SECUR

Safety Enhancement through Connected Users on the Road

SECUR V2X ROADMAP

2026-2032

11/01/2023 – Version 4.7

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Contributors

CSI
VUFO GmbH
IMT Atlantique

OUTLINE

SECUR
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Introduction

PROJECT OBJECTIVE

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EURO NCAP FOR SAFER CARS

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Main objective

Study the potential of V2X communication to improve safety of different road users:

- By studying the potential benefits of these technologies regarding accidentology
- By developing the testing tools that will enable the improvements to these systems and to evaluate their performances

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OBJECTIVES AND SCOPE

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- ❑ Identify the mains accident scenarios and their parameters
- ❑ Study the existing or upcoming technologies and their relevance to address the main accident scenarios
- ❑ Identify when and how V2X can improve ADAS performances
- ❑ Define the connected targets specifications and support target providers with the development
- ❑ Define a test and assessment proposals

Road user scope

Ego: Passenger car

Opponent:

- ❑ Passenger car
- ❑ Motorcyclist
- ❑ Bicyclist
- ❑ Pedestrian

V2X Scope

V2X types:

- ❑ V2V
- ❑ V2VRU
- ❑ V2N
- ❑ V2I

Project that brings great importance to technological neutrality.

PROJECT CONTENT

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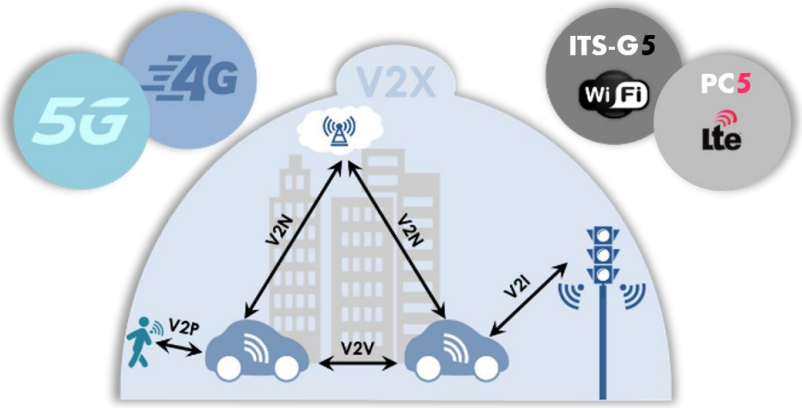
WP1

Dec. 2020 → Dec. 2021

ACCIDENT DATA STUDY

Identify the main accident scenarios, the corresponding use cases and their descriptive parameters



WP2

May 2021 → Aug. 2022

SUITABILITY OF THE TECHNOLOGIES FOR THE SELECTED USE CASES

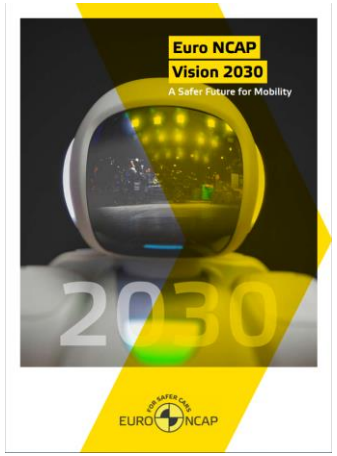
Study existing and upcoming technologies, their relevance to address the main use cases

WP3

Oct. 2021 → Nov. 2022

V2X POTENTIAL TO IMPROVE ADAS PERFORMANCES

Final use cases selection & definition



WP4

Sept. 2021 → Dec. 2022

DEVELOPMENT OF CONNECTED TARGETS

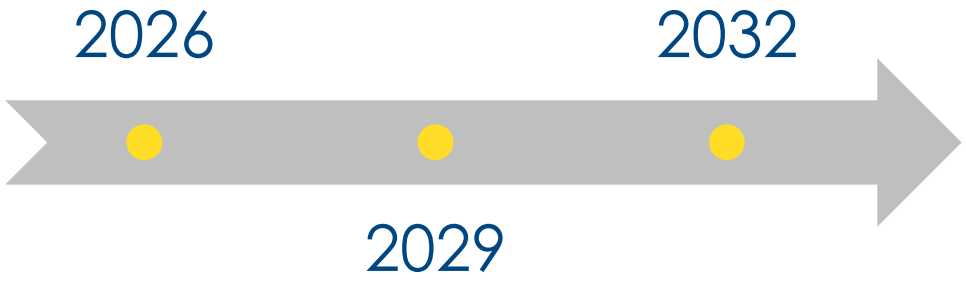
Develop a target specification allowing connection and visibility for identified V2X technologies

WP5

Sept. 2022 → Dec. 2022

TEST AND ASSESSMENT PROCEDURES

Define V2X test and assessment guidelines for the selected use cases



SECUR V2X ROADMAP INTRODUCTION

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The objective of this document is to propose to Euro NCAP a SECUR view on the V2X integration in the 2030 roadmap. The main elements considered are accident priorities, feasibility, expected maturity and availability of technologies. For this purpose, this V2X roadmap has the intention to adopt a progressive approach with several steps.

The following countermeasures were defined and used in SECUR based on previous works: **driver information**, **driver awareness**, **driver warning**, **non-safety-critical vehicle action** and **safety-critical vehicle action** (*definitions later in the presentation*).

Steps overview:

- Road users: Focus first on passenger car and PTW. Secondly, open V2X testing to bicyclist and pedestrian. Additionally, a small step is also suggested for bicyclist in the first stage, with “driver awareness” only.
- Countermeasures: In this proposal, **V2X** should mostly be considered as **an additional sensor**. With the proposed methodology **it is up to the OEM to use (or not) V2X for ADAS systems** (e.g., AEB) and all possible safety countermeasures. The SECUR assessment methodology allows first to evaluate the vehicle’s performance without connectivity and then with connectivity.
- V2X types: For crash avoidance infrastructure will only be considered in a second step. Furthermore, all V2X types are considered for Safe driving (V2V, V2N, V2VRU and V2I).

The use cases presented in this roadmap are derived from SECUR WP1 accident study. This study was focused on the most safety relevant scenarios (KSI-based) considering all road users as opponent and passenger car as ego vehicle.

Abbreviations

ABBREVIATIONS

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Euro NCAP	
CCCscp	Car-to-Car Crossing straight crossing path
CCCscpO	Car-to-Car Crossing straight crossing path Obstructed *(Scenario not existing yet with obstruction)*
CCRb	Car-to-Car Rear braking
CCHO	Car-to-Car Head-On
CCFhos	Car-to-Car Front Head-On Straight
CCFhol	Car-to-Car Front Head-On Lane change
CCFtap	Car-to-Car Front turn-across-path
CMC	Car-to-Motorcycle Crossing
CMFtap	Car-to-Motorcycle Front turn-across-path
CBNA	Car-to-Bicyclist Nearside Adult
CBNAO	Car-to-Bicyclist Nearside Adult Obstructed
CBFA	Car-to-Bicyclist Farside Adult
CBTA	Car-to-Bicyclist Turning Adult
CPNA	Car-to-Pedestrian Nearside Adult
CPFA	Car-to-Pedestrian Farside Adult
CPFAO & CPNAO	Car-to-Pedestrian Farside & Nearside Adult Obstructed
SAS	Speed Assist Systems

ABBREVIATIONS

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SECUR	
SCP-LD	Straight Crossing Path (ego) – Left Direction (opponent)
SCP-RD	Straight Crossing Path (ego) – Right Direction (opponent)
RE-FV	Rear-End – Following Vehicle (ego)
LTAP-OD	Left Turn Across Path (ego) – Opposite Direction (opponent)
SCP-OD/LTAP	Straight Crossing Path (ego) – Opposite Direction and Left Turn Across Path (opponent)
Other	
V2V	Vehicle-To-Vehicle
V2VRU	Vehicle-To-VRU
V2I	Vehicle-To-Infrastructure
V2N	Vehicle-To-Network (Uu communication)
V2X	Vehicle-To-Everything
VRU	Vulnerable Road User (Motorcyclist, Bicyclist, pedestrian,)
PTW	Powered two-wheelers (= Motorcyclist)
w/wo	With and without
Driver I/A/W	Driver Information / Awareness / Warning

SECUR Context

SECUR ACCIDENTOLOGY WP1 ACCIDENT SCENARIOS

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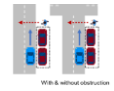
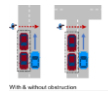
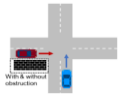
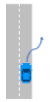
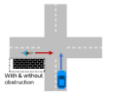
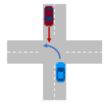
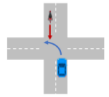
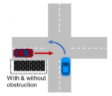
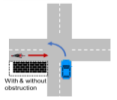
SECUR WP1 Use cases							Euro NCAP corresponding scenario
WP1 Scenario number	Designation	Acronym	Opponent	Pictogram	Obstruction	Description	
1	Oncoming	/	Passenger car		No	A collision where a vehicle is travelling along a straight path and strikes another vehicle travelling in the opposite direction.	CCFhol & CCFhos (Coming in 2023)
2	Straight Crossing Path – Right Direction	SCP-RD	Bicyclist		Yes & No	A collision in which a vehicle travels forwards along a straight path across a junction, towards a bicyclist crossing the junction on a perpendicular path, from the right direction.	CBNA & CBNAO
3	Straight Crossing Path – Right Direction	SCP-RD	Passenger car		Yes & No	A collision in which a vehicle travels forwards along a straight path across a junction, towards a vehicle crossing the junction on a perpendicular path, from the right direction.	CCCscp (Coming in 2023)
4	Straight Crossing Path – Right Direction	SCP-RD	Pedestrian		Yes	A collision in which a vehicle travels forwards towards an adult pedestrian crossing its path walking from the nearside and the frontal structure of the vehicle strikes the pedestrian.	CPNA
5	Straight Crossing Path – Left Direction	SCP-LD	Pedestrian		Yes	A collision in which a vehicle travels forwards towards an adult pedestrian crossing its path walking from the farside.	CPFA & CPNCO
6	Loss Of Control in CUrve	LOC-CU	None		No	An accident where the vehicle is alone, driving in a curve and the control of the vehicle is lost.	Not covered.
7	Straight Crossing Path – Left Direction	SCP-LD	Passenger car		Yes & No	A collision in which a vehicle travels forwards along a straight path across a junction, towards a vehicle crossing the junction on a perpendicular path, from the left direction.	CCCscp (Coming in 2023)
8	Loss Of Control in Straight Line	LOC-SL	None		No	An accident where the vehicle is alone, driving in a straight line and the control of the vehicle is lost.	No
9	Straight Crossing Path – Left Direction	SCP-LD	Bicyclist		Yes & No	A collision in which a vehicle travels forwards along a straight path across a junction, towards a bicyclist crossing the junction on a perpendicular path, from the left direction.	CBFA
10	Rear End - Following Vehicle	RE-FV	Passenger car		No	A collision in which a vehicle travels forwards towards another vehicle that is travelling in the same direction and the frontal structure of the vehicle strikes the rear structure of the other. From the following vehicle point of view.	CCRm & CCRb & CCRs
11	Rear End - Previous Vehicle	RE-PV	Passenger car		No	A collision in which a vehicle travels forwards towards another vehicle that is travelling in the same direction and the frontal structure of the vehicle strikes the rear structure of the other. From the previous vehicle point of view.	Not covered. Case partially covered by CCRm & CCRb & CCRs but not with this point of view (previous vehicle).
12	Left Turn Across Path – Opposite Direction	LTAP/OD	Passenger car		No	A collision in which a vehicle turns across the path of an oncoming vehicle, and the frontal structure of the vehicle strikes the front structure of the other.	CCFtap
13	Left Turn Across Path – Opposite Direction	LTAP/OD	PTW		No	A collision in which a vehicle turns across the path of an oncoming motorcycle, and the frontal structure of the vehicle strikes the front structure of the other.	CMFtap (Coming in 2023)
14	Left Turn Across Path – Left Direction	LTAP/LD	Passenger car		Yes & No	A collision in which a vehicle turns across the path of a vehicle crossing the junction on a perpendicular path from the left direction.	'Not covered. Partially covered by CCCscp.
15	Left Turn Across Path – Left Direction	LTAP/LD	PTW		Yes & No	A collision in which a vehicle turns across the path of a motorcycle crossing the junction on a perpendicular path, from the left direction.	Not covered. Partially covered by CMC, coming in 2025.

→ The final list of SECUR use cases is available on slide 15 & 16

SECUR ACCIDENTOLOGY COVERAGE

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KSI Ranking	Catalog category	Crash scenario name	Description	Opponent	Crash scenario catalog coverage (GIDAS-2020)				EU target population (CARE-2020)	
					KSI [n]	KSI [%]	Injured [n]	Injured [%]	KSI [%]	Injured [%]
1	9	Oncoming	Face to face impact between two passenger cars.	Passenger car	332	9%	1326	7%	6%	5%
2	13	Straight Crossing Path – Right Direction (SCP-RD)	Crossing bicyclist from right side at an intersection.	Bicyclist	248	7%	1162	6%	8%	9%
3	13	Straight Crossing Path – Right Direction (SCP-RD)	Crossing passenger car from right side at an intersection.	Passenger car	233	6%	1598	8%	4%	6%
4	13	Straight Crossing Path – Right Direction (SCP-RD)	Crossing pedestrian from right side.	Pedestrian	214	6%	497	3%	9%	10%
5	14	Straight Crossing Path – Left Direction (SCP-LD)	Crossing pedestrian from left side.	Pedestrian	194	5%	360	2%	9%	7%
6	21	Loss Of Control in CUrve (LOC-CU)	/	Ego single	190	5%	493	3%	6% *	3% *
7	14	Straight Crossing Path – Left Direction (SCP-LD)	Crossing passenger car from left side at an intersection.	Passenger car	179	5%	1230	6%	3%	5%
8	20	Loss Of Control in Straight Line (LOC-SL)	/	Ego single	174	5%	393	2%	6% *	3% *
9	14	Straight Crossing Path – Left Direction (SCP-LD)	Crossing bicyclist from left side at an intersection.	Bicyclist	167	5%	747	4%	5%	6%
10	11	Rear End - Following Vehicle (RE-FV)	Rear-end braking crash between two passenger cars.	Passenger car	164	4%	2051	11%	3%	8%
11	15	Rear End - Previous Vehicle (RE-PV)	Rear-end braking crash between two passenger cars	Passenger car	154	4%	2382	12%	3%	9%
12	1	Left Turn Across Path – Opposite Direction (LTAP/OD)	Passenger car turning left across the path of another vehicle coming from the opposite direction.	Passenger car	123	3%	828	4%	2%	3%
13	1	Left Turn Across Path – Opposite Direction (LTAP/OD)	Passenger car turning left across the PTW path coming from the opposite direction.	PTW	87	2%	188	1%	4%	3%
14	4	Left Turn Across Path – Left Direction (LTAP/LD)	Crossing passenger car from left side at an intersection.	Passenger car	86	2%	583	3%	1%	2%
15	4	Left Turn Across Path – Left Direction (LTAP/LD)	Crossing PTW from left side at an intersection.	PTW	82	2%	218	1%	4%	4%
				TOTAL	2627	71%	14056	73%		

GIDAS

Total of KSI	3720
Total of injured	19329

- **4** types of road users covered.
- **71%** of all the KSI in the SECUR catalog are covered by these 15 accident scenarios.
- **73%** of all the injured in the SECUR catalog are covered by these 15 accident scenarios

LEGEND

The target population is the estimation of occupants, which could be saved by a safety system, which is able to eliminate completely the occurrence of all accidents of a category.

*: Because of the similarity of the categories 20 and 21 (LOC in Straight Line / LOC in Curve) they got combined to one category “Loss Of Control”. EU target population percentage are therefore equal.

SECUR V2X ECOSYSTEM OVERVIEW

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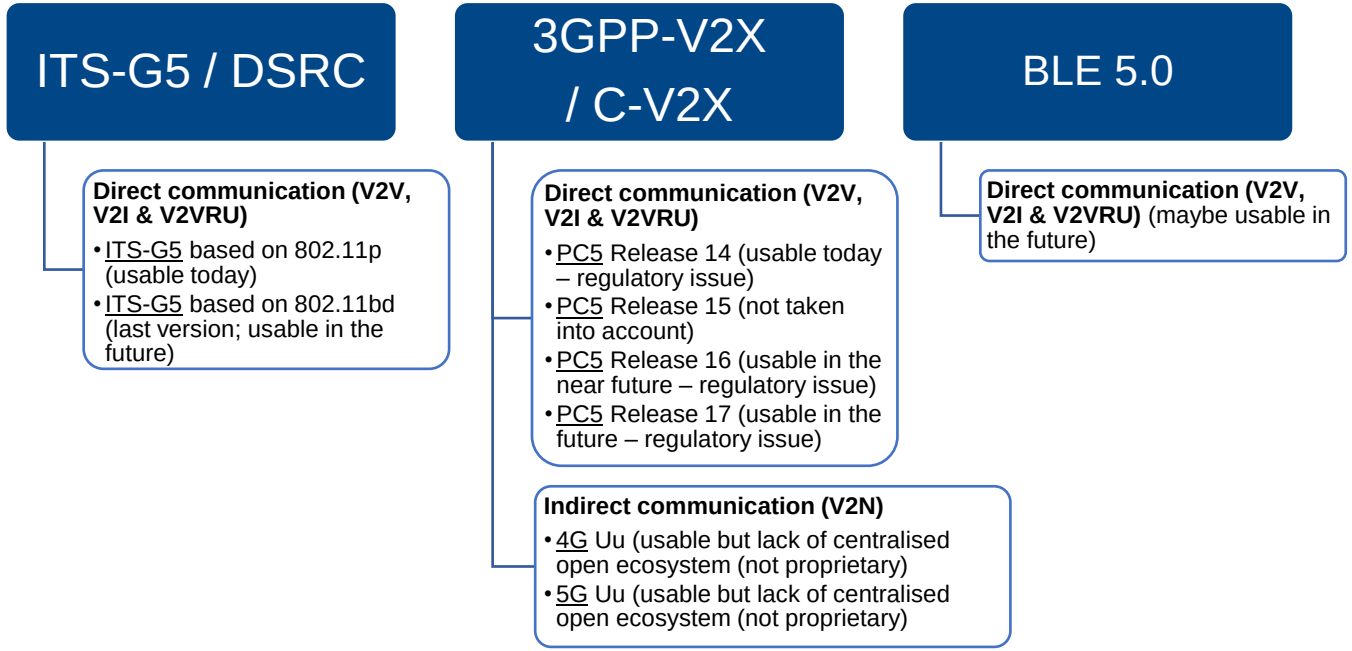
- All the following V2X communication types are considered in SECUR:
  V2V, V2N, V2VRU and V2I.

- All the following V2X technologies are considered in SECUR:
  - ITS-G5 based on 802.11p
  - PC5 based on 3GPP release 14
  - PC5 based on 3GPP release 16
  - 4G (Uu – Network)
  - 5G (Uu - Network)
  - Bluetooth Low Energy 5.0 (BLE 5.0)



As the previous points show, the V2X ecosystem is very diverse and fragmented. It is a growing field that is not yet harmonized with multiple non interoperable technologies.

SECUR is technology neutral, but it is important to maximize safety benefit by ensuring maximum market penetration, e.g., by domination of one set of technology.

SECUR V2X ECOSYSTEM ADAS & V2X SYNERGY

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❑ Besides the ADAS impact on casualties' avoidance and accident mitigation, **ADAS' systems based on onboard sensors have some limitations and are impacted by technical and physical aspects**:

- Impacted by obstruction / non-light-of-sight
- Possible important cost: better performances are brought by higher quality sensors which traditionally increase their cost
- Low to mid end vehicles may only be equipped to meet legal requirements
- Impacted by luminosity level and glare
- Robustness issues faced with the variability of contexts: different environments, opponents, nonlinear trajectories
- Risks of false positives and false negatives
- Impacted by weather conditions
- Impacted by speed / speed differential

	BENEFITS	DRAWBACKS
V2X	- Provides additional information to the systems. Knowledge of the road user type (classification) and their dynamic parameters (speed, positioning, driving lane, heading, accel/braking, turning indicator, airbag status, etc). These data could be used for path prediction. - Almost not impacted by ADAS' weaknesses (obstruction/NLOS, luminosity, weather conditions, speed, etc). - Ability to classify, communicate, confirm information about the opponent: infrastructure/vehicle/VRU, fix or mobile, etc. - Improve the opponent position information. - Allow new services to the user through the share of specific situation information with a wide range (crashes, traffic jam, VRU on the road, roadwork, slippery road, etc.). - Short range technologies offer V2X services without infrastructure cost. Free for the user anytime, anywhere.	- Not yet V2X safety integrity level (ASIL). - Need to ensure the quality and reliability of the transmitted information. V2X highly dependent of the positioning accuracy and confidence. - No consensus yet on the V2X communication technology to be used. - Not yet regulation of V2X open ecosystem (not proprietary) cross OEMs. Direct and indirect communication ecosystems should be connected in the future. Today an example for direct communication (V2V, V2I, V2VRU) is the European Certificate Trust list (ECTL). For indirect communication (V2N) an equivalent solution should be developed in the upcoming years. - Lack of test in real environment on highly congested situation for all direct technologies (ITS-G5 and PC5). - Remaining questions on the business model around connected infrastructure and especially who will fund the infrastructure costs.

❑ ADAS' systems are currently tested under ideal conditions of light or weather. Moreover, the test cases are defined by rules that might not fully reflect the reality and the various situations any driver can go through. **V2X as a new sensor is a key point to complete and increase existing ADAS robustness and efficiency.**

❑ V2X can have an effective impact on road safety (with driver information / awareness / warning / non-safety critical vehicle action). Fusion of V2X and ADAS will be the next step to brake in relevant situations, which is possible for non-safety critical vehicle actions. But V2X need to be adapted for safety critical vehicle actions like emergency braking: V2X has first to become ASIL-compliant.

SECUR USE CASES

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Type		Opponent	WP3 N.#	WP3 Use case
SAFETY	Crash avoidance	Passenger car	#3	**SCP-RD Passenger Car** Crossing passenger car from right side at an intersection.
			#7	**SCP-LD Passenger Car** Crossing passenger car from left side at an intersection.
			#10	**RE-FV Passenger Car** Rear-end braking accident between two passenger cars.
			#12a	**LTAP-OD Passenger Car** Passenger car turning left across the path of another vehicle coming from the opposite
			#01	**Head-On Passenger Car** Face to face impact between two passenger cars**.**
			#12b	**SCP-OD/LTAP Passenger Car** Passenger car going straight at an intersection and having an accident with a vehicle from the opposite direction turning left across its path.
		Powered two wheeler	#13	**LTAP-OD PTW** Passenger car turning left across the PTW path coming from the opposite direction.
			#015	**SCP-LD PTW** Crossing PTW from left side at an intersection.
		Bicyclist	#2	**SCP-RD Bicyclist** Crossing bicyclist from right side at an intersection.
			#9	**SCP-LD Bicyclist** Crossing bicyclist from left side at an intersection.
		Pedestrian	#4	**SCP-RD Pedestrian** Crossing pedestrian from right side.
			#5	**SCP-LD Pedestrian** Crossing pedestrian from left side.
	Safe driving	All	/	**Local Hazard** A situation, an event, or a state towards in which a vehicle is driving.
		None	/	**Red light violation ego** Ego driver behavior not in line with traffic light status.
		All	/	**Red light violation opponent** Red light violation of another road user (opponent) at an intersection.
	Post-crash safety	All	/	**V2X post-crash warning** The capability of a vehicle to warn the surroundings road users after an accident.
	Crash protection	All	/	**V2X crash protection (safety opportunity)** Fusion of V2X with pre-crash systems to improve the knowledge of the situation and the

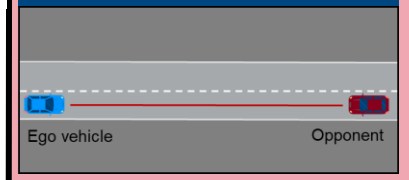
Use cases derived from WP1 accident scenarios through an in-depth accident data study based on GIDAS

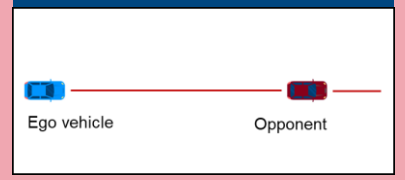
See next slide for the use cases pictograms

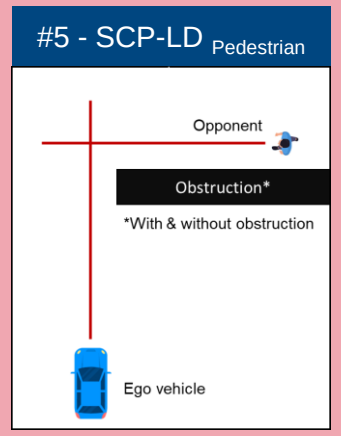
SECUR

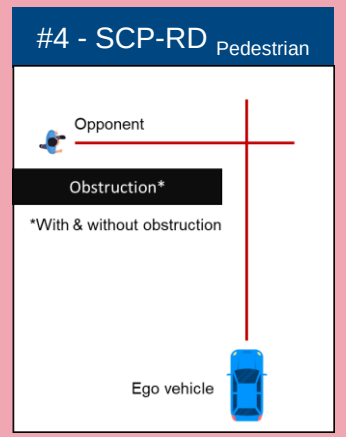
SECUR Use cases
by Euro NCAP rating schemes

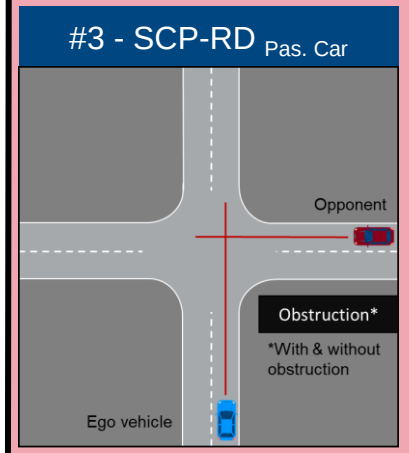
Crash Avoidance

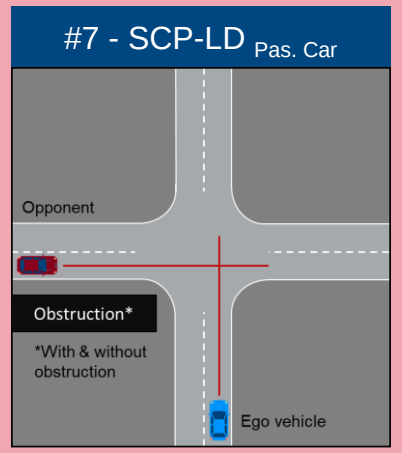
#01 – Head-On Pas. Car


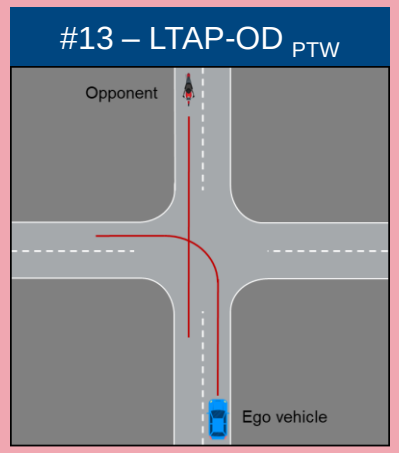
#10 - RE-FV Pas. Car


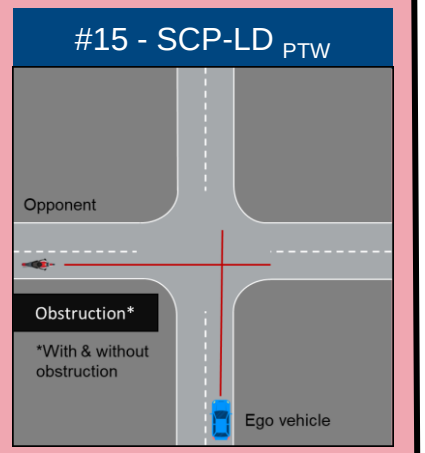
#5 - SCP-LD Pedestrian


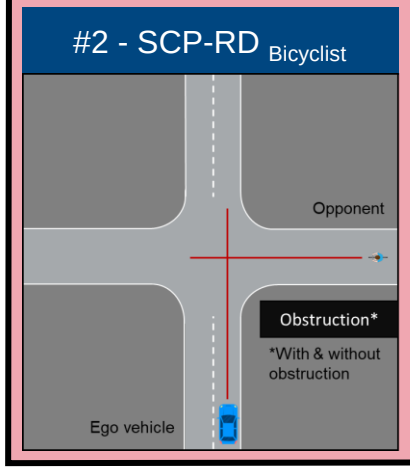
#4 - SCP-RD Pedestrian


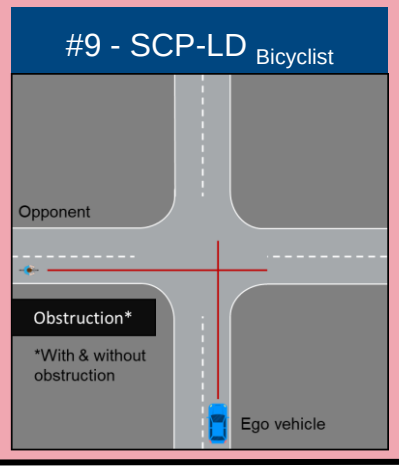
#3 - SCP-RD Pas. Car


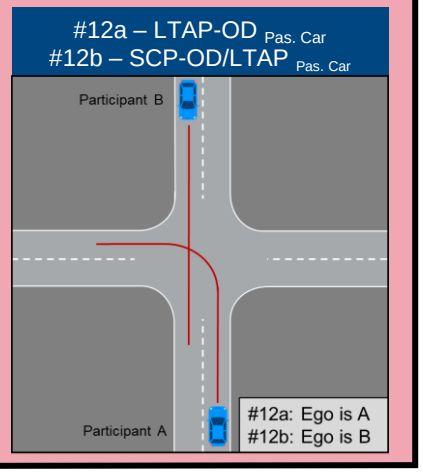
#7 - SCP-LD Pas. Car


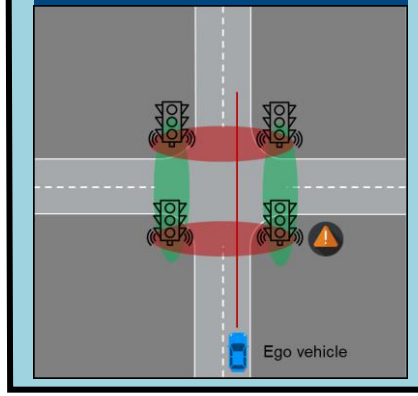
#13 – LTAP-OD PTW


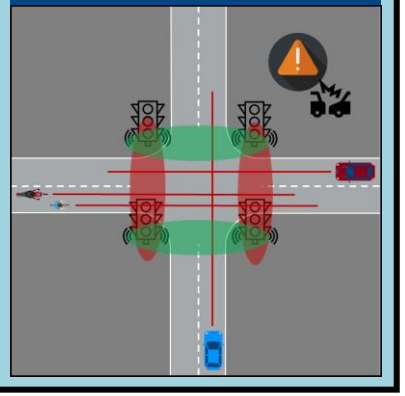
#15 - SCP-LD PTW


#2 - SCP-RD Bicyclist


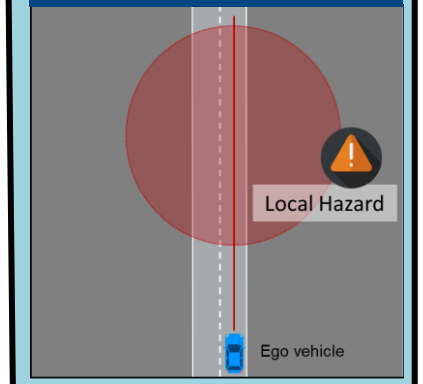
#9 - SCP-LD Bicyclist


#12a – LTAP-OD Pas. Car
#12b – SCP-OD/LTAP Pas. Car


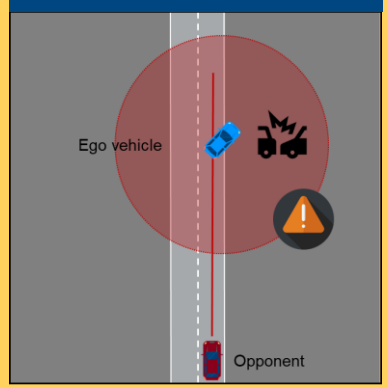
Red-light violation ego


Red-light violation opponent


Safe Driving

Local Hazard


Post-crash Safety

V2X Post-Crash Safety


Crash Protection
Safety opportunity

V2X Crash Protection

Crash Protection:
Fusion of V2X with Pre-Crash systems to improve the knowledge of the situation and the effectiveness.

SECUR V2X roadmap

SECUR countermeasures[1]:

- Driver Information (DI)[2]: The purpose of this application is **to provide static (or semi-static) information to the driver for a safe and comfort drive**. V2X can bring for example in-Vehicle Signage (IVS) information on the road to the driver (e.g., dynamic speed limit information, dynamic lane management, etc).
- Driver Awareness (DA)[3]: The purpose of this application is **to point the driver's attention to a situation ahead** on its vehicle trajectory that has the potential to become dangerous or critical if overlooked by the driver. This service can for example increase the driver vigilance to avoid a collision, in situations, which do not require an immediate action (e.g., roadwork, traffic jams, VRU awareness, etc).
- Driver Warning (DW): The purpose of this application is to **issue alerts to the driver requiring an immediate action** to avoid an accident (e.g., emergency brake, stay in lane, collision risks, etc). V2X could be used as an additional sensor.
- Vehicle Action: Mitigation and crash avoidance by active safety systems. V2X could be used as an additional sensor. According to SECUR, it might not be possible to rely on V2X for ASIL level applications before 2029. The Vehicle Action category could be divided between Non-safety-critical and Safety-critical actions:
  - Non-safety-critical Vehicle Action (NSC-VA) **is not subject to ASIL requirements due to the low consequence severity**. V2X is very relevant to reinforce quickly (2026) these applications' type (e.g., speed reduction, acceleration limitation, system parameter/sensitivity update, etc.)
    Non-safety-critical vehicle actions combined with V2X are already sufficient to have a quick impact on road safety.
  - Safety-critical Vehicle Action (SC-VA) **is subject to ASIL requirements due to the high consequence severity**. V2X should ensure enough safety confidence (ASIL level) before data fusion with those applications like Autonomous Emergency Braking (AEB).

LEGEND

[1]: SECUR definition based on ETSI C-ITS model.
[2]: Driver Information only matches "Safe driving" scenarios but not "Crash avoidance" ones based on TTC relevance.
[3]: The impact of the DA on safety has not been deeply analyzed in SECUR, especially the impact of too much information and the way to prioritize it very close to a potential hazardous situation.

V2X ROADMAP

		2026	OUTLOOK 2029	2032
V2X INTEGRATION AND COUNTERMEASURES (all rating schemes)	CAR-TO-CAR	Countermeasures: **DI / DA / DW* / NSC-VA***	**+ SC-VA***	
	CAR-TO-PTW	Countermeasures: **DI / DA / DW* / NSC-VA***	**+ SC-VA***	
	CAR-TO-BC	Countermeasures: **DI / DA**	**+ DW* / NSC-VA* / SC-VA***	
	CAR-TO-PD		Countermeasures: **DI / DA / DW* / NSC-VA* / SC-VA***	
POSSIBLE V2X TYPES IN EURO NCAP RATING SCHEMES	Crash Avoidance	**V2V / V2N / V2VRU**	**+ V2I**	
	Safe Driving	**V2V / V2N / V2VRU / V2I**		
	Post-crash Safety	**V2V / V2N / V2VRU / V2I**		
	Crash Protection (safety opportunity)		**V2V / V2N / V2VRU**	
ROAD ECOSYSTEM CONNECTIVITY LEVEL FORECAST	Passenger Car	**Available**	**Available**	
	PTW	**Initially available**	**Available**	
	Bicyclist	**Initially available**	**Available**	
	Pedestrian	**Not available**	**Initially available**	**Available**
	Infrastructure	**Initially available**	**Available** (for specific use cases)	

LEGEND

DI: Driver Information
DA: Driver Awareness
DW: Driver Warning

NSC-VA: Non-Safety-Critical Vehicle Action
SC-VA: Safety-Critical Vehicle Action
PTW: Powered-Two-Wheelers

BC: Bicyclist
PD: Pedestrian
* : V2X could be used as an additional sensor for warning and action

V2X ROADMAP

Scenario format: Euro NCAP Scenario (SECUR scenario)

LEGEND

PTW: Powered-Two-Wheelers
BC: Bicyclist
PD: Pedestrian

DI: Driver Information
DA: Driver Awareness
DW: Driver Warning
NSC-VA: Non-Safety-Critical Vehicle Action
SC-VA: Safety-Critical Vehicle Action

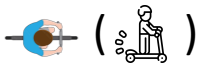
[1]: V2X could be used as an additional sensor for warning and action

[2]: C-ITS day 1 - Described in C2C-CC and C-ROADS Triggering conditions documents

[3]: To be defined in a later stage (not in SECUR scope).

[4]: Extension of the previous step with the consideration of additional, more critical scenarios and countermeasures.

[5]: Use a soft-landing process.

	2026	OUTLOOK 2029[4]	2032[4]
CRASH AVOIDANCE			
CAR-TO-CAR 	**DA / DW[1] / NSC-VA[1]** STEP 1 • CCCscp (#3&7 SCP-LD or RD) • CCRb (#10 RE-FV) → EEBL[2] • CCCscpO (#3&7 SCP-LD or RD)[5]	**+ SC-VA[1]** STEP 2 • CCFtap (#12 LTAP-OD) • CCFhol & CCFhos (#01 Head-on)	STEP 3 • Additional/Advance Use Cases not defined yet[3]
CAR-TO-PTW 	**DA / DW[1] / NSC-VA[1]** STEP 1 • CMCscp (#15 SCP-LD)	**+ SC-VA[1]** STEP 2 • CMCscpO (#15 SCP-LD) • CMFtap (#13 LTAP-OD)	STEP 3 • Additional/Advance Use Cases not defined yet[3]
CAR-TO-BC 	**DA** STEP 1 • CBNAO (#2 SCP-RD) • CBFAO (#9 SCP-LD)	**+ DW[1] / NSC-VA[1] / SC-VA[1]** STEP 2 • CBTA • (eScooter: safety opportunity)	STEP 3 • Additional/Advance Use Cases not defined yet[3]
CAR-TO-PD 		**DA / DW[1] / NSC-VA[1] / SC-VA[1]** STEP 1 • CPNAO (#4 SCP-RD) • CPFAO (#5 SCP-LD)	STEP 2 • Additional/Advance Use Cases not defined yet[3]
SAFE DRIVING	**Local Hazards[2]** Dossier and on-track testing (if feasible) to evaluate the capability of a vehicle to trigger, send, receive and display local hazards. **Red-light violation of the ego** (outlook - infrastructure dependant)	**Red-light violation of the opponent**	
POST-CRASH SAFETY	**V2X Post-crash warning** Passive safety testing to evaluate the capability of the vehicle to warn the surroundings road users when this one has an accident.		
CRASH PROTECTION (Safety opportunity)		**V2X pre-crash exchange with potential collision opponent**	

V2X TESTING PROPOSAL SUMMARY

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Safety Enhancement through Connected Users on the Road

CRASH AVOIDANCE

Integrate V2X in the considered and assessed safety systems.

A specific focus should be done on **scenarios with obstruction** considering that there is an overlap between obstructed and non-obstructed ones. Additionally, this is where V2X is the most valuable and will bring fast and significant benefits.

SAFE DRIVING

Local Hazards assessment based on a dossier and testing when feasible. It should evaluate the capability of a vehicle to trigger, send, receive and display to the driver alerts correctly.

Integrate V2X in the considered and assessed safety systems of the red-light violation scenarios.

POST-CRASH SAFETY

Integrate V2X in passive safety testing to evaluate the capability of a vehicle to warn the surroundings road users when this one has an accident to prevent from additional crashes.

What are the V2X testing needs?

V2X TESTING NEEDS AND CAPABILITY BY V2X TYPES

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Safety Enhancement through Connected Users on the Road

V2V

Passenger car connected target for the test:
- On-board connected target (preferable solution) | ✓ Available
  Off-board connected target | ✓ Available
  - ➢ Real non connected target on-track and use of a remote V2X system (direct communication) to send the V2X messages with the target live dynamic data)
- V2X simulation | ✓ Available
  - ➢ Digital twin solution with simulated dynamic and scenario data

Testing V2X acquisition – V2X messages log:
- Road-Side Unit (RSU) near to the test track | ✓ Available
- Log with the on-track connected module use for the test | ✓ Available
- V2X test data logging software | ✓ Available

V2I

If only V2X consider infrastructure during the test:
- Use of a V2X system to simulate a connected infrastructure with realistic parameters (e.g. internal treatment timing) (preferable solution) | ✓ Available
  - ➢ Simulation of the infrastructure possible without the need of real on-track infrastructure
- Use of real infrastructure for the test | ◌ Connected infrastructure available but not tested in Euro NCAP scenarios.

If other systems (e.g. camera) consider infrastructure during the test:
- Use of real infrastructure for the test | ◌ Connected infrastructure available but not tested in Euro NCAP scenarios.

V2VRU

VRU connected target for the test:
- On-board connected target (preferable solution) | ✗ Not available
- Off-board connected target: | ✓ Available
  - ➢ Real non connected target on track and use of a remote V2X system (direct communication) to send the V2X messages with the target live dynamic data
- V2X simulation | ✓ Available
  - ➢ Digital twin solution with simulated dynamic and scenario data

Testing V2X acquisition – V2X messages log:
- Road-Side Unit (RSU) near to the test track | ✓ Available
- Log with the on-track connected module use for the test | ✓ Available
- V2X test data logging software | ✓ Available

V2N

Testing environment should be homogeneous between labs and representative of the current average network | ✗ Network requirements still to be defined for testing

Road user network connected target for the test:
- On-board connected target (preferable solution) | ✓ Available
- Off-board connected target | ✓ Available
  - ➢ Real non connected target on track and use of a remote V2X system (indirect communication by the network) to send the V2X messages with the target live dynamic data
- V2X simulation | ✓ Available
  - ➢ Digital twin solution with simulated dynamic and scenario data

Testing V2X messages acquisition: V2X messages log with the connected target or the remote V2X system

SECUR

Safety Enhancement through Connected Users on the Road

THANK YOU!

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