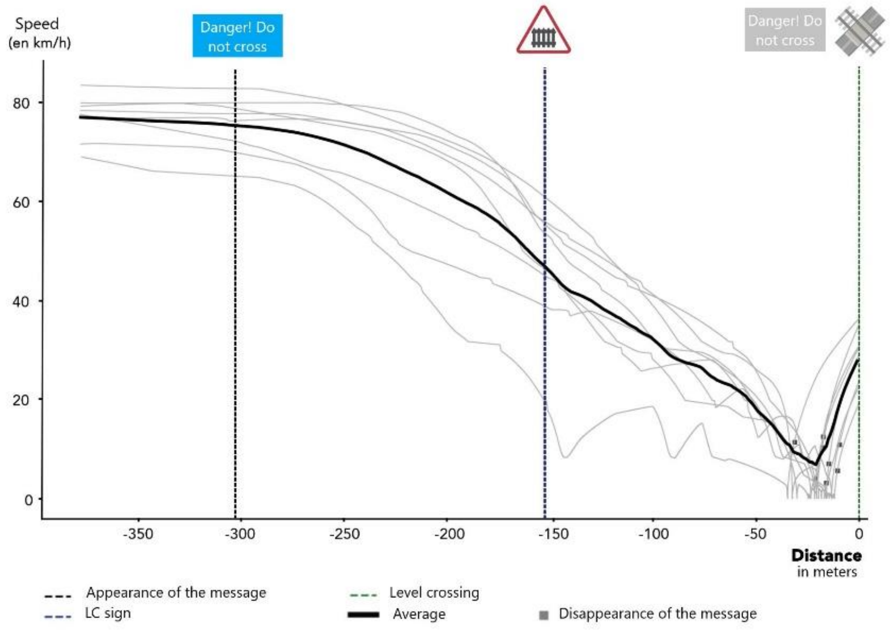
Results: work/disturbance situation

Message Road closed at xxx meters



Message Danger do not cross



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Conclusion

- ✓ The results complement those observed in the ARPAN study conducted in 2019
- ✓ Messages undeniably encourage changes in driver behavior when approaching level crossings when the messages are concise, clear and consistent with the situation experienced by drivers.
- ✓ In any case, this new study provides guidance for railway managers, vehicle manufacturers or equipment suppliers in their choice of how to take account of level-crossing use cases in C-ITS equipment.

- ✓ The form of certain messages remains to be discussed.
- ✓ Prospects for further reflection
- ✓ Importance of road training to support C-ITS technology
- ✓ Possibility of configuring message activation by the driver

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More information

- More information on the International Railway Crossing Prevention Day at https://ilcad.org/

- 16th edition on June 6, 2024 in Buenos Aires

- Study available on HAL https://hal.archives-ouvertes.fr/hal-03526620

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2.3.4 Behaviour, Distraction and Road Safety

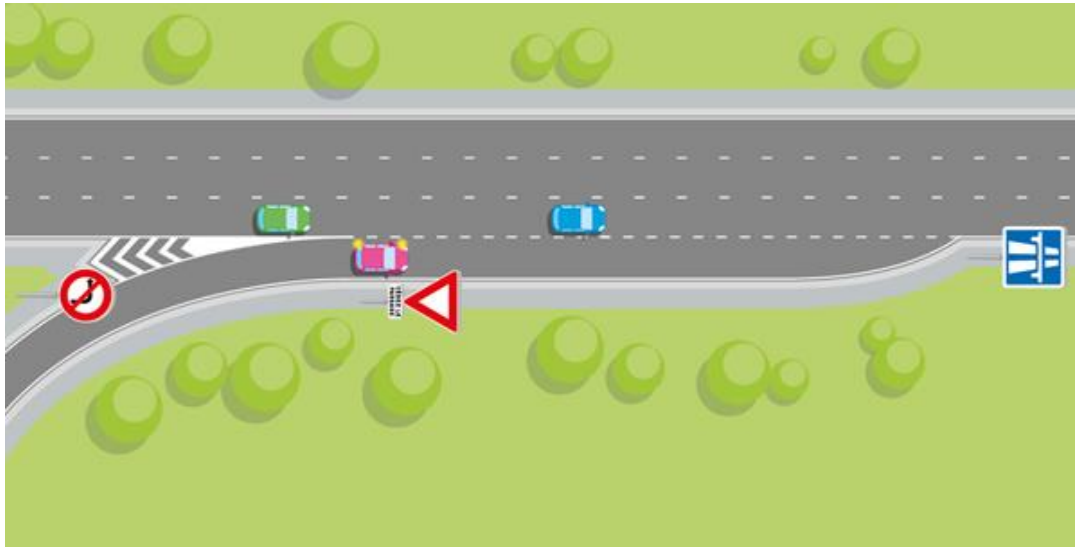
Impact of connected infrastructure on automated driving at lane merge situation

Pierre Merdrignac (VEDECOM)

Co-financed by the Connecting Europe Facility of the European Union

Introduction

Conflicts situations with interactions between users



- Challenges for automated driving
  - Road users detection
  - Intention prediction and detection
  - Decision making

- Limitations
  - Inability to engage on-ramp merging manoeuvre
  - Sudden braking due to late decision by vehicles on the main road

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Problem formulation

- Alert of collision risks with Infrastructure-to-Vehicle (I2V)

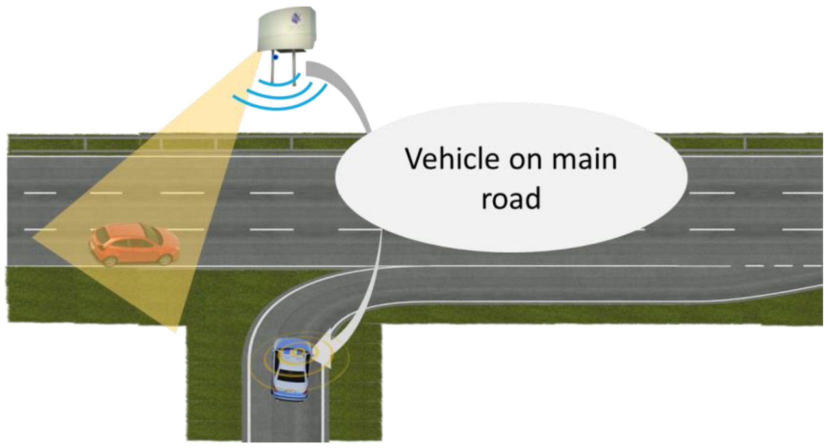
  Case 1: In-vehicle signage at a merge for vehicles on the entry slip road

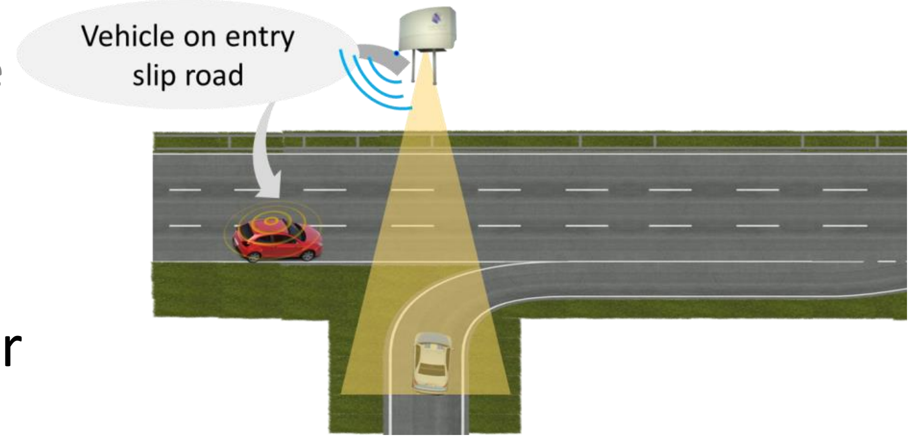
  Information send by connected infrastructure to vehicles driving on the insertion lane

  Case 2: In-vehicle signage at a merge for vehicles on the main road

  Information send by connected infrastructure to vehicles on the main road

- What are the safety benefits of such services for automated vehicles?





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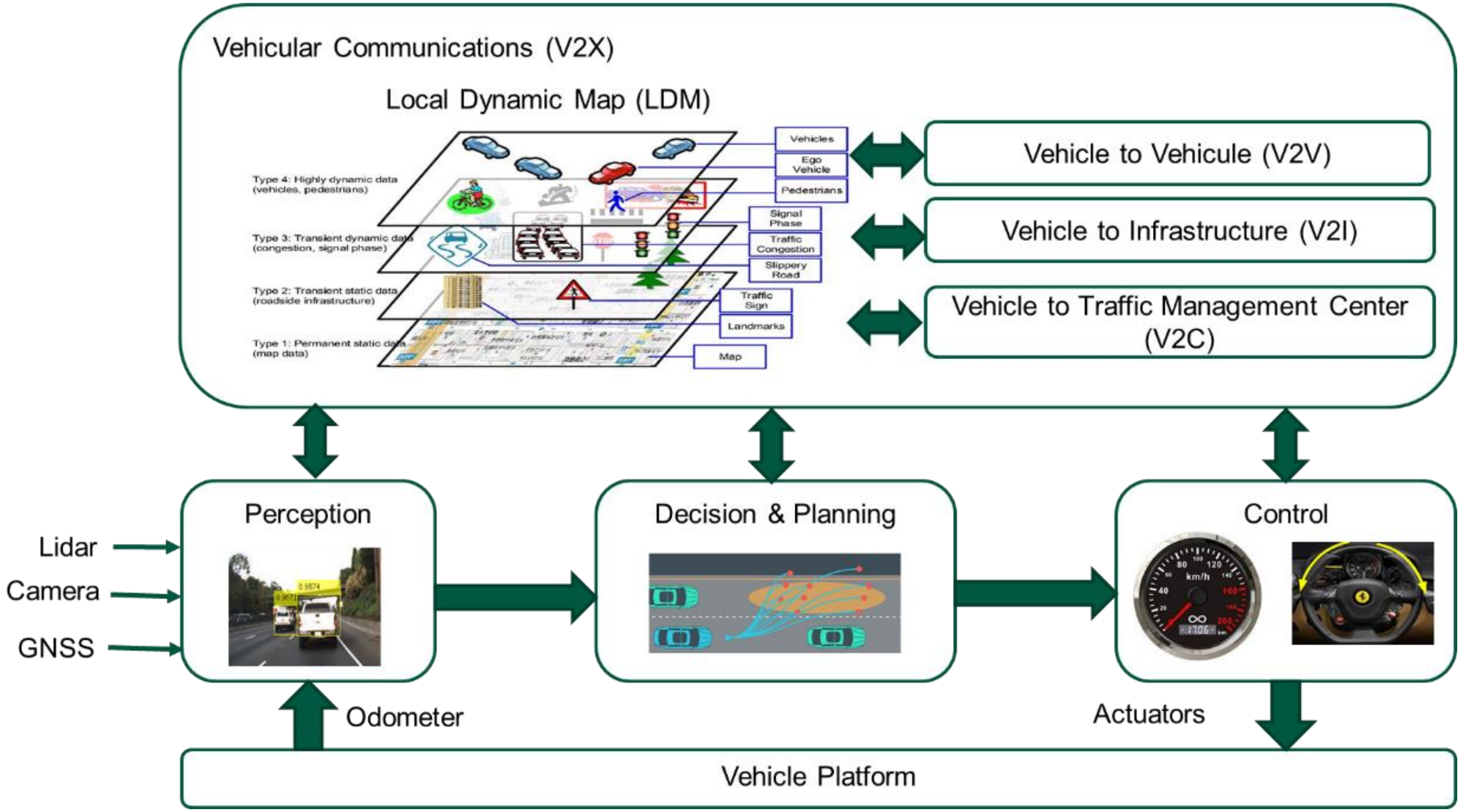
Functional components of a connected and automated vehicle



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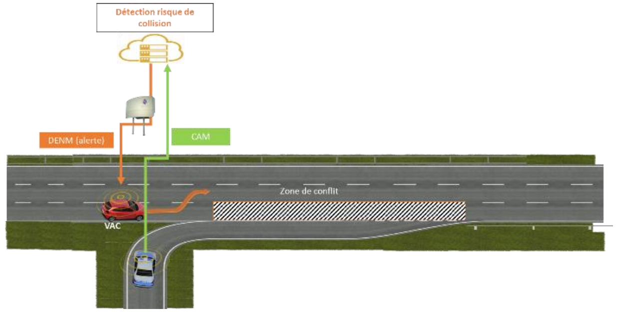
Evaluation protocol

- Hypothesis
  - I2V Communication has the ability to extend the range of the sensors embedded in the AV. (Augmented perception)
  - With I2V, a vehicle on the main road can anticipate the insertion of another vehicle in front of it.
- Expected behavior
  - Maneuver anticipation, i.e. time-to-collision (TTC) is greater compared to AV
  - Speed control to minimized strong deceleration and conflict situations, e.g. by lane change
  - Respect of the inter-vehicle gap



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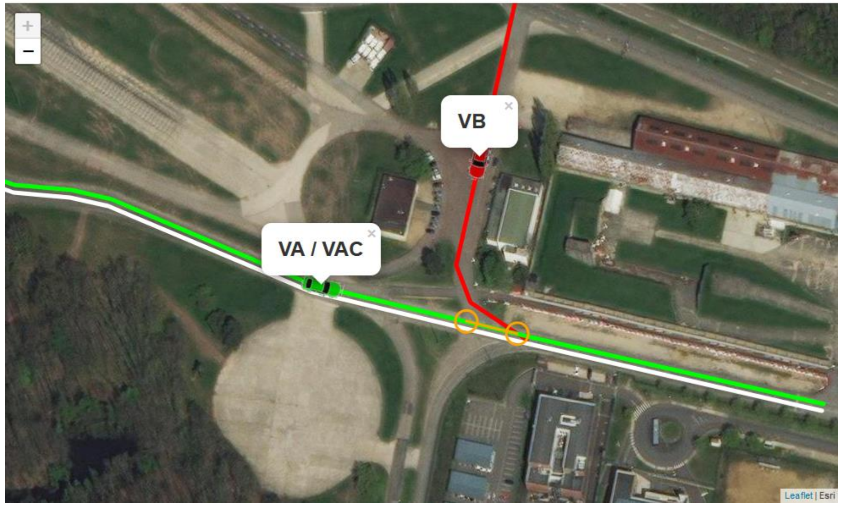
Scenarios and Metrics

- Different vehicle technologies
  - Manually driven vehicle
  - Automated vehicle (AV)
    - No connectivity with infrastructure
  - Connected and automated vehicle (CAV)
    - Adapts its behavior using I2V Communication



- Evaluation metrics
  - Road safety indicators: Time-to-collision, Maximum deceleration, Inter-vehicle gap
  - Vehicle response indicators: Time to reaction

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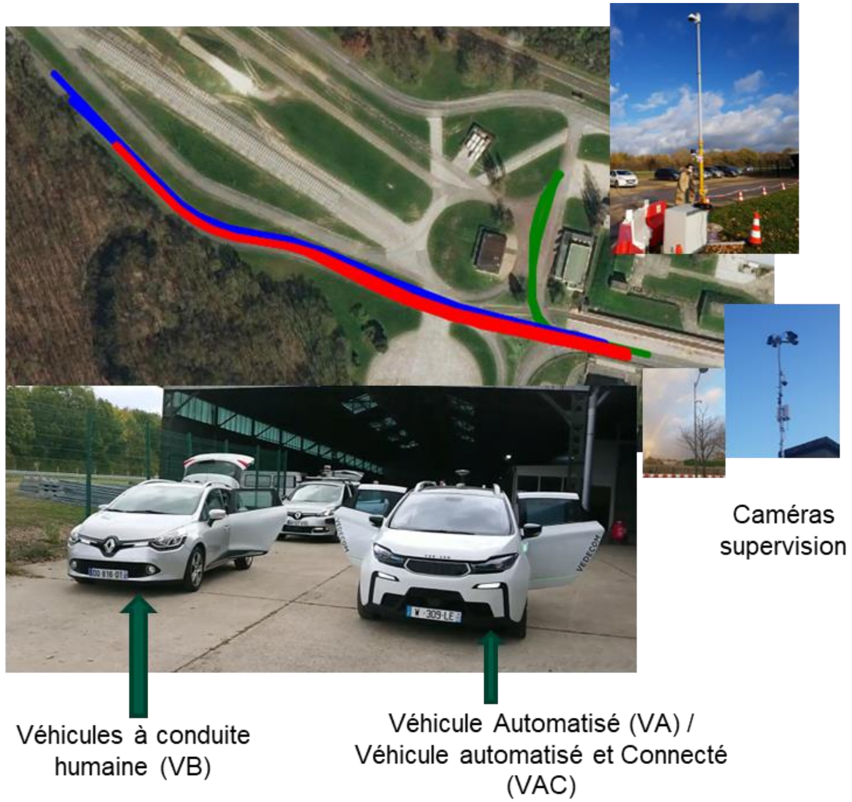
Experimentation setup

- 2 Vehicles
  - 1 Connected and automated vehicle
    - Equiped with sensors and V2X communication
  - 1 Manually driven vehicle
- Infrastructure
  - Lidars and Cameras monitoring the merging area
  - ITS G5 Roadside Units
  - Closed test track (Versailles Satory)
- Data collection
  - Véhicules instrumentation (position, speed, Tx/Rx messages)



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Results

- Scenario
  - CAV approaching lane merging
  - Detection from roadside infrastructure
  - RSU sends an alert
  - CAV triggers lane change maneuver

- Trials
  - Baseline scenario repeated 3 times (no I2V communication)
  - Target scenario repeated 13 times

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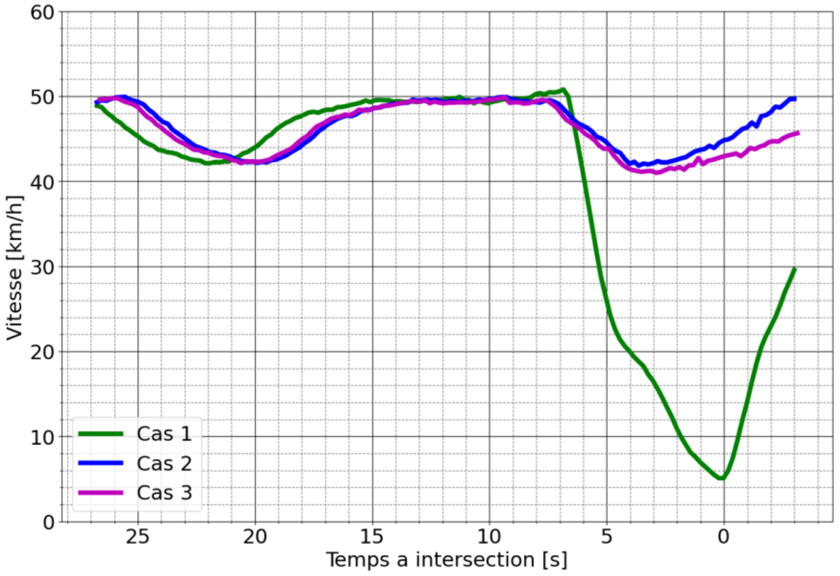
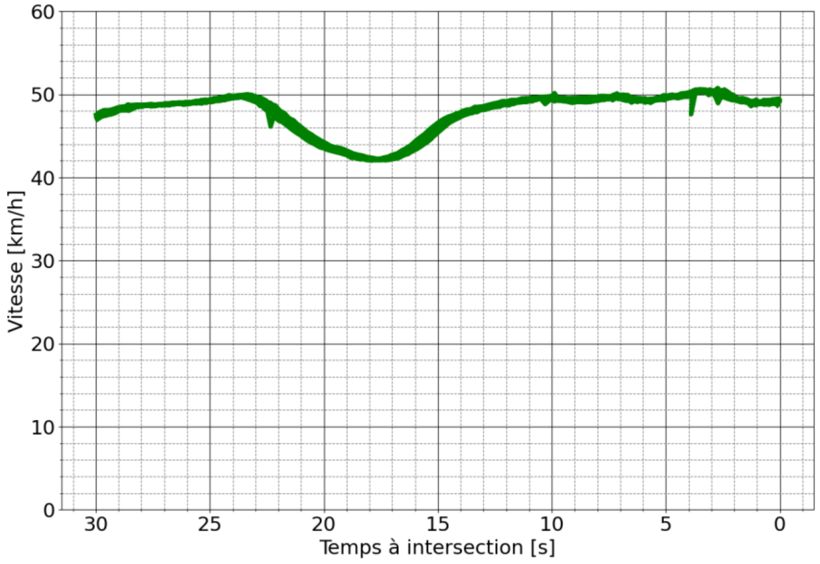
Vehicles speed profiles



AV Speed profile



CAV speed profile

- High deceleration of CAV when reaching to the intersection
- Constant speed of CAV for crossing the intersection

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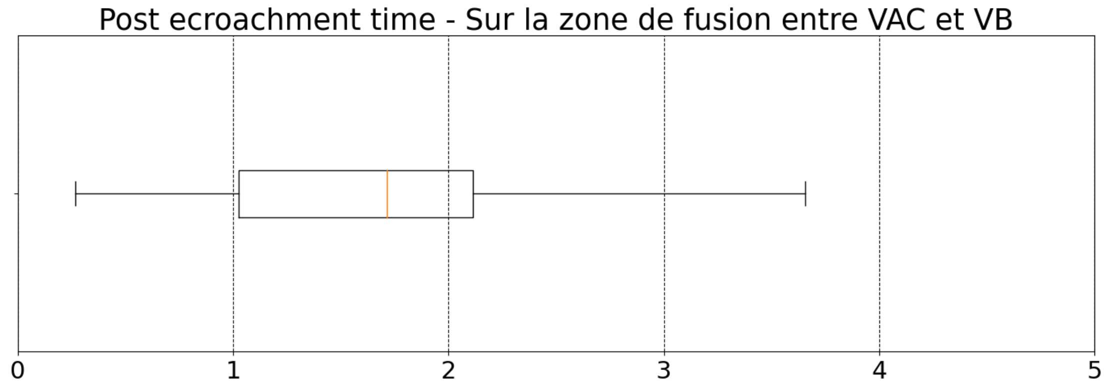
Time to detection of collision risk

- Alert send on average 12s before intersection
  - CAV can engage a maneuver for collision avoidance
  - Easier decision making thanks to the infrastructure information

- Post encroachment time lower than 2s
  - Collision risk situation encountered by the vehicles during experimentation



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Conclusion

- Field evaluation of a conencted infrastructure for automated drving assistance

- Limites number of scenarios could be executed due to the complexity of such experimentation (access to protoypes, test tracks, number of people required)

- Highlight different behaviors between AV and CAV
  AV is limited due to late decision makingVA risque de prendre des décisions trop tardives
  CAV can trigger collision avoidance maneuver by alert reception before the conflict

- Major contribution of connected infrastructure to facilitate CAV behavior adaptation to complex situation and to extend awareness by multiple seconds

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2.3.5 Acceptability and Organisational Impacts

Analysis of the system technology-human-organisation

Mehdi Chahir (UR2)

Organizational impact study (2.3.5.3e)

Introduction: why this study?

- C-ITS = unprecedented technological innovation for road managers
- Deploying an innovation is a challenge in more ways than one:

95% of inventions brought to market fail (Andréani, 2001)

20% of deployments in organizations are successful (Jørgensen, 2014)

Deploying a technological innovation provokes change (Bobillier-Chaumon, 2016; Brangier, 2003; Chahir et al., 2019, 2022; Chahir, 2021; Pichot, 2018).

- The need to assess how these technologies are perceived/accepted by the professionals concerned, and the changes brought about by deployment.

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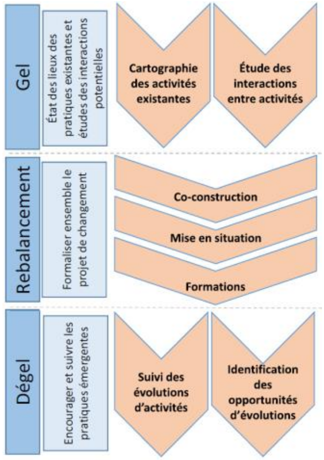
Organizational impact study (2.3.5.3e)

Introduction: context of the study

- In previous studies (2.3.5.3.d - Chahir et al., 2019, 2022 ; Chahir, 2021), we had :
  - Proposed a change management method
  - Applied this method to DIR Ouest (national pilot site) for :
    - Identify the impact of C-ITS a priori
    - Contribute to deployment preparation with recommendations
- Following on from this work, the aim of the present study was to assess the organizational impact and acceptability of C-ITS tools once deployed.
  - CIGT* deployment: interconnection between the tool already in use and C-ITS; little impact at this stage.
  - Deployment in CEI**: deployment of a new touch-screen tablet; supposedly greater impact

➢ Focus on CEI deployment



The 3-step method

*CIGT : Centre d'Ingénierie et de Gestion du Trafic / Traffic Engineering and Management Center
**CEI : Centre d'Entretien et d'Intervention / Maintenance and Intervention Center

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Organizational impact study (2.3.5.3e)

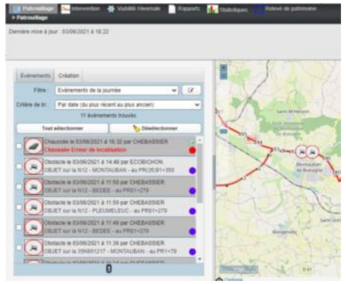
Introduction: zoom in on the tool deployed in CEI

- One of our recommendations: ensure the ergonomics of driving positions (CEI)
- However, in addition to C-ITS, DIR Ouest was planning to deploy an "MCE" (*Main Courante Embarquée* = onboard logbook) in operating vehicles.

C-ITS application

MCE application
(onboard logbook)

+



Web interface
(or Offboard
Logbook Viewer)

Merging the two systems

C-ITS/MCE Application
(+Offboard
Logbook Viewer)

- ➢ **Merger of the two systems**
- ➢ **Evaluation centered on the C-ITS application shared with the MCE (C-ITS/MCE) in the CEI**

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Organizational impact study (2.3.5.3e)

Method

	Questionnaires	Interviews
Population	• 301 responses (120 in T1, 110 in T2, 71 in T3) • Profile: operatives (63.9%), supervisors (25.1%), unknown (11%). • Majority men (> 95%)	• 89 users of MCE/C-ITS tools • Profile: operating staff (75.3%) and supervisors (24.7%). • Majority men (> 95%)
Material	• Questionnaire T1 with 41 questions in 2 parts (acceptability) • Questionnaires T2-T3 with 80 questions in 7 parts (experience with C-ITS/MCE tools and acceptability)	• Interview guide with 34 questions divided into 6 themes. • Objectives: description of experience with C-ITS/MCE tools and acceptability
Procedure	• Paper questionnaire distributed before training (T1), 2 months after training (T2) and 6 months after training.	• Professionals met 2 months after training • Individual or group sessions ~1h

=> 11 CEI surveyed between April 2022 and September 2023

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Organizational impact study (2.3.5.3e)

Questionnaire results (acceptability)

Dimension	T0 (2019) C-ITS (20 CEI ; N = 208)		T1 (Déploiement) C-ITS/MCE (8 CEI ; n = 120)		T2 (2 mois) C-ITS/MCE (10 CEI ; n = 110)			T3 (6 mois) C-ITS/MCE (7 CEI ; n = 71)		
	α	*M* (*ET*)	α	*M* (*ET*)	α	*M* (*ET*)	Δ	α	*M* (*ET*)	Δ
Intention to use	-	4,25 (*1,56*)	0.93	5,96 (*1,24*)	0.92	6,24 (*1,15*)	→	0.96	5,85 (*1,33*)	↘
Attitude	0.91	4,11 (*1,21*)	0.94	5,01 (*1,22*)	0.97	5,21 (*1,48*)	→	0.98	4,83 (*1,88*)	→
Sense of mastery (or control)	0.67	4,22 (*0,97*)	0.90	5,65 (*1,00*)	0.92	5,99 (*1,08*)	→	0.93	5,68 (1,*20*)	→
Social norms	0.17	4,07 (*0,58*)	0.78	5,81 (*0,85*)	0.83	6,07 (*1,00*)	→	0.85	5,98 (*0,85*)	→
Ease of use	0.22	3,82 (*0,89*)	0.87	5,20 (*1,06*)	0.91	5,46 (*1,38*)	→	0.92	5,24 (*1,53*)	→
Compatibility	0,42	4,04 (*1,05*)	0.84	5,04 (*1,17*)	0.91	5,41 (*1,43*)	→	0.94	5,07 (*1,76*)	→
Comfortable with technology	0,77	4,80 (*1,57*)	0.61	4,63 (*1,34*)	0.71	4,97 (*1,42*)	→	0.54	4,61 (*1,43*)	→

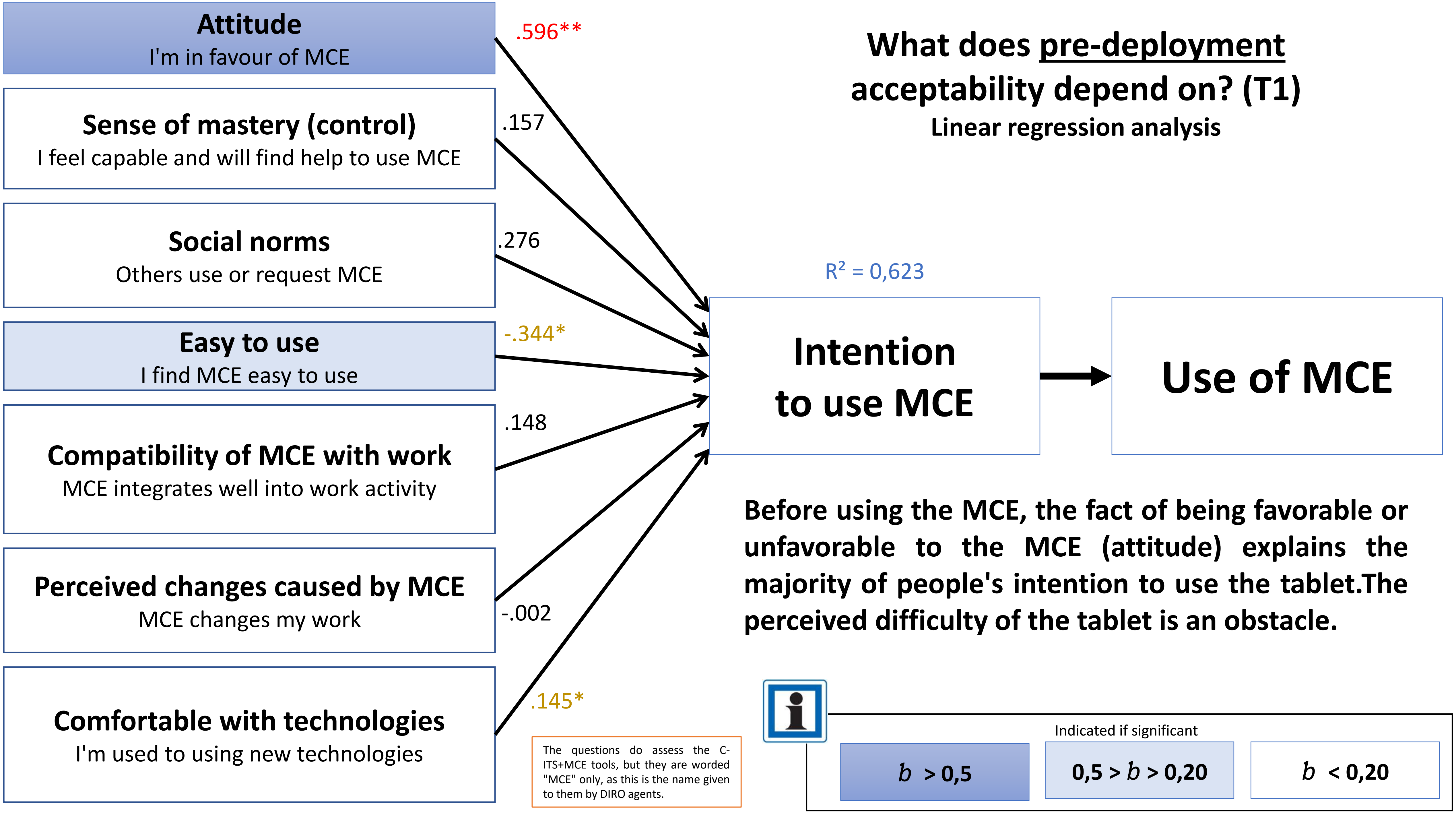
7-point agreement scale (from 1 strongly disagree to 7 strongly agree)

α: indicator (Cronbach's alpha) of internal consistency for the dimension*; M*: mean; *SD*: standard deviation*; Δ:* difference from previous time

Comparison between different times based on tests of comparison of means (Student's T): increase ↗ stagnation → decrease ↘

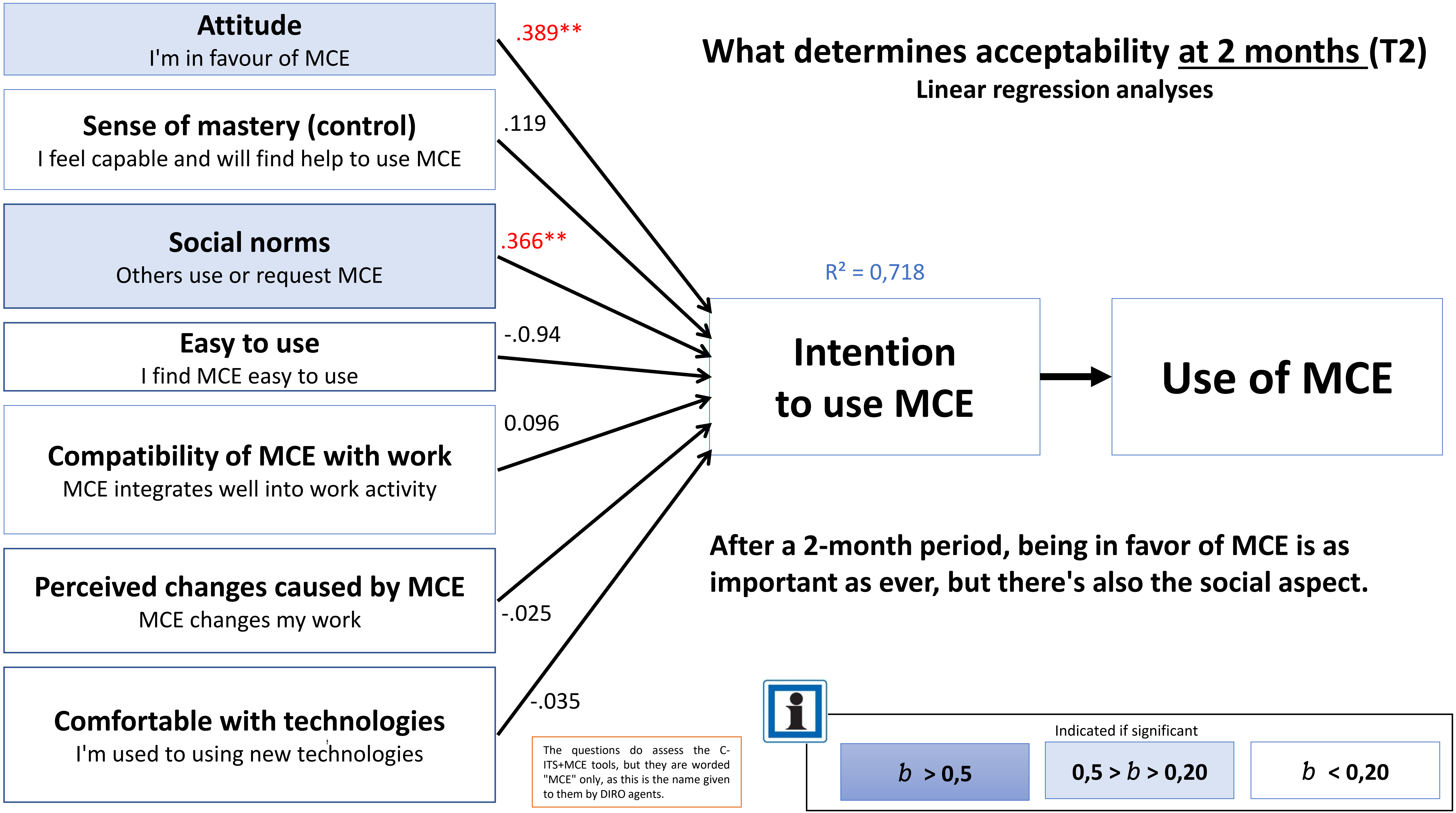
What does pre-deployment acceptability depend on? (T1)

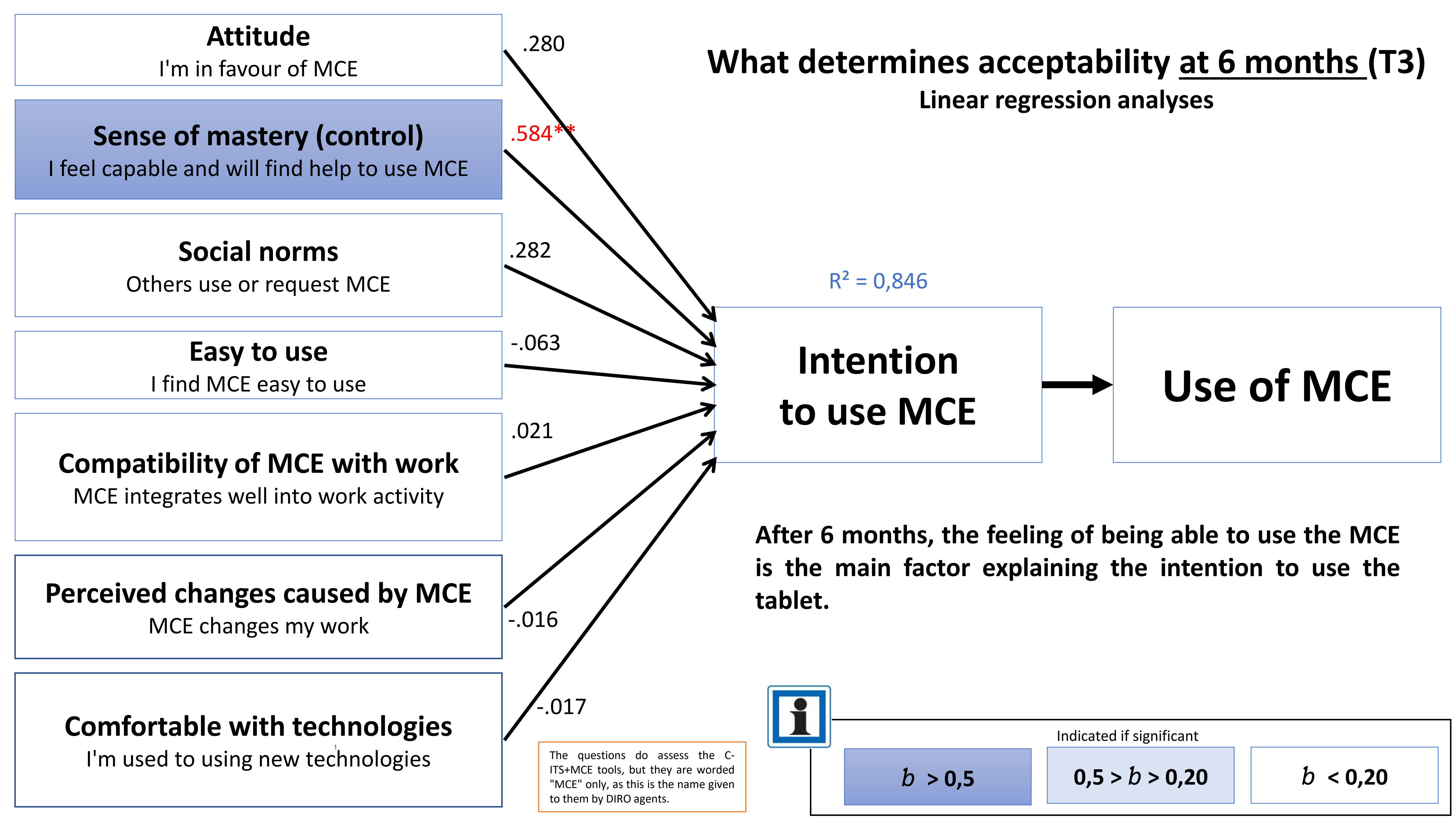
Linear regression analysis



Before using the MCE, the fact of being favorable or unfavorable to the MCE (attitude) explains the majority of people's intention to use the tablet.The perceived difficulty of the tablet is an obstacle.

The questions do assess the C-ITS+MCE tools, but they are worded "MCE" only, as this is the name given to them by DIRO agents.


What determines acceptability at 2 months (T2)
Linear regression analyses
Attitude
I'm in favour of MCE
.389**
Sense of mastery (control)
I feel capable and will find help to use MCE
.119
Social norms
Others use or request MCE
.366**
Easy to use
I find MCE easy to use
-.0.94
Compatibility of MCE with work
MCE integrates well into work activity
0.096
Perceived changes caused by MCE
MCE changes my work
-.025
Comfortable with technologies
I'm used to using new technologies
-.035
R² = 0,718
Intention to use MCE
Use of MCE
After a 2-month period, being in favor of MCE is as important as ever, but there's also the social aspect.
The questions do assess the C-ITS+MCE tools, but they are worded "MCE" only, as this is the name given to them by DIRO agents.
Indicated if significant
b > 0,5
0,5 > b > 0,20
b < 0,20


What determines acceptability at 6 months (T3)
Linear regression analyses
Attitude
I'm in favour of MCE
.280
Sense of mastery (control)
I feel capable and will find help to use MCE
.584**
Social norms
Others use or request MCE
.282
Easy to use
I find MCE easy to use
-.063
Compatibility of MCE with work
MCE integrates well into work activity
.021
Perceived changes caused by MCE
MCE changes my work
-.016
Comfortable with technologies
I'm used to using new technologies
-.017
R² = 0,846
Intention to use MCE
Use of MCE
After 6 months, the feeling of being able to use the MCE is the main factor explaining the intention to use the tablet.
The questions do assess the C-ITS+MCE tools, but they are worded "MCE" only, as this is the name given to them by DIRO agents.
Indicated if significant
b > 0,5
0,5 > b > 0,20
b < 0,20

Organizational impact study (2.3.5.3e)

Questionnaire results (tool experience)

- **Training attended** by nearly 95% of participants, **well evaluated** and deemed **useful**.
- **Extensive use of tools** (more than 20 days' experience, for 65,4 %).
- **Tools well integrated**, paper used systematically by 11% of professionals at 6 months.
- 40% feel that their **work has changed** with these tools; stronger perception of change for supervisors (M=4.88)[1] than for operatives (M=4.19)[1].
- **Few changes in relations** between colleagues.
- **A majority encountered at least one technical problem** (87.3% at 2 months and 80% at 6 months).
- Help obtained in most cases, either from a supervisor (67.4%), colleagues (29.8%) or someone outside the ILC (15.5%) [no help: 11.1%].

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[1] Agreement scale from 1 (strongly disagree) to 7 (strongly agree)

Organizational impact study (2.3.5.3e)

Questionnaire results (tool experience)

- Main contributions from the point of view of :
  - Modernization (82.2%)
  - Traffic information processing (75.7%)
  - Legal protection (58.1%)
- Tablet deemed just as effective, if not more so in certain situations.
  - More efficient equipment monitoring (43.3%)
  - More efficient for event reporting (39.4%)
  - More efficient for event handling (34.6%)
- Barriers to the use of C-ITS
  - The tablet reinforces control over work activity (but not systematically perceived as a hindrance)
  - Some feel that their workload has increased with the tablet (40.9%)
  - The tablet is a source of distraction while driving (55.3%)

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Organizational impact study (2.3.5.3e)

Interview results: tool contributions

- Overall, the opinion is very positive, with a focus on the simplicity of the tools.
- There have been numerous practical contributions that have saved time :
  - Reduction/elimination of paper format (restrictive because difficult to use at night or in bad weather, losses, forms to be retrieved from teams, incomplete or difficult to decipher forms).
  - Direct photo-taking (avoids carrying a camera and transferring data to a computer)
  - Eliminates the need to retype forms in digital format [supervisors].
  - Automatic PR localization
  - Instant transmission of information
  - Extraction of data to produce reports
  - Easy search for past events
  - Extracts a list of current events to organize CEI interventions
  - **Transmission of information to users, real added value of the tablet**
  - **Location of teammates on the road during interventions, for better coordination**

C-ITS { (last two items)

Organizational impact study (2.3.5.3e)

Interview results: problems and difficulties encountered

- Request for simplification of forms: too much information to enter according to teams, despite instructions to fill them in the same way as on paper forms.
- The tablet is sometimes perceived as a source of disruption to driving or work activities, especially during the learning phase (24.7%).
  - Priority is given to the tablet when arriving at an event, by signaling it before using direct safety equipment (e.g., flashing beacon).
  - Use while driving to switch on the tablet and/or authenticate.
  - Lack of attention during data entry, once on the road.
- Difficulty navigating menus and distinguishing between MCE and C-ITS events.
- 'Christmas garland' effect when supervisors fail to close events as they progress.

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Organizational impact study (2.3.5.3e)

General conclusion

- Initially, the plan was to deploy a C-ITS application and an MCE application separately.
- Deploying the two tools separately would have caused usability issues, driver station ergonomics problems, and therefore acceptability issues.
- The interfaced application made it possible to offer the functionalities of both tools in one tablet.
- Event reporting is done at both the C-ITS and MCE levels.
- Since MCE functions are at the core of CEI activities, their use feeds into C-ITS.
- C-ITS functions are **considered useful** for informing users and improving safety.
- **Merging the tools thus enables greater use of C-ITS functions and better adoption.**

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Organizational impact study (2.3.5.3e)

Thank you for your attention!

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Thanks to DIR Ouest.

Organizational impact study (2.3.5.3e)

Thank you for your attention!

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2.3.5 Acceptability and Organisational Impacts

Analysis of the system technology-human-organisation. Pre-deployment state for autonomous vehicle.

Mehdi Chahir (UR2)

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Introduction

- InDiD: adaptation and development of C-ITS services for automated driving vehicles* (AGVs). Objective: to enhance the ACV's ability to anticipate risks and optimize its movements and trajectories (Muzet et al., 2022).
- Some use cases are likely to be implemented by road managers. However, deploying these services could (1) represent a challenge in terms of maintenance and development (Rocchi et al., 2017) and (2) lead to impacts in the organization of road managers (Adelé, 2017, 2018; Adelé et al., 2024; Chahir, 2021, 2024; Chahir et al., 2019; Cippelletti et al., 2023).

➢ **Study objective: to assess the perception of InDiD use cases for ACV and, more broadly, to study the perceived impacts of ACV for road managers and their perceptions****.

*terminology recommended by the CNPEN in 2021 to talk about autonomous vehicles // ** based on the theory of social representations (Moscovici, 1984)

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Method

Population	• 124 professional road managers • 70 responses to the "ADV" questionnaire and 54 to the "AV" questionnaire • Majority of professionals from DIR Ouest (110) • Almost all participants were men (92.7%), average age 49 (*SD* = 7.74)

Material	• Questionnaire with 70 questions divided into 6 sections.
	• Measurement of :
	    • Evaluation of perceptions of InDiD use cases
	    • Individual perceptions (evocation task)
	    • Distance to object
	    • Perceived potential impacts

Procédure	• Solicitation of C-ITS project partners to participate in the study • Adaptation of survey distribution to suit partners • Survey distributed either online or in paper format

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Results: evaluation of use cases

Evaluated services

Warning of areas not suitable for automated driving (H8)

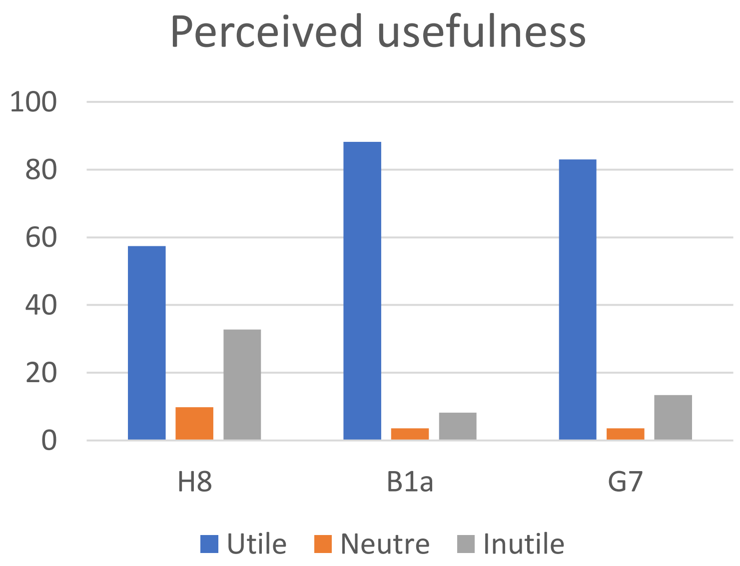
Lane closure alert (B1a)

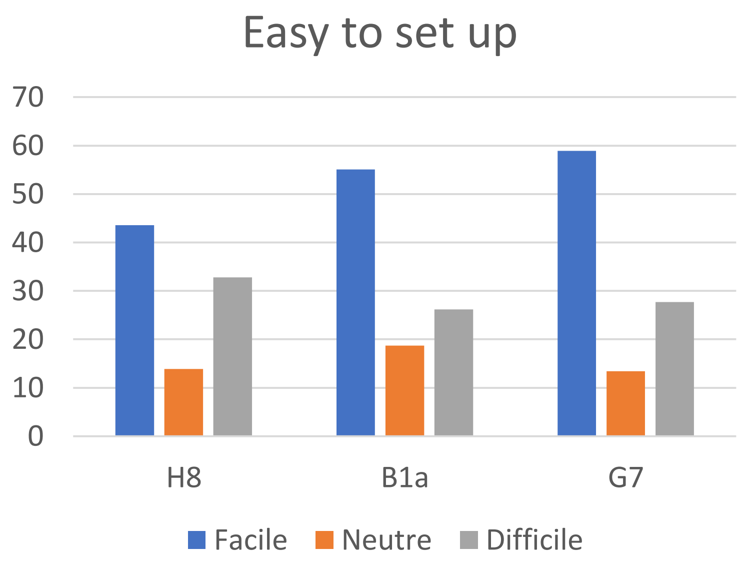
HD mapping (G7)

Results

InDiD use cases considered useful to very useful.

Deployment judged rather easy to implement, but responses mixed.





Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Results: ADV and AV perceptions

		Importance moyenne					
		≤2.3 (*M*)			>2.3 (*M*)		
			n	*M*		*n*	*M*
Fréquence	≥2.5 %	Danger	16	1.6	Sécurité	16	2.6
		Autonome	11	1.6	Futur	6	2.7
		Sans conducteur	7	1.9	Assistance	5	2.4
		Intelligence artificielle	5	2.2	Robot	5	2.6
		Liberté	5	2.2			
		Risque	5	1.2			
		Electrique	5	1.6			
	<2.5 %	Connecté	4	2.3	Capteur	4	2.5
		Progrès	4	1.8	Fiable	4	3.0
		Responsabilité	4	2.3	Conducteur	3	3.0
		Automatique	3	1.3	Confiance	3	3.3
		Inutile	3	2.0	Vigilance	3	2.7

ADV perceptions, classified by frequency and rank of appearance

		Importance moyenne					
		≤2.4 (*M*)			>2.4 (*M*)		
			n	*M*		*n*	*M*
Fréquence	≥3.5 %	Sécurité	14	2.4	Futur	9	2.6
		Danger	11	2.1	Couteux	6	3.0
		Sans conducteur	9	2.0	Facile	4	2.8
		Automatique	5	2.0	Technologie	4	3.0
		Electrique	5	1.0			
	<3.5 %	Conduite	3	2.0	Accident	3	2.7
		Liberté	3	1.3	Connecté	3	2.7
		Progrès	3	2.0	Fiable	3	3.3
		Accessible	3	2.3	Risque	3	2.7

AV perceptions, ranked by frequency and rank of appearance

- **Most important/central common terms**: "danger", "driverless", "electric".
- **Main differences**: more "original" associations with the term ADV (e.g. "autonomous", "artificial intelligence", "assistance", "robot").

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Results: ADV/AV distance

- **Attitude** to ADV/AV slightly below average (*M* = 3.78, *SD* = 1.77)[1]. The majority of participants had no opinion or did not express an opinion (*M* = 4)1 , while a third of participants were very unfavorable to ADV/AV (*M* < 3)[1].
- Relatively good **level of knowledge**, despite some gaps.
  - Few errors for "ADVs/AVs guarantee a total absence of accidents on the road" (*Δ* = 0.82).
  - Many errors for "ADVs/AVs can legally circulate on French roads" (*Δ* = 3.57).
- Average to low **personal involvement** with the subject (*M* = 3.46, *SD* = 1.36)[1] .
- **Very limited experience** with ADVs/AVs: the majority of participants had never used an ADV/AV (78.2%).

[1] Agreement scale from 1 (strongly disagree) to 7 (strongly agree)
[2] Gap between expected answers to knowledge questions and participants' answers on scales ranging from 1 (definitely false) to 7 (definitely true).

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Results: impact of ADV/AV for professionals

- **Impacts of ADV/AV are expected on infrastructure** (M = 5.44, SD = 1.95)[1]. Impacts of ADV/AV on road infrastructure: professionals expect road infrastructure to have to be adapted with the arrival of ADV/AV on their network (M = 5.44, SD = 1.95)[1] [no ADV/AV difference]. Adaptations specifically expected in :

  C-ITS (M = 6.03, SD = 1.56)[1]

  Traffic information (M = 5.80, SD = 1.60)[1]

  Road markings (e.g., road markings; M = 5.56, SD = 1.96)[1].

- **More broadly, they also expect ADV/AV to have an impact on :**

  Their job (M = 5.47, SD = 1.91)[1]

  Their department (M = 5.48, SD = 1.87)[1]

  The organization as a whole (M = 5.40, SD = 1.83)[1]

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[1] Agreement scale from 1 (strongly disagree) to 7 (strongly agree)

Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Conclusion

- Making these C-ITS services available to VCAs is, on the whole, **considered useful and rather easy**.
- **Encouraging results for the deployment of these use cases**: we could have imagined that these use cases would be considered too complex to implement (e.g., difficulty in making this information available or updating it).
- Recommendation: **continue to reflect on the organizational impact of these use cases to ensure their successful integration with road managers**. For example:
  - Which actors would be in charge of disseminating the information needed for these services to function properly?
  - How often should these services be provided or updated?
  - What would be the organizational impact of deploying such services for road managers?
  - What would be the legal liability of a road manager who failed to provide information on these services?

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Thank you for your attention !

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Our thanks to the participants in the study, and in particular to DIR Ouest.

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Assessment of Automated Driving Vehicle use cases, perceptions and impacts for road managers (2.3.5.3f)

Thank you for your attention !

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2.3.5 Acceptability and Organisational Impacts

Evaluation of the acceptance of Coopits application by users.

Mehdi Chahir (UR2)

User acceptability of the smartphone application (2.3.5.6c)

Introduction

- Coopits is a mobile application enabling users to receive information from the C-ITS ecosystem (e.g., notifications of hazardous events, roadworks, specific signage...) and to report events.
- Coopits was deployed nationally in April 2023. Its acceptability was then assessed (May-November 2023), with a view to improving the application and integrating it into existing services. This involved answering several questions:
  - How is Coopits used by users?
  - What do users see as the benefits of Coopits?
  - What improvements can be made to Coopits?
  - What factors explain the intention to use Coopits?
  - More generally, what positioning should Coopits adopt to help improve road safety?

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User acceptability of the smartphone application (2.3.5.6c)

Methods*

	Questionnaires	Interviews
Population	• 101 Coopits users • Majority men (88.1%) • Experienced drivers • Ordinary users	• 7 Coopits users • Mostly men (6) • Experienced drivers • Road managers
Material	• Questionnaire with 84 questions divided into 5 sections. • Objectives: description of user experience & evaluation of Coopits, particularly in terms of acceptability (Lee, 2010)	• Interview guide with 34 questions divided into 8 themes. • Objectives: description of Coopits user experience & evaluation
Procedure	• Online survey sent approx. 1 week after Coopits download, followed by two reminders in subsequent weeks. • Compensation of €15	• Recruitment of DIR Ouest professionals who use Coopits • Duration 1 hour • 30 € compensation

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*Two pre-tests had already been carried out to validate the procedure and equipment.

User acceptability of the smartphone application (2.3.5.6c)

Questionnaire results: user experience

- **Low usage experience**: 82.2% have used it 1 to 5 times.
- **Mainly used** in intercity (92.1%).
- **Overlay used**: by more than half of users (56.4%).
- **Information received**: more than a quarter of users (28.7%) were informed of events (mainly traffic conditions or accidents (23.8%) and roadworks (13.9%)).
- **Features deemed useful**: 1) receipt of information and alert messages (76.2%), 2) event reporting (46.5%), 3) overlay use (43.6%), 4) navigation assistance (35.6%).

User acceptability of the smartphone application (2.3.5.6c)

Questionnaire results: acceptability

Psychological dimension	α	*M* (*ET*)
Intention to continue using	0,88	3,37 (1,62)
Perceived usefulness	0,82	2,41 (1,21)
Perceived ease of use	0.93	3,80 (1,65)
Attitude (favorable or unfavorable)	0.95	3,01 (1,40)
Perceived control (sense of mastery)	0.91	3,60 (1,38)
Social norms	0.97	2,30 (1,23)
Satisfaction	0,93	2,28 (1,45)
Confirmation of expectations	0,90	2,19 (1,32)
Pleasure	0,79	2,20 (1,07)
Concentration	0,80	2,16 (1,16)

- **10 psychological dimensions assessed** (Lee, 2010).
- Positioning in relation to proposals on agreement scales ranging from 1 "strongly disagree" to 6 "strongly agree“ [center value 3.5].

  Example proposition: "I find Coopits useful".
- **Strengths**: perceived ease of use and sense of control.
- **Weaknesses***: confirmation of expectations and satisfaction.

*Excluding pleasure and concentration, which are somewhat separate and less relevant to the evaluation of a driving aid.

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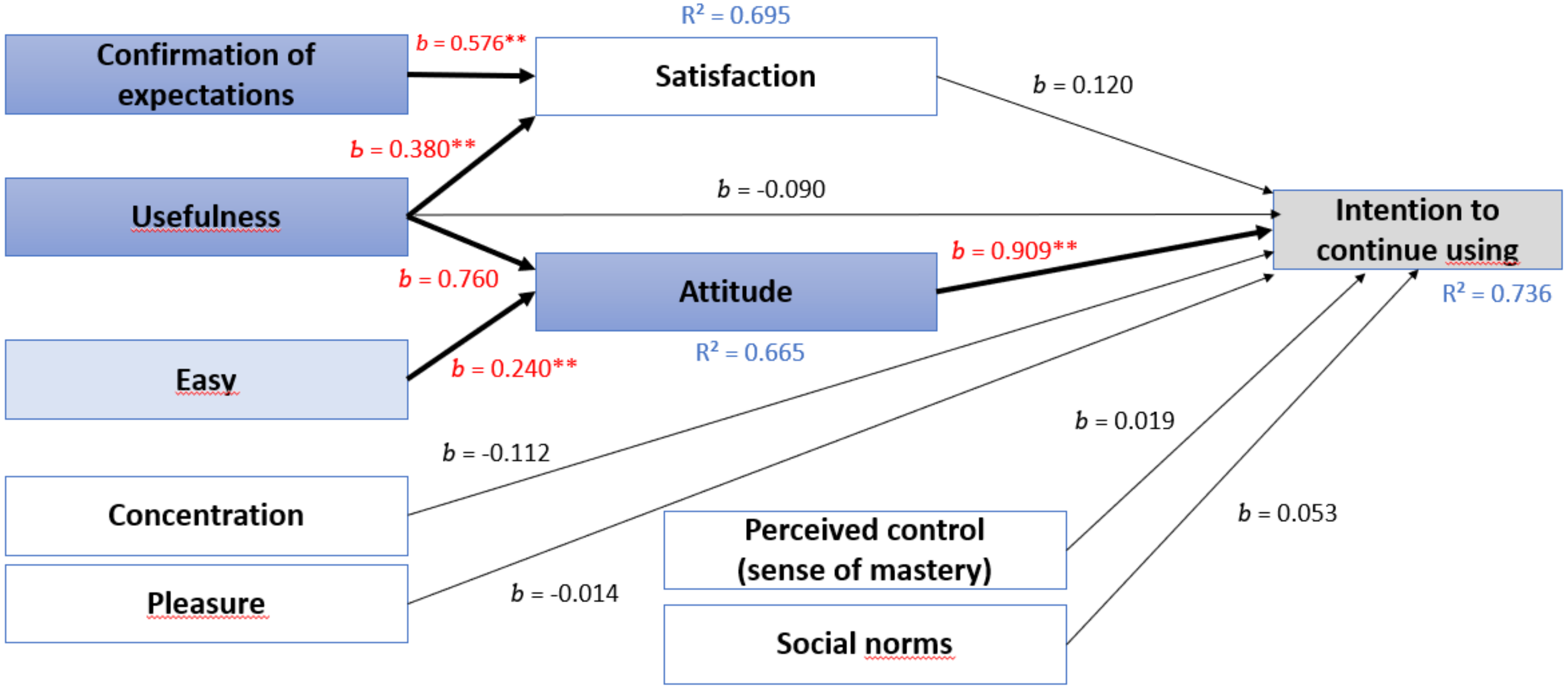
User acceptability of the smartphone application (2.3.5.6c)

Questionnaire results: acceptability



- Very strong link between attitude and intention to continue using Coopits (b = 0.984, p < .001).
- Attitude explains nearly 72% of intention to continue using Coopits (BIC = 268, RMSE = 0.850).

Linear regression analyses based on the model proposed by Lee (2010).

b > 0,5
0,5> b >0,20
b <0,20

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User acceptability of the smartphone application (2.3.5.6c)

Interview results

- **Perspectives d'utilisation** : malgré les critiques, la majorité des participants prévoyait de continuer à utiliser Coopits, par exemple lors de tests techniques ou des vacances.
- **Message reception**: participants mainly received traffic- and accident-related messages, although they felt they received few overall.
- **Useful features**: 1) alerts, 2) overlays with other applications, 3) information on construction sites.
- **Opinions were divided**: some found it suited to their needs, while others criticized the lack of information, with less favorable comparisons with other applications in use.
- **Suggested improvements**: 1) make the information transmitted more reliable, 2) improve ergonomics and 3) integrate the application with Android Auto.Future use: despite the criticisms, the majority of participants planned to continue using Coopits, for example during technical tests or vacations.

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User acceptability of the smartphone application (2.3.5.6c)

Conclusion

- **Gap** measured between users' expectations and the tested version of Coopits.
- **Two main areas for improvement identified**: 1) ensure that the application is technically sound and easy to understand, 2) provide users with more information.
- **Overlay to be retained**, but consider improving it to make it easier to use, and eventually reintegrate navigation to enable independent use of Coopits (will increase the number of alerts + enable recommended itineraries to be broadcast).
- **Continue strategic reflection on Coopits' positioning in the ecosystem**, building on its strengths (e.g., qualified information, information on manager interventions and restrictions, adapted rerouting or infrastructure-related services [Glosa / TTG]).

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User acceptability of the smartphone application (2.3.5.6c)

Thank you for your attention !

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2.3.6 Socio-economic impact and Business Model

Jamel Chakir (DGTIM)

Socio-economic assessment

Objectives

- Estimate the benefits provided by C-ITS use cases with regard to investment compared to a baseline scenario under the assumption of a national deployment
- Estimate costs and benefits according to different technological scenarios (ITS-G5; 4G; ITS-G5 + 4G; 5G)
- Sensitivity test on assumptions

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Socio-economic assessment

Assumptions

- Baseline scenario: evolution of the current situation “as it goes”, without investments in C-ITS equipment. Smartphones will represent the main driving assistance tool.

Scenarios	Vehicle equipment	Road network equipment	Transmission logic retained for use cases
Baseline	No equipment	No equipment	I2V
ITS-G5	Equipment of vehicles in C-ITS station (ITS-G5)	Equipment of road networks with RSU	I2V, V2V, V2I2V
4G	Equipment of vehicles in C-ITS station (4G communication)	No equipment	I2V, V2I2V
ITS-G5 + 4G	Vehicle equipment in hybird C-ITS (ITS-G5 and 4G)	Equipment of road networks with RSU	I2V, V2V, V2I2V
5G long range + short range	Vehicle equipment in C-ITS station short-range and long range communicaiton based on 5G	Equipping road networks with 5G infrastructure	I2V, V2V, V2I2V

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Socio-economic assessment

Assumptions

- <u>Infrastructure deployment</u>

Speed of infrastructure deployment	Low	Medium	High
National network RSU coverage - At launch - each additional year	10% 3%	15% 3.5%	30% 7%
RSU departmental network coverage - At launch - each additional year	1% 0.2%	2.5% 0.25%	5% 0.5%
RSU network coverage of metropolitan areas - At launch - each additional year	5% 1%	7.5% 2.75%	15% 5.5%
4G coverage of road networks - In 2022 - each additional year	80% 2.5%		
5G coverage of road networks - In 2026 (short range) and 2022 (long range) - each additional year	Long range (2022) 50% 10%	Short range (2026) 0% 10% (limited to 70% in rural areas)	

Socio-economic assessment

Hypotheses

- Vehicle fleet deployment

	Low	Medium	High
Annual deployment speed in the vehicle fleet	1%	3%	5%

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Socio-economic assessment

Assumptions

- Unit costs

Actor	Cost item	Amount	Unit
Road operator	Roadside unit (includes installation)	€14,700	By new RSU
	Maintenance, energy, data, security	€680	Per RSU and per year
	Upgrading Traffic Management Centers	€	By traffic management center
	Costs of traffic management centers	€250,000	Per traffic management center and per year
State	Installation of the national acces point	€273,500	By country
	Annual costs, data collection and processing	€	Per year
OEMs	Vehicle equipment	€210	Per new vehicle
	Annual maintenance	5% of costs	Per vehicle and per year

Socio-economic assessment

Assumptions

- Use cases evaluated:

Use case Ricardo	InDiD
Emercy electronic brake light	D10 – Alert emergency brake
Emergency vehicle approaching	D12 – Emergency vehicle approaching
Hazardous location notification	D1/D3/D6/D8 – Hazardous location notification
Slow or stationary vehicle	D4/A4/L2 – Alert station vehicle / slow vehicle
Traffic jam ahead warning	E7/D11 – Alert end of queue
In- vehicle signage	C3/B7 – In vehicle signage
Road works warning	B1a/B1b/B1c/B2a/B2b /B2c/B2d/B3/B4/B5 – Road Work Warning
Weather conditions	E6/E1 – Alert extrem weather conditons
Shockwave Damping	C2 – Dynamic speed limit information
Green Light Optimal Speed Advisory (GLOSA)	G1/G2 – GLOSA, Time to green
Wrong-way driving	D7 – Alert wrong way driving

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Socio-economic assessment

Assumptions

- Calculation methods

Transmission mode	Calculation principle
I2V	$P_{I2V} = Coverage\ rate * Vehicle\ penetration\ rate$
V2I	$P_{V2I} = P_{I2V}$
V2I2V	$P_{V2I2V} = Coverage\ rate * Vehicle\ penetration\ rate^2$
V2V	$P_{V2I2V} = Vehicle\ penetration\ rate^2$

NB: P_{I2V}= Probability of processing use cases on vehicles using the road networks considered, here from the infrastructure to the vehicles (I2V).

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Socio-economic assessment

Results

- Results: Net Present Value (NPV)

Vehicle equipment deployment	4G	ITS-G5	ITS-G5 + 4G	5G
Low	- €2,555 million	-€3,044 million	**€548 million**	**€280 million**
Medium	- €7,849 million	- €3,982 million	**€738 million**	- 943M
High	-€11,563 million	- €3,222 million	**1,703 million**	1,075 million

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Socio-economic assessment

Results

- <u>5G assumption sensitivity tests:</u>

Vehicle equipment deployment	5G (initial 5G coverage of 100% as of January 1, 2026)
Low	**€280 million**
Medium	- 702M
High	1,163 million

Vehicle equipment deployment	5G (initial 5G coverage of 50% as of January 1, 2024)
Low	**€885 million**
Medium	**€97 million**
High	**€**

Vehicle equipment deployment	5G (initial 5G coverage of 100% as of January 1, 2024)
Low	**€280 million**
Medium	**178M**
High	**305 million**

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Socio-economic assessment

Conclusions and limitations

- **The most effective scenarios are those combining several technologies, allowing short and long range communication (ITS-G5 + 4G, 5G long range and short range).** Conversely, scenarios based solely on one type of communication are the least relevant.
- This is explained on the one hand by an efficiency of use cases proportional to the level of network coverage (hybrid scenarios cover a larger perimeter) and on the other hand, by an equipment cost (vehicles in particular) not compensated by the potential benefits of these same use cases.
- In addition, the evaluated scenarios have different deployment dates: for road infrastructure it is chosen at the beginning of 2022 for ITS-G5 and 4G, and at the beginning of 2026 for 5G short range; concerning vehicles this starts from 2022 for all scenarios . These differences in deployment generate, according to the methodology of our socio-economic model, greater gains for scenarios that generate benefits from the start of the project compared to scenarios that generate benefits only from a certain level of project progress. **It is therefore necessary to favor a synchronized deployment of roadside equipment and equipment on board vehicles in order to maximize benefits**.
- This delay gives a fairly significant economic advantage to the scenarios starting in 2022 compared to the 5G scenario (the 5G scenario will have to support the costs of equipping vehicles before deploying the equipment on the roadsides).

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2.3.7 Traffic et Environment

Pierre-Antoine Laharotte (UniEiffel)

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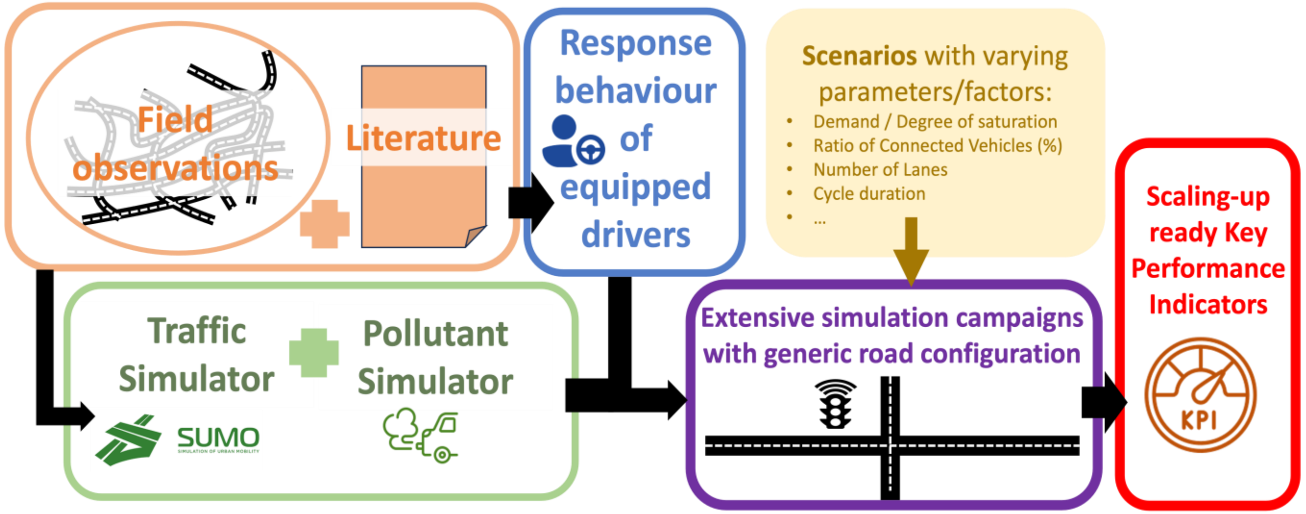
2.3.7 Working Group -Traffic Efficiency, safety and environmental Impact

- **Objectives:**
  - Impact assessment of C-ITS services for
    - Traffic efficiency
    - (road) safety
    - Environmental impact (pollutant emissions)

- **Process = a generic methodology based on**
  - A simulation framework combining a microscopic traffic simulator with a pollutant emissions simulator to:
    - Reproduce a large set of scenarios with varying factors / parameters
  - Field observations and literature findings to :
    - Model the response behaviour of equipped drivers
      - How do drivers react to C-ITS stimuli?
    - Calibrate the simulators
      - How does the traffic flow usually behave?



-> Achieve an analysis of Key Performance Indicators (KPIs) covering a wide range of situations, enabling scaling-up processes!

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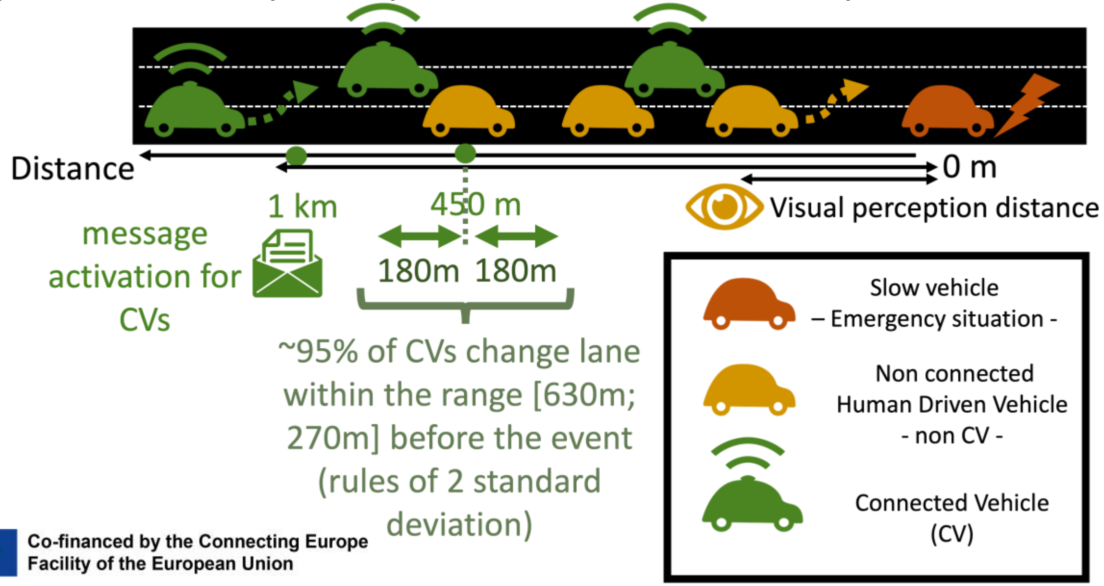
Credits: SUMO; https://www.flaticon.com [tempo_doloe; barrizon; Juicy-fish]

2.3.7 Traffic Efficiency, safety and environmental Impact

- **Use cases under consideration (on Motorways)**

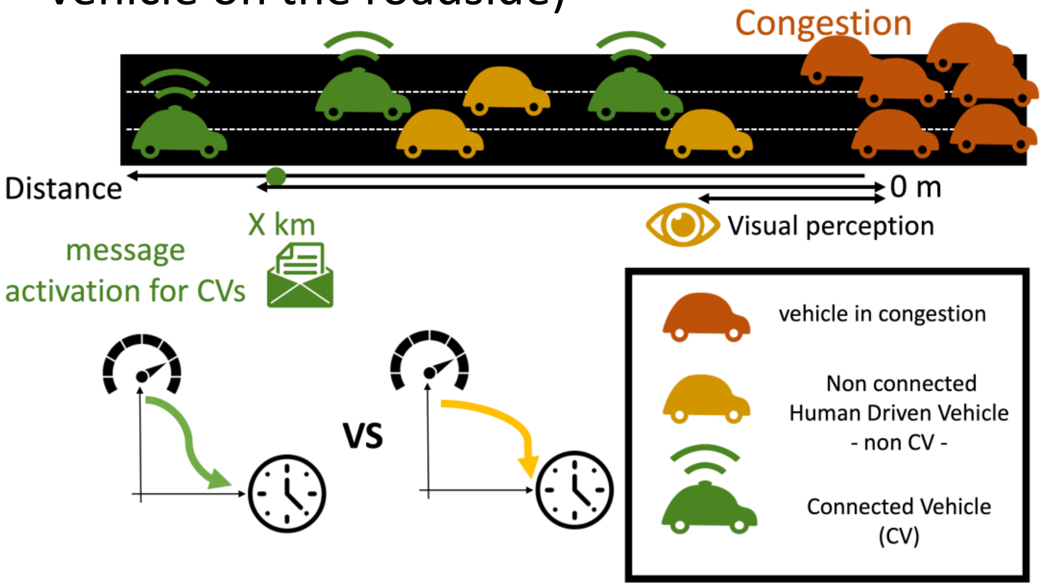
Topic 1 = Lane-changing behaviour on highways due to a downstream obstacle (RWW, stationary vehicle, slow vehicle, etc)

related use cases: A4 (vehicle in distress), B1a/c (RWW), D4 (stationary vehicle, breakdown), D14 (slow vehicle), D3 (obstacle on the road)



Topic 2 = Approaching Congestion with (dangerous) End of Queue

related use cases: D11 (End of Queue in dangerous areas), E7 (Traffic Jam Ahead); B2-d (Signalling the End of Queue with a dedicated vehicle on the roadside)



2.3.7 Traffic Efficiency, safety and environmental Impact

- Topic 1 - Lane-changing behaviour on highways due to a Downstream Obstacle

  Design of Experiment (Factors under study)

  - **Traffic demand** (volume to capacity): [10%; 20%; 30%] (higher demands lead to ≠ use case)
  - **Ratio of Connected Vehicles** in the traffic flow (%): [0; 10; 20; 30; 50]
  - **Speed of the Downstream Obstacle** (kph): [0; 30; 50]

  Key Performance Indicators

  - **Safety**: Time-to-Collision (s), hard brakings (acc/de-celeration)
  - **Traffic Efficiency**: Average Speed
  - **Pollutant Emissions**: Fuel / CO2 / NOx / PMx

  } Focus on the performance of Connected Vehicles only

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2.3.7 Traffic Efficiency, safety and environmental Impact

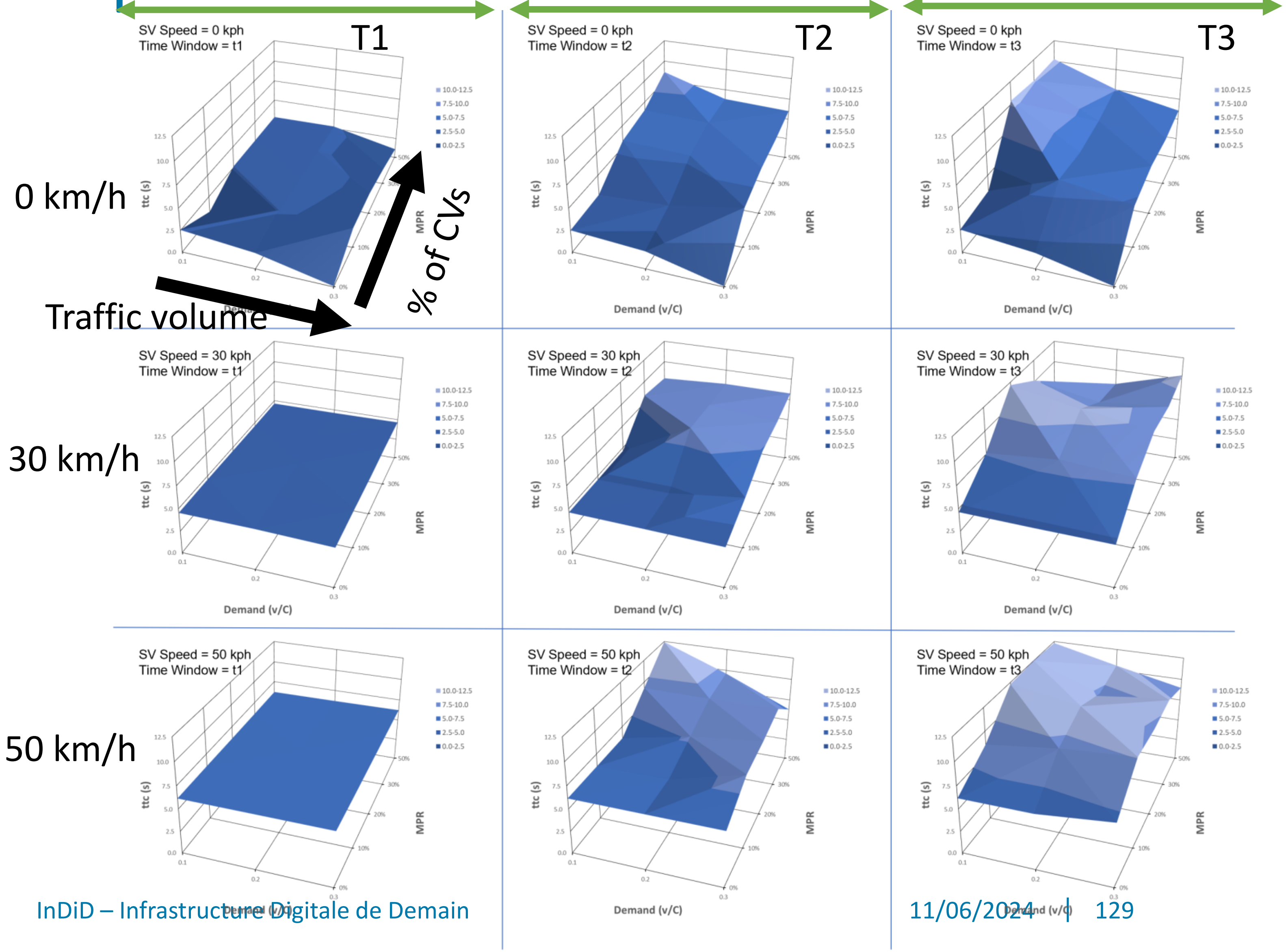
Hou, Y., Sun, C., & Edara, P. (2012). Statistical test for 85th and 15th percentile speeds with asymptotic distribution of sample quantiles. *Transportation research record*, *2279*(1), 47-53.

- Topic 1 - <u>Lane-changing behaviour on highways due to a downstream obstacle</u>
- SAFETY KPI = 15th percentile of Time-to-Collision (TTC)
- TTC ≤ 1.5s -> near collision!
- Safety improvements
  - With an increasing % of CVs
  - With a more minor speed difference between the obstacle and the traffic flow
  - At moderated traffic demand

T1 = Detection period

T2 = short-term effect

T3 = long-term effect



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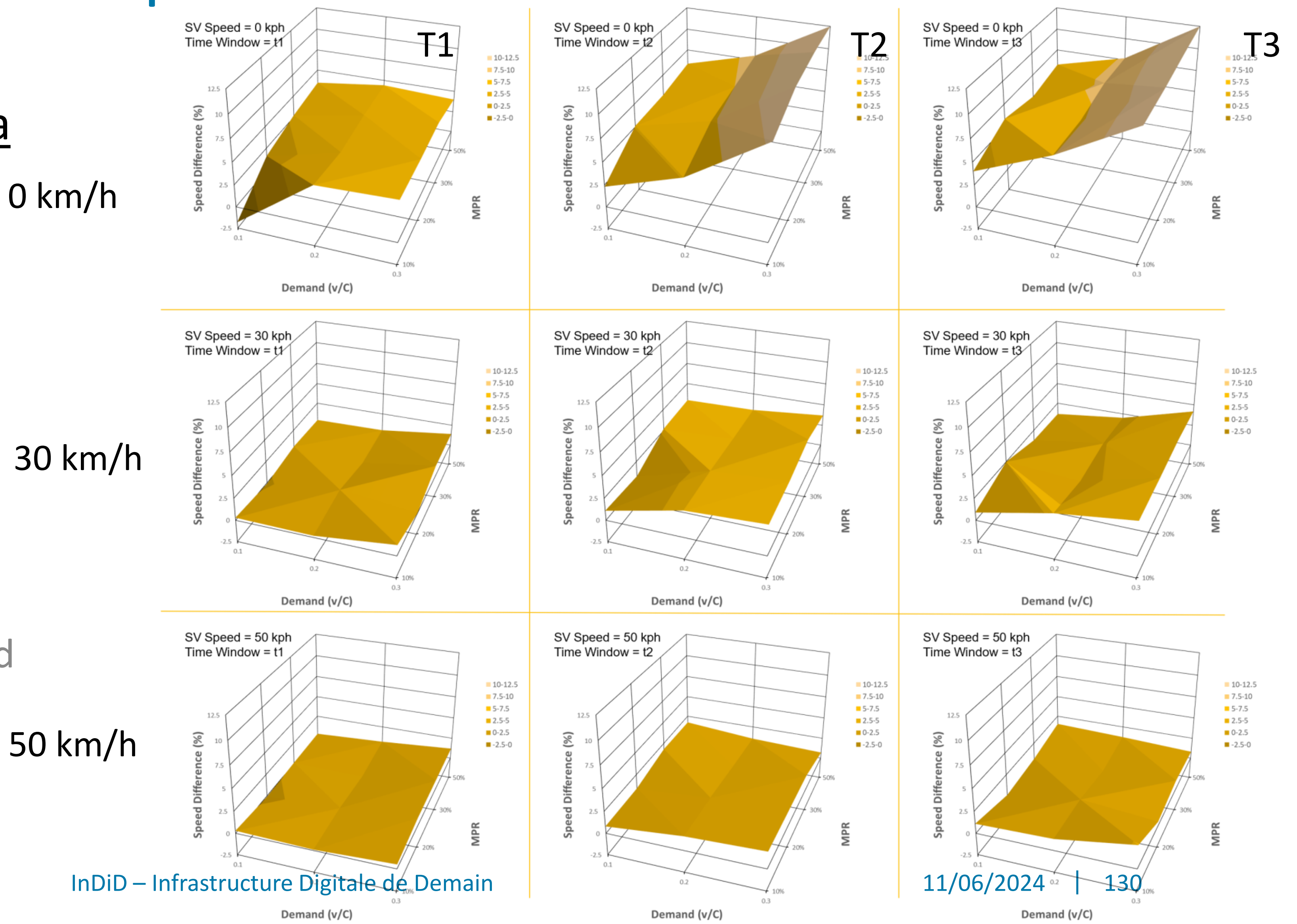
2.3.7 Traffic Efficiency, safety and environmental Impact

- Topic 1 - Lane-changing behaviour on highways due to a downstream obstacle
- TRAFFIC KPI = % of speed improvement
- Speed improvements
  - Between +2% and +10%
  - With an increasing traffic demand



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2.3.7 Traffic Efficiency, safety and environmental Impact

- Topic 1 - <u>Lane-changing behaviour on highways due to a downstream obstacle</u>

- ENVIRONMENT KPI = {Fuel / CO2 / NOx / PMx}

- Pollutant emission benefits
  - Depending on the **traffic volume** & the **speed difference** between the obstacle and the traffic flow
    - Negative effects are observed with high traffic densities for the use case with stationary
  - When gains are observed,
    - it grows with the ratio (%) of CVs in the flow
    - It can reach a reduction by -20% of the emissions in some cases

- Analysis and recommendations:
  - Negative effects might be due to the interaction between CVs and non-CVs leading to heterogeneities in traffic densities by lane: by anticipating the lane change, CVs increase the traffic density on left lanes, which might prevent non-CVs from executing smooth lane change and affect the acceleration/deceleration profiles, then pollutant emissions.
  - **Recommendations**: Apply stationary obstacles warning with C-ITS service at low traffic demand only

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2.3.7 Traffic Efficiency, safety and environmental Impact

- Topic 2 - Approaching Congestion with (dangerous) End of Queue
  - Design of Experiment (Factors under study)
    - **Traffic demand** (volume to capacity): [25%; 50%; 75%]
    - **Ratio of Connected Vehicles** (%): [0; 10; 20; 30; 50; 100]
    - **Jam speed** (km/h): [30; 50]
    - **Activation Distance** (m): [500; 1000; 1500]
  - Main findings per Key Performance Indicator (computed for CVs only)
    - **Safety:** 15th percentile of Time-to-Collision (s), hard brakings (acc/de-celeration)
      - Stronger impact on the Time-to-Collision (TTC) with longer activation distance: from no impact with an activation distance of 500m to TTC multiplied by 2 with 1500m
    - **Traffic Efficiency**: Average Speed
      - As expected, this use case decreases the average speed (-10% every 500m from 500m) to enhance road safety: a stronger decrease in speed comes with a longer activation distance regardless of the ratio of CVs in the flow
    - **Pollutant Emissions:** Fuel / CO2 / NOx / PMx
      - As expected, due to the speed reduction, pollutant emissions are reduced accordingly: from a maximal reduction of ~-10% with an activation distance of 500m to a maximal reduction of ~-60% with 1500m

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2.3.7 Traffic Efficiency, safety and environmental Impact

Main findings

- About use cases with lane restrictions or capacity reduction due to obstacles and requiring lane changes
  - **Safety** is improved with an increasing ratio of CVs, for moderated traffic densities, and with shorter speed differences between the obstacle and the traffic flow
  - **Traffic Efficiency** benefits are enhanced with higher traffic densities
  - **Environmental impact** gains are observed when the obstacles are dynamic (slow vehicle), but are only observed for moderated traffic densities with stationary obstacles leading to a short lane blockage
- About use cases with a warning on congestion with a dangerous end-of-queue requiring an anticipated slowdown
  - **Safety** is improved with activation distance encompassed between 1000m and 1500m
  - **Traffic Efficiency** is reduced with activation encompassed between 1000m and 1500m (until -20% of the average speed of CVs)
  - **Environmental impact** is reduced accordingly to the speed reduction

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2.3.8 Legal Study

Impact of use cases on actors’ liability

Me. Rébécca Véricel (Cabinet Lexing)

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1. Presentation of the legal study

1.1 Our mission

Presenting issues and generally associated solutions

A technical and legal analysis of use cases, their actors and their objects

Establishing the legal frameworks of general and individual liabilities

Risk evaluation and SWOT analysis

Recommendations et action plan ranked by priority

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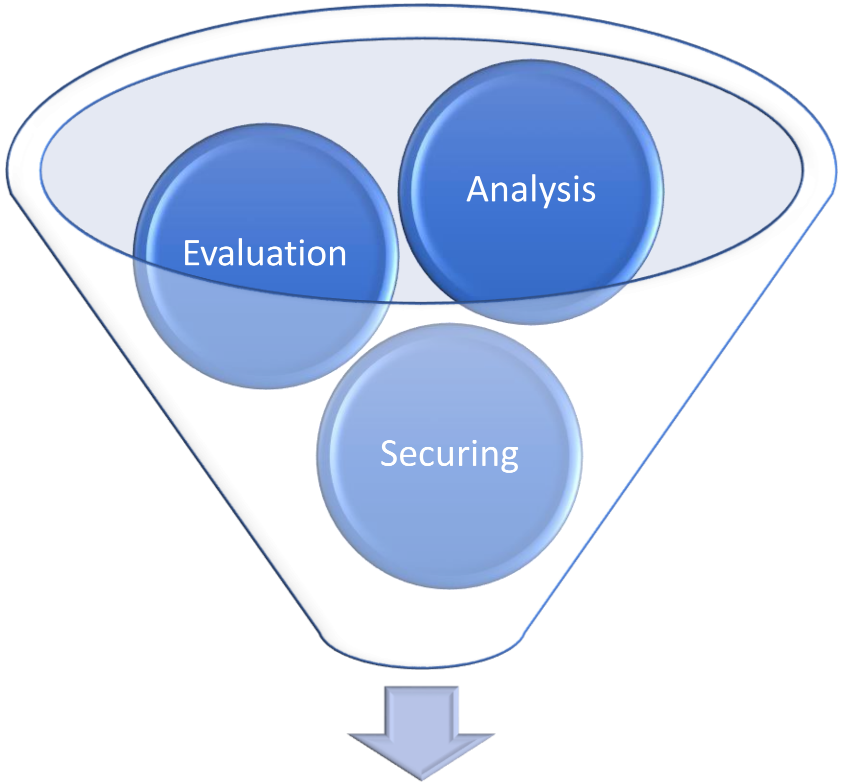
1.2 Aims of the legal study



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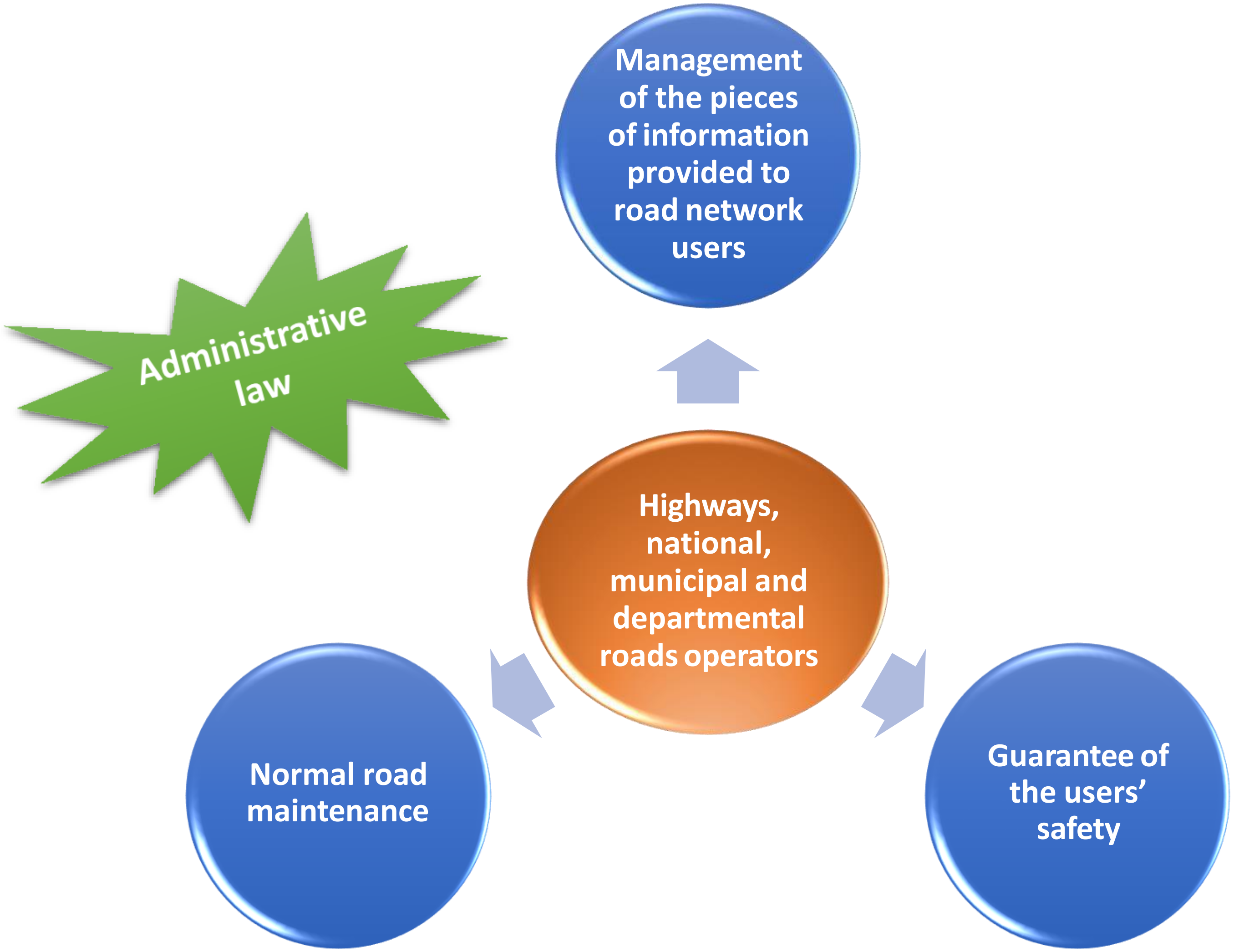
2. Actors

2.1 The information issuer



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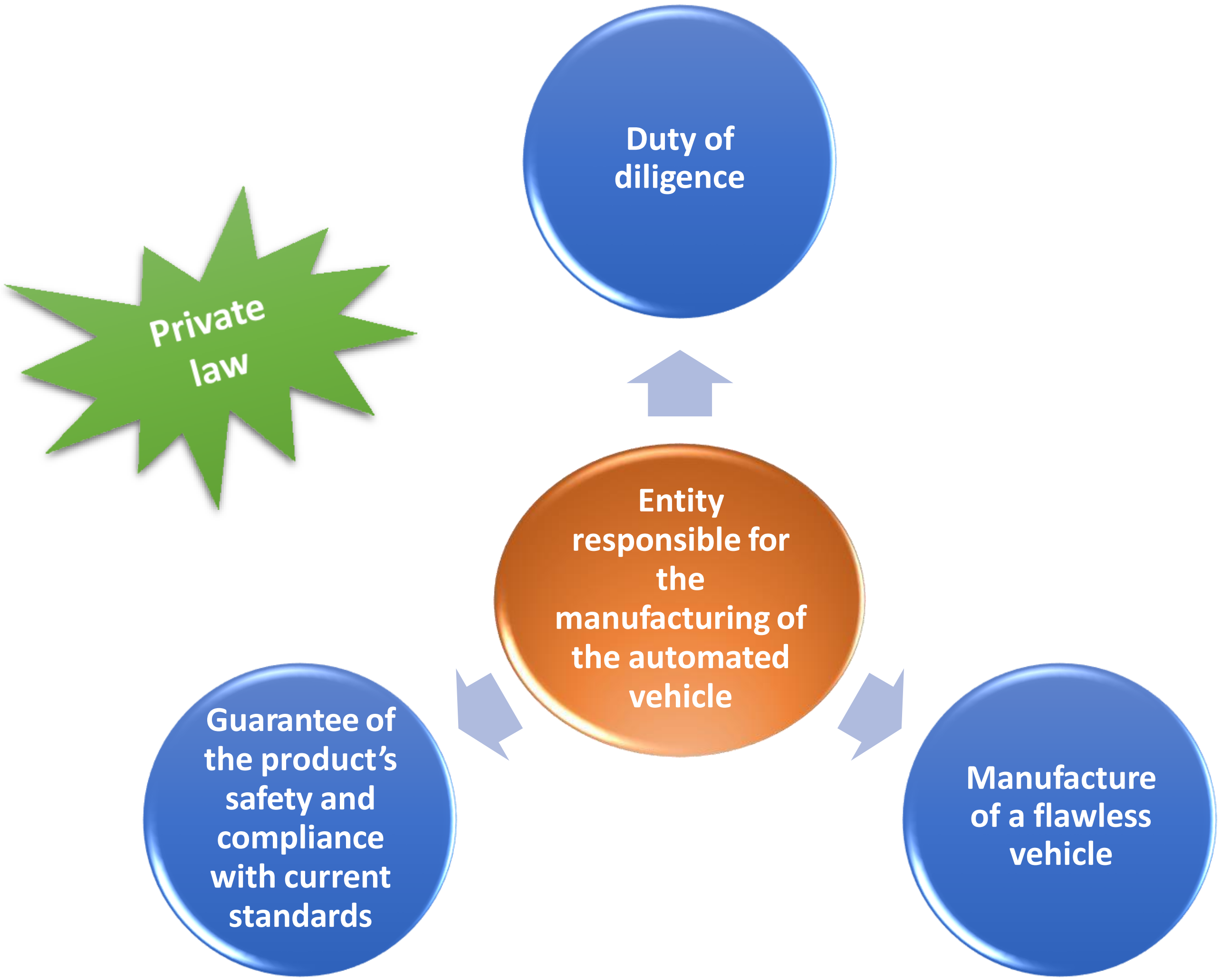
2.2 The automated vehicle’s manufacturer



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2.3 The automated control system's designer

Private law

Duty of diligence

Entity responsible for the conception of the automated control system

Guarantee of the product's safety and compliance with current standards

Manufacture of a flawless automated control system

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2.4 The automated vehicle's driver

- Person in charge of driving the automated vehicle
  - Duty of prudence and vigilance
  - Use of the vehicle in compliance with the terms of use
  - Regaining control over the vehicle when necessary
  - Active surveillance of the vehicle

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3. Objects

3.1 Objects covered by use cases

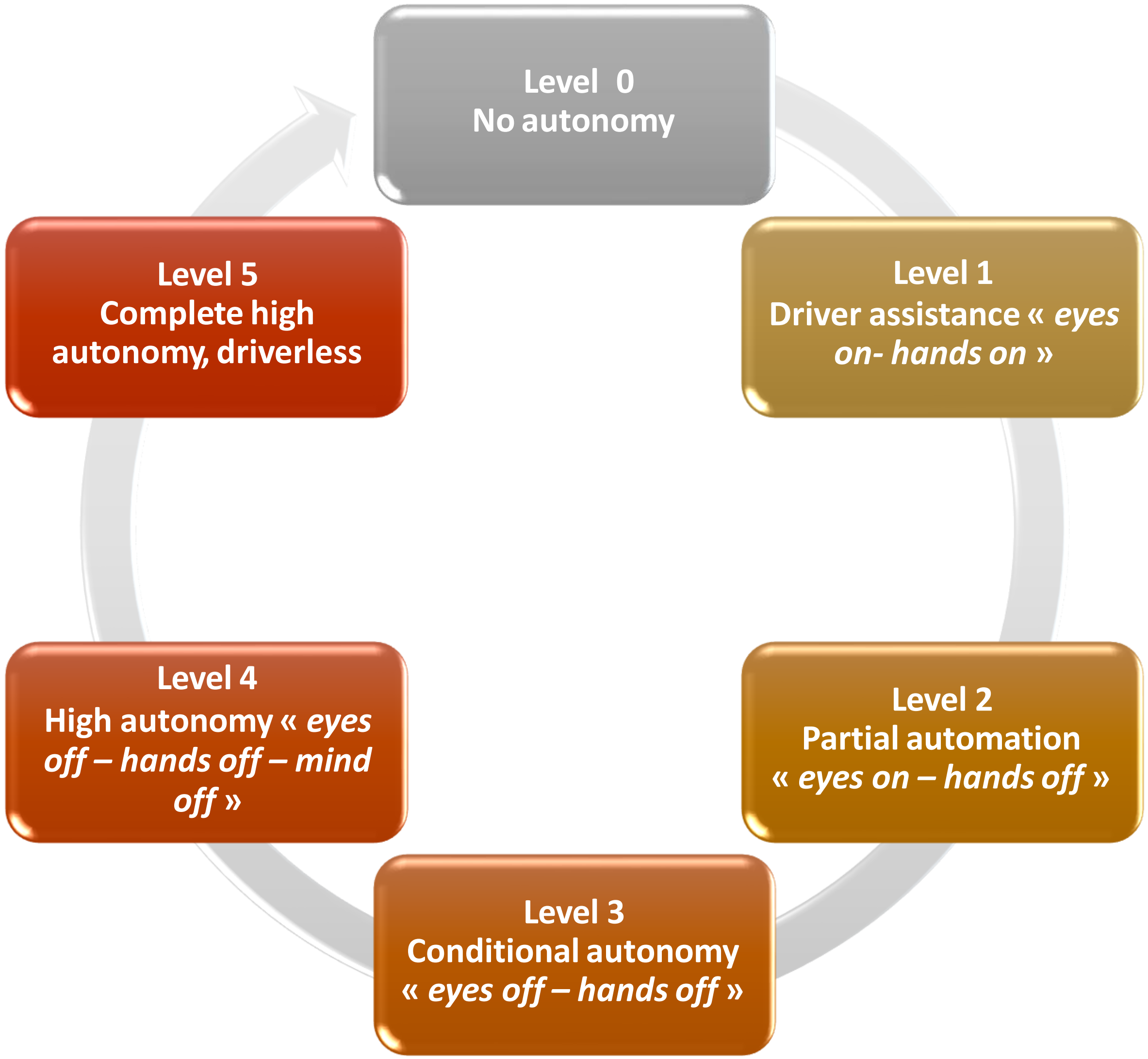
Connected vehicle:

Motor vehicle equipped with connected apps which allow it to exchange data and to interact with other cars or with intelligent transport interfaces to support and facilitate human driving.

Automated vehicle or automated driving vehicle:

Motor vehicle which uses captors, connected apps and a Coordinated Global Positioning System and which is able to drive by itself, without an active human intervention.

3.2 The vehicle's level of autonomy



G7 : level 3 or higher automated vehicle

Influence on the designation of the person held responsible

4. Use cases

4.1 C4 Use case

«Approaching the toll station: orientation of drivers»

When a vehicle approaches a toll station, a specific message is sent by the highway manager, helping it with pre-selecting the appropriate toll lane.

Context	Orientation difficulties when approaching a toll station
Goal	Helping with orientation
Desired behaviour	Steering itself according to the received data
Expected advantages	Safety and improvement of traffic flow

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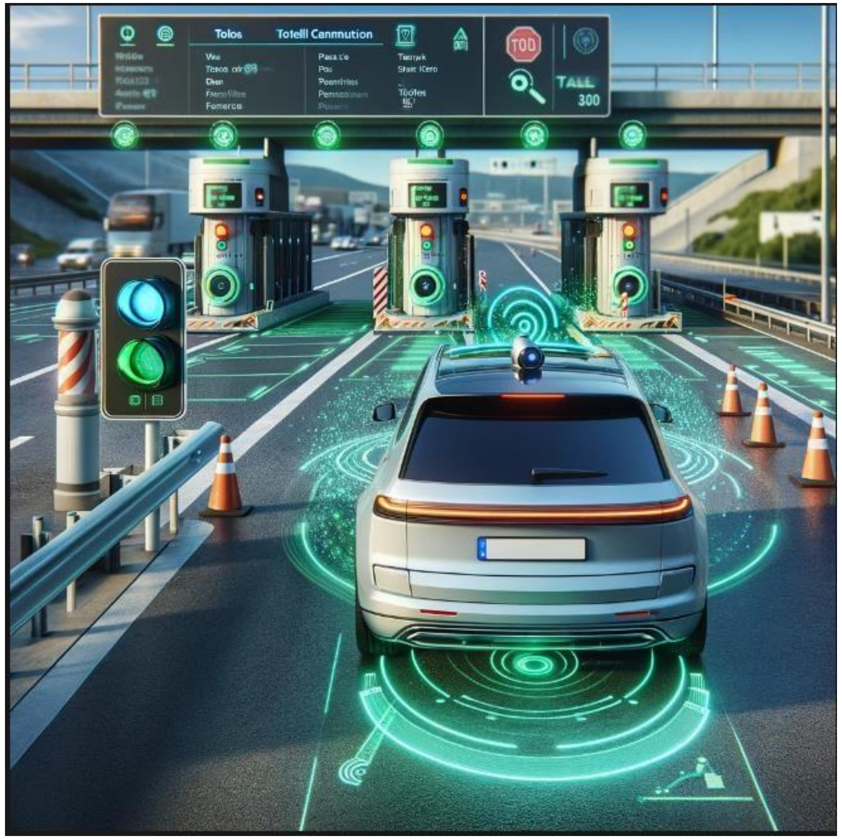
4.2 C8 Use case

«Crossing of the toll barrier for automated vehicles»



Once the automated vehicle has selected the toll lane and has crossed the platform (G7), the highway operator sends information about the state of the traffic light and barrier.

Context	Complex environment for an automated vehicle
Goal	Giving the automated vehicle relevant pieces of information
Desired behaviour	The automated vehicle must take the appropriate decision
Expected advantages	Safety and fluidity

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4.3 G7 Use case

«Extended high-definition cartography services»

<u>In urban areas</u>, the infrastructure sends detailed data describing the intersections with various storage tracks to improve the automated vehicle's perception and understanding of the lane, with details in real time (traffic signs, location and state of traffic lights).

<u>On the highway</u>, the high-definition cartography can be displayed for toll passage, passage through construction zones and for constructions on rest areas.

Context	Complex environment for the automated vehicle
Goal	Giving the automated vehicle relevant pieces of information
Desired behaviour	The automated vehicle must adapt its speed and its path
Expected advantages	Safety & Improvement of traffic flow

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4.4 B1a Use case

« Closure warning of part of a lane, a full lane or multiple lanes»

The vehicle receives pieces of information about the neutralisation of a part of the lane or about a lane closure (but without the closure of the road). The neutralisation can be due to a static road construction site, but also due to an accident.

Context	Difficulty for a vehicle with a delegated driving system to understand a construction/accident situation
Goal	Anticipation
Desired behaviour	Adaptation
Expected advantages	Safety & Improvement of traffic flow

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5. Actors’ liability and associated risks

5.1 Types of incurred liabilities

Civil liability

- Tort liability for personal fault
- Tort liability by operation of law for defective products
- Contractual liability

Administrative liability (road operators)

- Administrative liability for fault
- Administrative liability for presumed fault in case of a lack of normal road maintenance

Criminal liability

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5.2 Risks incurred by the actors

Financial risks

- Damage compensation (material, physical, moral)
- Legal fee reimbursement
- Criminal fine (contravention or offence)
- Amende administrative

Other risks

- Confiscation of the good
- Prohibition on excercising the profession
- Judicial oversight
- Publication of the judicial decision
- Moral damage
- Agencies' disciplinary sanctions

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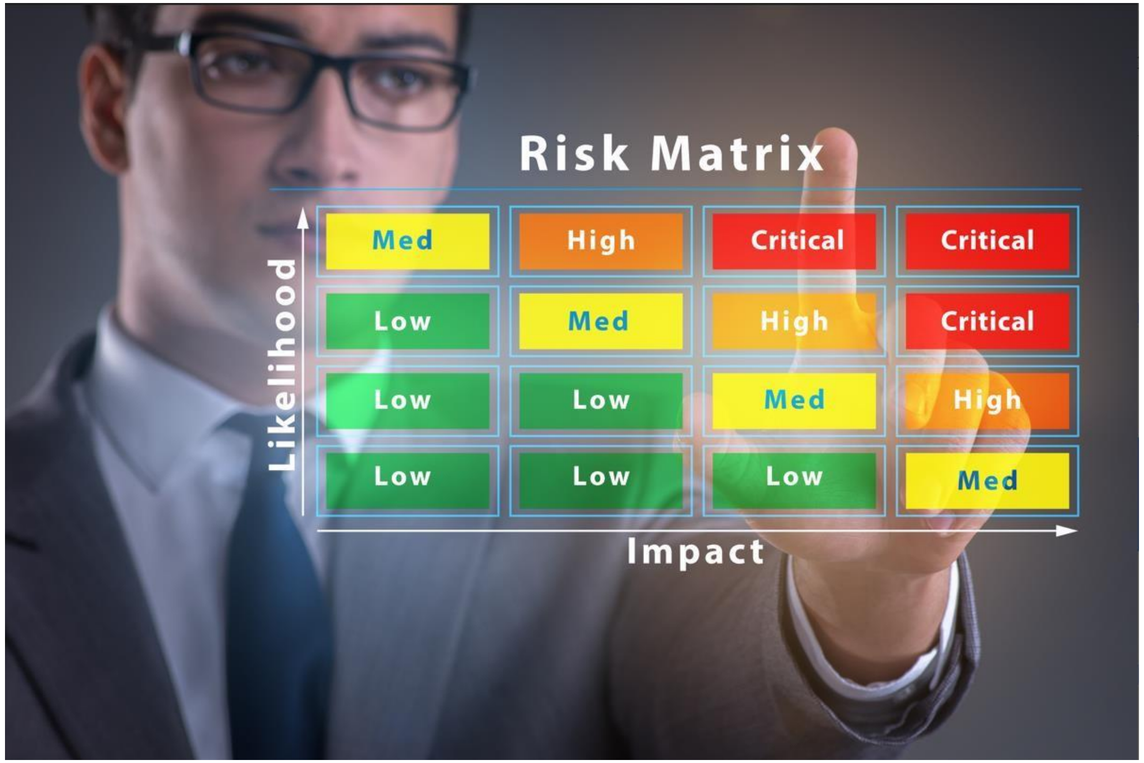
5.3 Risks assessment : information issuer



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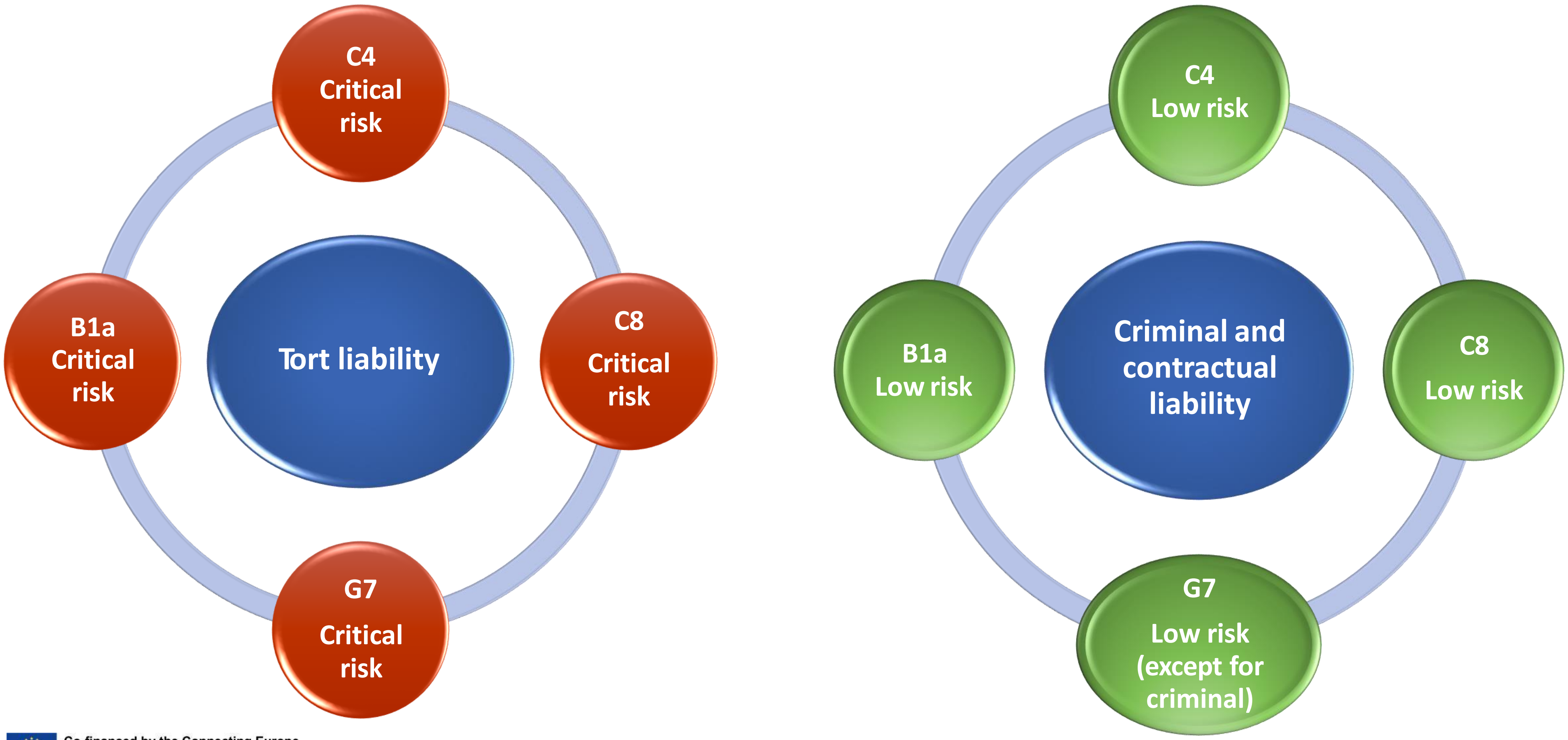
5.4 Risks assessment : manufacturer and designer



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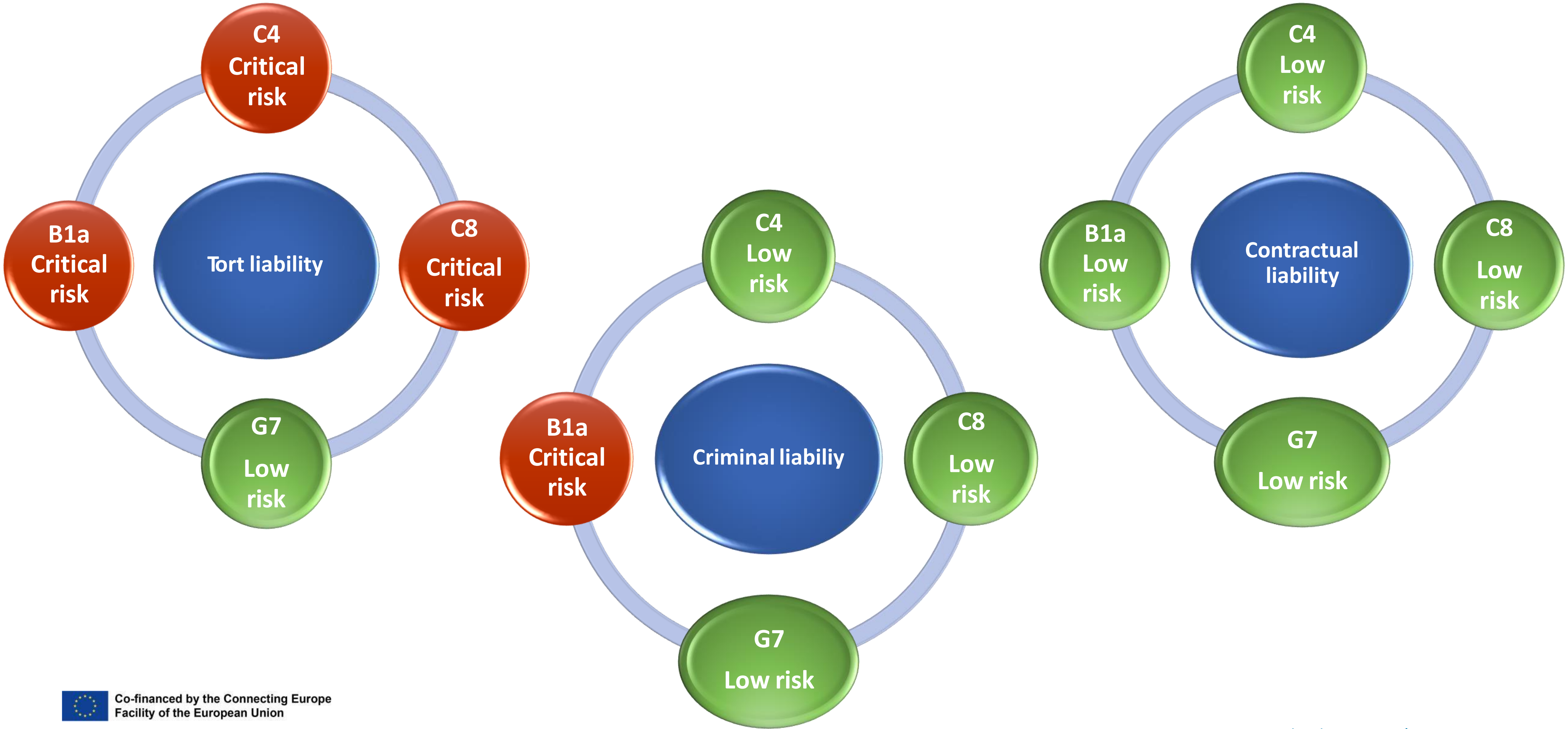
5.5 Risks assessment: vehicle driver



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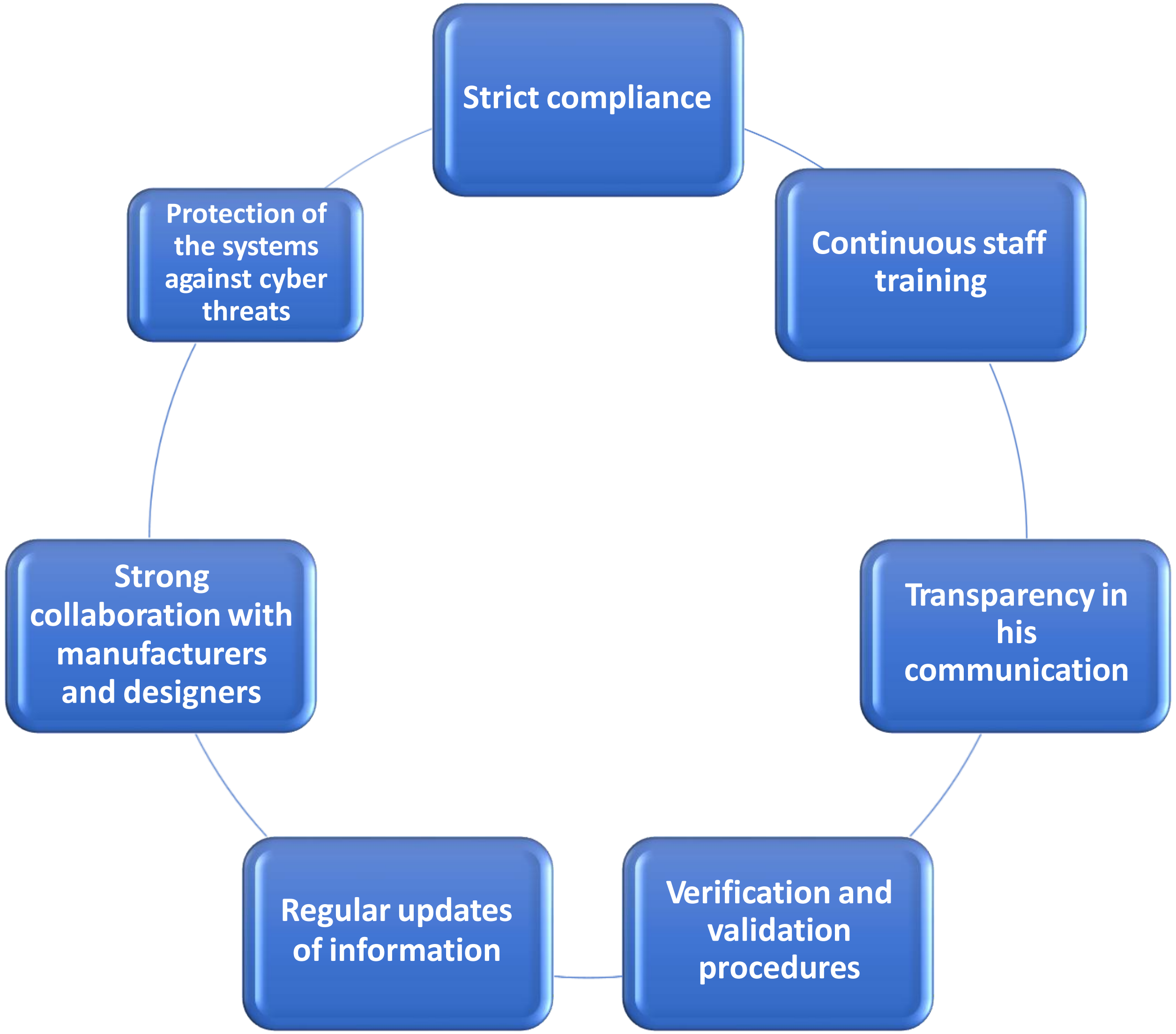
6. Recommendations

6.1 For the information issuer



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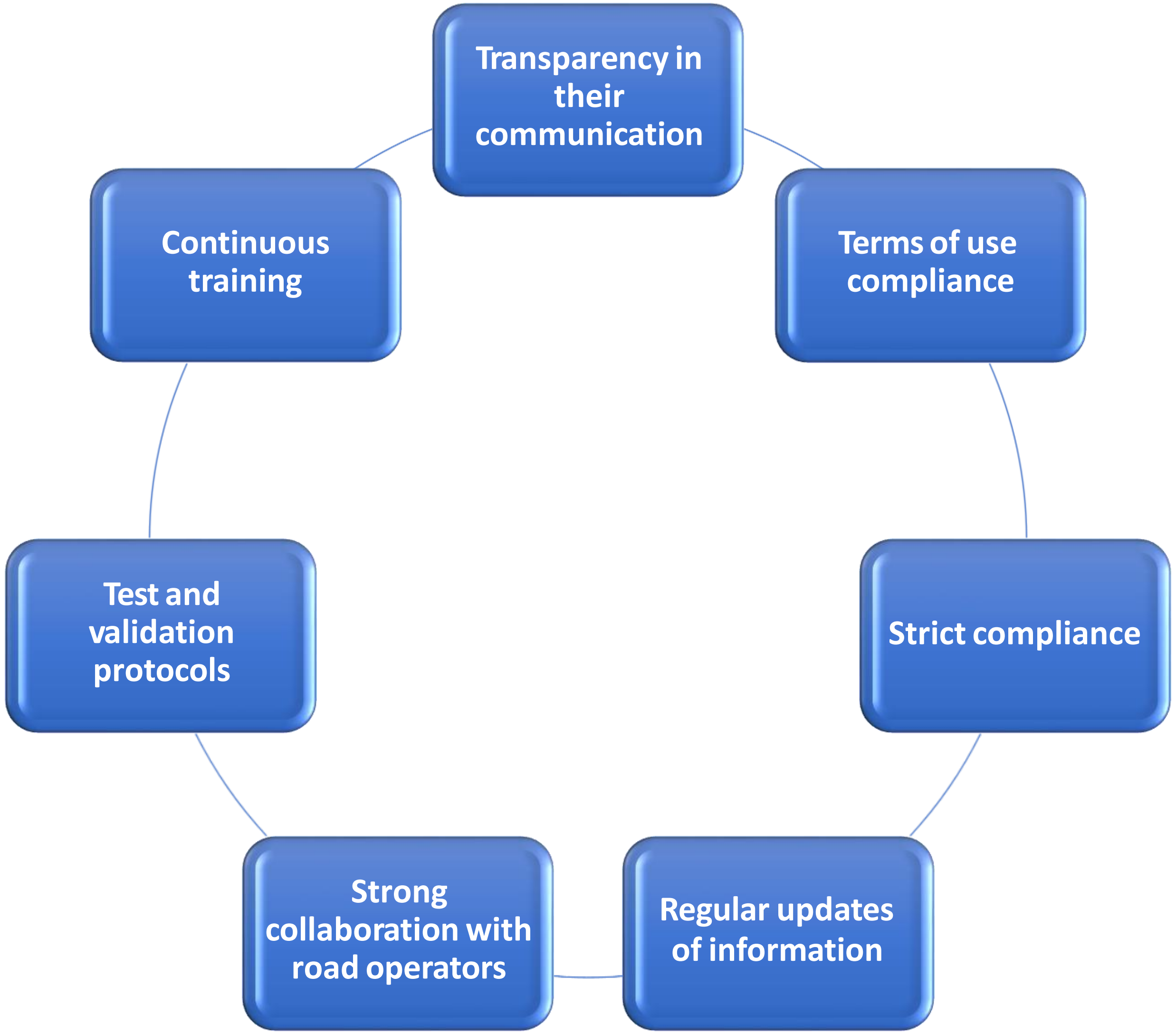
6.2 For the manufacturer, designer and seller



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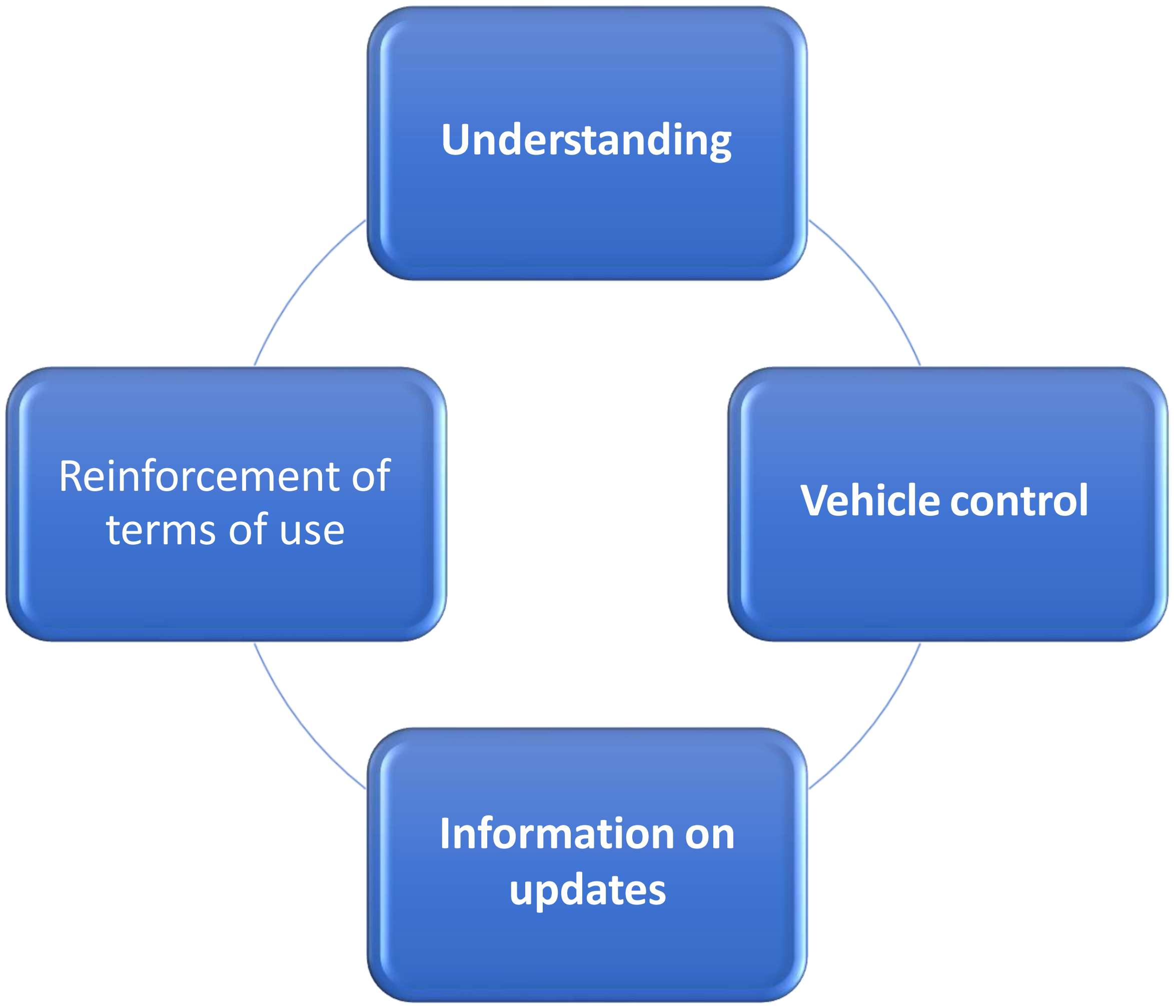
6.3 For the driver



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8. The action plan

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