

# Q&A on Direct V2X Communication

Information for Euro NCAP

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# Q&A on Direct V2X Communication

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## Introduction

V2X is a foundational enabler of Vision Zero in Europe, delivering its full safety potential only when deployed across a large, interoperable, and unified fleet encompassing all road users and road infrastructure. Europe is leading the Direct V2X deployment supporting this ambition and providing an installed base of more than 2.5 million vehicles and extended infrastructure installations already covering 30%<sup>1</sup> of the TEN-T road network<sup>2</sup> today.

EU regulations<sup>3</sup> establish key principles for Direct V2X deployment, including interoperability, backward compatibility, trust, and privacy. Related Direct V2X requirements are laid down in Cooperative ITS (C-ITS) specifications referencing to harmonized C2C-CC and C-ROADS profiles answering these principles.

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<sup>1</sup> C-ROADS; <https://www.c-roads.eu/>

<sup>2</sup> TEN-T network; European Highways including large city interfaces.

<sup>3</sup> EU regulations; ITS Directive 2010/40/EU and its amendment, Radio Equipment Directive (RED) 2014/53/EU; European Electronic Communications Code (EECC) (EU) 2018/1972 (Note: to be replaced by Digital Networks Act (DNA) in 2028), Spectrum regulation by ECC Decision (08)01 and Radio Spectrum Decision 676/2002/EC.

This document clarifies how interoperability and backward compatibility are met within the C-ITS framework, along with the practical implications.

## Summary

- The EU ITS impact assessment report from 2021<sup>4</sup> identified that Direct V2X is important for realizing road safety objectives of Vision Zero of the EU Commission, as it provides safety beyond the basic warnings. In the future it will enable machine-level cooperation between vehicles and infrastructure, that has the potential to unlock greater safety benefits.
- EU principles for Cooperative ITS (C-ITS)—interoperability, backward compatibility, trust, and privacy imply that all stations must exchange and interpret a common, standardized message set without prior knowledge (i.e. without pairing or negotiation), using spectrum efficiently, and at lowest costs.
- Operational Safety-critical functions (e.g., Safe Driving support and Crash Avoidance) use data of CAM/DENMs. Duplication of these messages across parallel technologies and spectrum is inefficient, fragments safety benefits and increases costs.
- System evolution should add capabilities through backward-compatible extensions and, where needed, complementary channels, while preserving safety baseline for the installed fleet.
- Direct V2X Interoperable data exchange can't rely on Cellular network interoperability mechanisms as there is no central management (base-station/central-station involved in the communication) managing different technologies. The interoperability in Direct V2X (AdHoc networks<sup>5</sup>) has to be realized for each scenario (message set or exchange) individually. For each the information path should be specified (including the technology used).
- Backward compatibility is only realized when older operational equipment can interpret information shared by newer versions of the equipment such that they can continue in realizing their safety related scenarios. New equipment may choose other methods and technologies for new functions which are not understood by older equipment.
- Euro NCAP could incrementally incorporate the individual vehicle's contribution to cooperative, multi-vehicle scenarios, notably collective perception and cooperative manoeuvring.

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<sup>4</sup> EU ITS impact assessment report <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC0813>

<sup>5</sup> AdHoc networks; a decentralized, temporary wireless connection that allows devices to communicate directly with one another without relying on fixed infrastructure.

## Q&A

### What is V2X communication?

- V2X (Vehicle-to-Everything) refers to communication between vehicles and other entities in the transport system, including other vehicles (V2V), infrastructure (V2I), vulnerable road users (V2P) and networks (V2N).
- Direct communication does not rely on a network – vehicles, vulnerable road users, and infrastructure communicate directly with each other over the air.
- Cloud communication relies on telecom networks (V2N) and cloud services.

### What are Cooperative Intelligent Transport Systems (C-ITS)?

- C-ITS is defined by European regulations<sup>6</sup>.
- C-ITS enables vehicles, infrastructure and other road users to exchange information to improve road safety, traffic efficiency and comfort. Communication is cooperative, meaning participants share relevant data such as position, speed or road events to support safer and more predictable driving behaviour.
- C-ITS uses V2X communication to enable cooperative awareness and coordinated traffic behaviour.

### What is the goal of C-ITS deployment in Europe?

- The goal is to improve road safety, traffic efficiency and sustainability by enabling interoperable communication between all road users and infrastructure in a common ecosystem across Europe.

### What do interoperability and backward compatibility require?

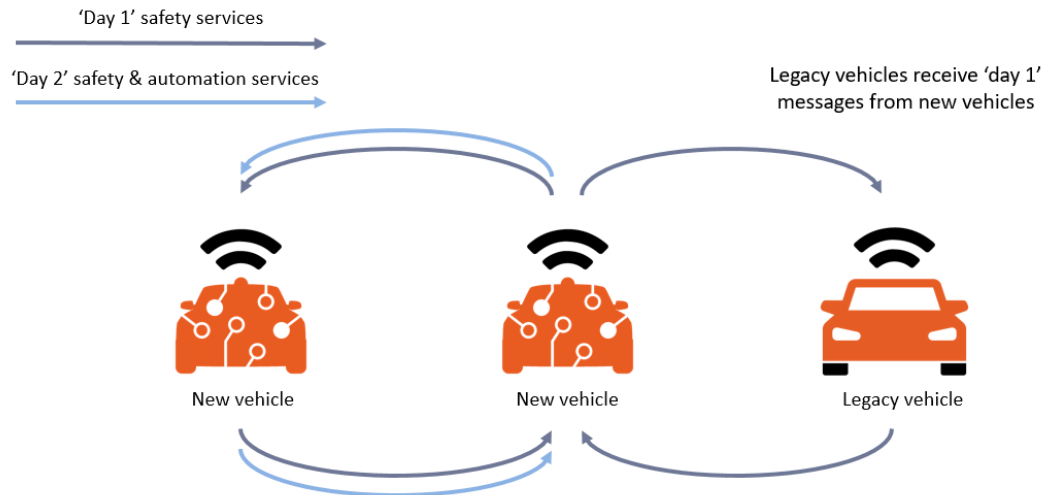
- Interoperability: In a Direct V2X ecosystem, messages are broadcast among the participants without prior knowledge or network management. Therefore, all stations within the same Direct V2X ecosystem (e.g., the C-ITS deployment as supported by C2C-CC) must implement a common, standardized “baseline” of message definitions, protocols and technologies. This ensures that every station can operate correctly and interpret the relevant safety-critical content, in line with European principles for C-ITS deployment.
- Backward compatibility: Because vehicles and road infrastructure have long lifecycles, new service implementations may extend the baseline but must remain compatible with previous versions. This ensures that successive generations of

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<sup>6</sup> EU regulations; ITS Directive 2010/40/EU and its amendment.

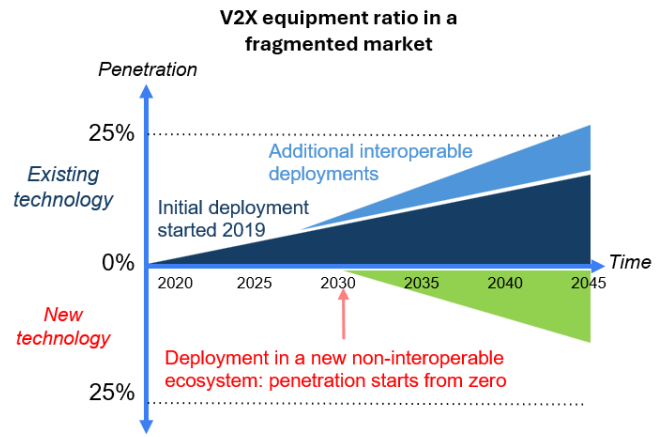
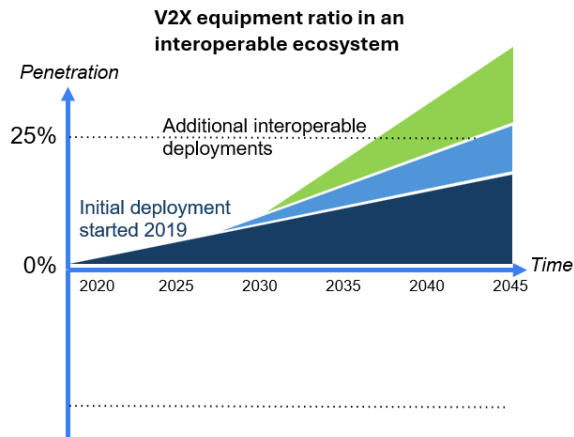
vehicles can interoperate, while evolution may add new functionality without breaking existing operation.

Interoperability and backward compatibility are of practical and economical importance, since it ensures continuity of safety services and avoids stranded investments.



## How does V2X support Safe Driving and Crash Avoidance scenarios?

- Safe Driving enhancements (e.g., improved ACC performance, driver awareness) and Crash Avoidance (e.g., early warning, pre-crash soft braking) depend on timely, reliable availability of Cooperative Awareness Messages (CAM). The CAM baseline can also strengthen Euro NCAP's crash-avoidance scenarios. By providing a digital 360 degree view of surrounding vehicles and vulnerable road users (VRU), the CAM baseline supports a wide range of Safe Driving and Crash Avoidance scenarios.
- Altering the present protocols and transmission technologies (and not complying with the ITS Directive) would set the deployment progress back: it would restart a 7 year long market penetration and adoption process, shrink the interoperable fleet and delay common system-level safety benefits, while wasting capital investments.
- Euro NCAP 2029 protocol scenarios are supported by the current single-channel configuration, while the implementation of a second channel will facilitate the realisation of additional future Direct V2X services such as CPM.
- C2C-CC advocates that evaluation frameworks (such as Euro NCAP) prioritize functional interoperability and system-level safety performance over the mere presence of multiple communication technologies.



Note 1: Resetting the equipment ratio upon introduction of a new technology leads to delay in reaching penetration is illustrated in the figure above. The figure shows the C-ITS safety ecosystem equipment ratio. The right graph shows fragmented interoperability (two ecosystems), while the left one shows unified interoperability on a single channel, reaching an effective basis for cooperative safety and Automated Driving by 2040-45.

Note 2: Duplication leads to inefficient use of the available spectrum. It is inconsistent with the principles of efficient spectrum utilisation set out in the Radio Equipment Directive (RED) 2014/53/EU, which both recognise spectrum as a constrained resource that must be used effectively across competing services.

## How can new scenarios and functions be supported?

- The data in V2X messages enable new scenarios and functions, either by using data from existing messages or by defining new ones. Examples include:
  - The Collective Perception Message (CPM) enables vehicles and infrastructure to share sensor-detected objects, expanding situational awareness beyond V2X-equipped participants. CPM is inherently multi-vehicle/multi-infrastructure, which is not yet fully captured in safety assessments, but might be central to future safety.
  - The Manoeuvre Coordination Message (MCM) supports negotiated interactions like merging, lane changes, and intersection handling to increase safe relations of these manoeuvres for automated driving.
- Swarm intelligence perspective: Safety and automation increasingly emerge from the collective behaviour of many actors—vehicles, infrastructure, and VRUs. As coverage grows, V2X shifts from single-vehicle capability to a “swarm” that perceives and decides better together. Assessment frameworks such as Euro NCAP could consider a single-vehicles contribution to scenarios that evaluate benefits realized through multi-actor cooperation.

## What is important when adding new scenarios?

- The conditions for success are:

- Maintain the Direct V2X baseline ecosystem for sharing CAMs and DENMs in the same trust framework and avoid duplication of these services outside the baseline V2X ecosystem.
- Enable visionary services such as CPS by extending the existing ecosystem by including appropriate additional protocols in the same trust framework. This enables innovation without fragmenting the safety ecosystem.
- Assessment frameworks like Euro NCAP's emerging V2X criteria can clarify performance expectations and incentivize deployment while preserving interoperability.

## Glossary (abbreviated)

- ACC: Adaptive Cruise Control
- CAM: Cooperative Awareness Message (periodic state broadcast).
- C-ITS: Cooperative Intelligent Transport Systems.
- CPM: Collective Perception Message (shared sensor detections).
- CPS: Collective Perception Service.
- DENM: Decentralized Environmental Notification Message (event-driven hazard information).
- MCM: Manoeuvre Coordination Message.
- V2X: Vehicle-to-Everything (vehicles, infrastructure, VRUs).
- VRU: Vulnerable Road User.